Chapter

Classic and Traditional Music Role in Cognitive Function and Critically Ill Patients

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Abstract

Music has been known since the ancestral era, and undoubtedly it has become an integral part of human life. Music has been widely studied, and its purpose encompassed not only as art and recreational but also as therapeutic agents. Listening to music enhances modulation in the mesolimbic pathway and affecting accumbens nucleus (NAc), ventral tegmental area (VTA), hypothalamus, and insula. Evidence support that music could enhance neuroplasticity and stimulate cognitive function. Laksmidewi et al. have already investigated that listening to western classical music and instrumental Balinese flute music therapy improved cognitive function in the elderly. Cognitive improvement by listening to music has been linked to the relationship between the orbitofrontal cortex and the dopaminergic mesocorticolimbic circuit. Besides, musical intervention in severely ill patients showed its advantages in alleviating anxiety and distress symptoms. Patients with mechanical ventilation are prone to high anxiety and stress levels triggered by many factors such as endotracheal tube placement, critical care environment, frequent suctioning, and fear. Non-pharmacological intervention with music therapy is expected to help patients manage their anxiety and distract patients from stressful environments to assist their ventilator weaning effort.

Keywords: classic, cognitive, critical ill, music, role, traditional

1. Introduction

Cognitive function can be improved with pharmacological and non-pharmacological measures. The non-pharmacological methods generally more familiar and safe methods to apply, especially in the elderly population. Non-pharmacological methods for improving cognitive function include physical, emotional, mental, artistic, and musical exercises. Music is a universal human culture and is received by listeners differently depending on one's culture, history, location, and tastes [1]. Various musical activities can be listening to music, singing, playing musical instruments, and composing songs [2].

Munro and Mount first introduced music therapy in 1978. Music therapy is used in the health sector to overcome deficiencies in the physical, emotional, cognitive, and social aspects of someone who has a particular disorder or disease. However, the effects of music therapy cannot be generalized to all mental processes, and not all types of music can be used as music therapy [3].

Music contains various elements, including rhythm and melody, that will reach different parts of the brain. Music mainly affects the right hemisphere and the limbic system related to emotion and language and the function of the left brain hemisphere. The auditory cortex accepts musical waves as complex input because it contains pitch, tempo, and harmony components. Those components distinguish it from auditory information when listening to a voice or conversation on the phone [4].

Listening to music activates brain areas related to memory, cognitive function, and emotions [5]. Music can help maintain cognitive function by decreasing brain dysfunction and activating memory-related regions, especially in the elderly with critical illness [6]. Besides their role in cognitive function, music might reduce anxiety and stress level. Music has been studied in intensive care units (ICU) for critically ill patients using mechanical ventilation. Emotional stress and psychological factors influence weaning failure from a ventilator. Many studies show the usefulness of music therapy in the ICU to reduce stress and anxiety in patients [7].

Classical music has long been studied and is known to have a Mozart or Vivaldi effect which results in increased concentration and cognitive function [8]. Some classic song titles used in research are Four Seasons, Spring, and White Noise by Antonio Lucio Vivaldi, Fur Elise by Beethoven, Sonata (K.488) by Mozart [8]. The positive effects of western classical music cannot be generalized to all cognitive processes. However, there have not been many studies regarding the role of traditional music on cognitive function and biological markers related to memory and brain plasticity. Certain community groups have long known traditional music close to their daily culture. Therefore traditional music can be a potential choice of music therapy for society. In this chapter, we will discuss the role of classical and traditional music on cognitive and psychological functions, especially in critical patients in the ICU. In addition, the results of the author's studies will also be presented concerning this topic.

2. Music therapy

Music therapy is defined by American Music Therapy (AMTA, 2005) as a clinical and evidence-based musical intervention used to achieve specific goals. The selection of music type for therapy needs to consider the listener's preferences, comfort, personality, and education level. These things will affect persons' psychological and physiological responses to the type of music they listen to. Music therapy can be done by listening to music through a headset with a volume of 70–90 dB, which is a volume that is generally comfortable for the listener [1].

Joseph and Ulrich in 2007 explain the frequency of sound measured in Hertz (Hz) [9]. The hertz is the number of beats per second at which the wave vibrates. The human ear has a limit on listening to sounds with a frequency of 20–20,000 Hz. These acoustic waves can be captured by the human ear and then carried to the auditory cortex. AMTA 2008 states that music frequencies above 40 Hz can affect cognitive function. The 40 Hz frequency is the basic frequency in the thalamus so that the same frequency will trigger a cognitive effect on music therapy [9].

The tempo or rhythm also plays a critical role in brain stimulation [10]. Music with a slow beat will affect the whole body by decreasing the pulse and breathing rate. That condition happens because the human body tries to adjust to the music's rhythm or tempo being heard. Wigram also explained characteristics of music therapy are pleasant music for listeners, with a soft and harmonious tempo of 60–80 beats per minute and usually non-lyrical [11]. The volume in music therapy is a comfortable volume for the listener. Based on previous studies, music volume

provides a therapeutic effect of at least 40 dB to 60 dB. The duration recommendation for music therapy is 20–60 minutes at least two times a week which can be done at bedtime [12].

Pharmacological and non-pharmacological steps can improve cognitive function. Non-pharmacological measures are a more general and safe method to apply, especially to the elderly population. Non-pharmacological methods for improving cognitive function include physical, emotional, mental, artistic and musical exercises. Musical activities include listening to music, singing, playing musical instruments and composing songs. This series of activities is expected to stimulate various cognitive functions and increase brain plasticity in the elderly to compensate for the decline in cognitive function with aging [2].

Music therapy is a non-pharmacological modality that can manage anxiety and stress and is a therapeutic modality provided by board-certified music therapists. In contrast to music therapy by specially trained and board-certified music therapists, a music listening intervention is a self-administered intervention that requires minimal assistance from a music therapist. This type allows the patient to use music whenever needed, even when there is no music therapist. Previous studies have shown that at least 30 minutes of listening to music can induce relaxation and reduce anxiety in the ICU in mechanically ventilated patients. However, not all previous studies used a method where participants could choose and arrange the music they used. Allowing patients to choose the desired music ensures that the patient avoids the discomfort of listening to music that is unfamiliar or that they do not like [13, 14].

2.1 Classical music

Kamus Besar Bahasa Indonesia (KBBI) in 2008 defines classical music as music whose compositions are born from European culture and are classified according to certain periods. Listening to classical music can have a positive effect called the "Mozart effect" or "Vivaldi effect". Some of the classic songs that have been used in research on the relationship between music and cognitive function are Spring, Four Seasons and White Noise by Antonio Lucio Vivaldi, Fur Elise by Beethoven, Sonata (K.448) by WA. Mozart. Several studies showed an increase in mean memory function (recall memory) and visuospatial in 36 subjects who listened to Mozart Sonata K 448 music for 10 minutes [8, 15].

2.2 Traditional music

Traditional music is music that has developed over a long period in certain social communities. Traditional music develops in various regions and countries and is passed down from generation to generation. In general, traditional music uses local languages, styles and traditions. The concept of traditional music was created from the general habits of society and has undergone many developments. One of the famous traditional music in Indonesia is gamelan music. There are several types of gamelan in Indonesia, including those from Java, Bali and Lombok. One of the instruments in Balinese gamelan is Balinese flute music. The flute is a wind instrument made of bamboo [16]. Until now, Balinese flute playing is increasing in number. This music is very popular among Balinese people, which is used in religious ceremonies and everyday life and is combined with modern musical instruments. One of the Balinese flute players is a Balinese artist named Mr. Agus Teja Sentosa, S.Sn, known as Gus Teja. He is a composer and player of Balinese flute instruments and several types of flutes from other countries. Songs that have been known across Japan, Korea, America, Malaysia are "Hero" and "Morning

Happiness" [17]. The frequency of both songs is 440 Hz, and the tempo is between 70 and 90 beats/minute. Those songs are soft and slow. It is widely known and used in various public facilities.

3. The physiologic effect of music

The choice of music needs to consider aspects of personal preference. However, music with a slow rhythm without lyrics with a tempo of 60–80 beats per minute shows its effectiveness in reducing anxiety [18]. Furthermore, a relatively slow music rhythm is considered necessary because of its ability to synchronize with the listener's heart rate and breathing rate [19].

Pleasant, relaxing music triggers the brain's pleasure and reward centers during functional MRI (fMRI) and PET imaging [20]. Relaxing music is proven to effectively release endorphins and enkephalins and simultaneously decreases catecholamines associated with stress in listeners [19]. In contrast, sad music indicates activation of parts of the brain (amygdala, hippocampus etc) that are often associated with negative conditions or anxiety. Researchers suspect that different musical genres can activate nine affective states: joy, sadness, nostalgia, peacefulness, power, wonder, tenderness, transcendence, and tension [20]. The emotions that are generated depend on the specific type of music being played.

Listening to music shows activation of areas in the brain related to memory, cognitive function, and emotions [5]. Thus, music can help maintain cognitive function by decreasing brain dysfunction and increasing activation of memory-related areas, especially in the elderly who are critically ill [6].

4. Music and anxiety

4.1 Biomarkers of anxiety

Two previous studies used biological markers to evaluate anxiety. Beaulieu-Boire et al. examined the effects of music on sedative drug consumption, vital signs and markers of inflammation and hormonal stress. Markers studied were IL-6, prolactin, C-reactive protein, ACTH, and cortisol. A post-hoc analysis was also carried out for leptin and MET-enkephalin. The study group consisted of patients who used mechanical ventilation and listened to classical music for two hours in the morning and night. The music therapy study group showed significant cortisol reduction ($p = 0.02$) after intervention compared to controls. There was also a decrease in prolactin ($p = 0.038$) in the therapy group but not in the placebo. Music therapy does not affect leptin and MET-enkephalin levels. The markers of inflammation (CRP and IL-6) decreased with time but not significantly [19].

Another study by Chlan et that examined a 24-hour collection of urinary cortisol samples showed no significant reduction in cortisol levels in the music therapy group. Subjects in the study were acutely ventilated, conscious, able to understand commands and be able to hear. However, the pattern of cortisol levels showed extreme rates over time, while the control group's cortisol levels tended to increase throughout the trial [21].

4.2 Physiologic measures of anxiety

Physiological measures of anxiety from most studies include examining heart rate (HR), respiratory rate (RR), systolic blood pressure (SBP), and diastolic blood

pressure (DBP). Korhan et al. in 2011 studied 60 ICU patients with mechanical ventilation who were hemodynamically stable and able to hear with a minimum GCS of 9. The study group listened to classical music through headphones, and sedation was stopped 30 minutes before data collection. Researchers found a significant decrease in SBP, DBP and RR in the treatment group, but there was no significant difference between SaO2 and HR compared to the control group [22].

Beaulieu-Boire et al. in 2013 also studied whether music could affect the amount of sedative drugs needed by patients in the ICU. It was found that music did not affect the amount of sedative medicines required, but this study showed a decrease in narcotics consumption by subjects after the music intervention ($p = 0.06$) [19]. A study by Chlan et al. 2013 also showed subjects in the music therapy group required less frequency and intensity of sedative medication than controls and reported decreased anxiety levels after music intervention [21].

An experimental (quasi) study by Sung et al. 2010 in Taiwan on 29 elderly with dementia showed that the anxiety level of the elderly who received music therapy with Taiwanese music was lower than the elderly who did not receive music therapy. In the study, the length of listening to music varied with 30–50 minute intervals per session for at least 2–3 times a week. Music therapy duration 1–6 weeks [23].

4.3 Music therapy in mechanically-ventilated patients

Patients who are mechanically ventilated in intensive care units are particularly prone to high stress and anxiety levels. In addition to critical illnesses suffered by patients, the treatment environment is full of constant alarm sounds, various equipment and invasive measures. Thus, it will increase the patient's stress susceptibility. Sedative drugs are commonly used in mechanically ventilated patients to reduce pain and anxiety. However, it can cause many side effects. These emotional and psychological factors also influence weaning failure from a ventilator. Many studies show the usefulness of music therapy in the ICU to reduce stress and anxiety in patients. It is also related to patients' attempt to wean from the ventilator successfully [7].

Things that can contribute to the increase in stress and anxiety levels of patients in the ICU are constant alarm sounds and machines, frequent examination and repositioning, bright lighting, and minimal patient communication [24]. Inserting an endotracheal tube into the patient will hinder the patient's ability to speak. The patient is unable to express complaints and communicate with other people. Patients also feel lonely due to minimal family assistance while in the ICU and unknown faces. Patients desperately need a more calming environment that can be obtained from a pharmacological and non-pharmacological perspective. Non-pharmacological methods can be applied to provide a more soothing care environment for the patient.

The prolonged use of a ventilator can have an impact on various complications. High levels of stress and anxiety can hinder the patient's ability to breathe independently and adequately [25]. Posttraumatic stress disorder is also found in some patients discharged from the ICU [24].

Music therapy has been used in various hospital settings, and most studies have shown a positive effect of reducing anxiety levels and increasing patient comfort [26]. Music is known to evoke a series of emotional and physiological reactions in listeners. In one subgroup of patients with dementia, music therapy improved the quality of interactions between patients and their caregivers [27]. A comparison study between regular patients groups and those receiving music therapy showed a significant reduction in anxiety levels in the experimental group [28].

Music therapy has also shown a reduction in pain perception seen in Randomized Controlled Trials (RCTs) of women at delivery. Pain assessment was performed hourly with Visual Analogue Scale (VAS) [29]. The decrease in pain level and anxiety is associated with the patient's rapid recovery period.

It is essential to control anxiety and panic in patients in the ICU because it is related to increased heart rate, blood pressure, respiratory rate and airway constriction. Panic feelings when patients had difficulty breathing will make the body instinctively fight the ventilator resulting in ventilator dyssynchrony and alveolar damage [24]. In addition, commonly used sedative agents often cause hypotension and respiratory depression, an increased risk of pressure ulcers, venous stasis, muscle atrophy and respiratory muscle weakness [25].

Evidence supports the use of music to calm the patient because of its ability to change the atmosphere. It will help patients rest and sleep better, which is very important in the recovery process [30]. The use of headphones to listen to music in the ICU also helps to distract patients from background noise that often disturbs patients [19].

5. Music and cognitive function

Music is the strongest auditory stimulation in the human brain. Listening to music triggers cognitive and emotional components with different neural substances. Even though listening to music may seem very simple, even humming in a familiar tone necessitates a complex auditory pattern-processing mechanism, attention, memory storage and recall, motor programming, sensory and motor integration [31].

Music will be processed in the right brain hemisphere since it is the center of creativity, spatial form, emotion, music, and color. The memory from the right brain is a long term memory. The inner ear processes sounds produced by musical instruments into neural impulses. This information travels through several pathways to the brainstem and mesencephalon, leading to the auditory cortex. Information from the auditory cortex then interacts with various areas of the brain, especially the frontal lobe, for memory information and its interpretation. The orbitofrontal area plays a role in emotional evaluation [32].

Listening to music is a powerful modulation activity in the mesolimbic pathway. It also affects accumbens nucleus, ventral tegmental area, hypothalamus, and insula [33]. Altenmuller also stated that music is a strong stimulus to the brain for adaptation and brain plasticity. The molecular and cellular mechanisms that explain the neuroplasticity induced by music are not well understood. The efficiency and size of the synapse can change within 10 minutes of listening to music. New synapse and dendrite growth occur within hours to days. Changes in synaptic density and other supporting structures such as capillaries and glial cells may take up to several weeks [33]. Music tempo will affect neurons in the brain stem. It activates several neurotransmitters, including norepinephrine, cholinergic, and dopaminergic in the brain stem. Activation in the brainstem also mediates sensory and motor functions via epinephrine, norepinephrine and serotonin. It is believed that music triggers the activation of a higher cortical function [1].

Music directly activates the neurovegetative system (hypothalamus, pituitary, suprarenal glands) to produce neurotransmitters. Listening to music affects neurotransmitters, especially dopamine. Most nerve cells are sensitive to neurotransmitters, especially those in the posterior frontal cortex called the mesolimbic system, which is responsible for emotions. Dopamine is recognized by almost all nerve cells. It plays roles in neurobiology, memory, learning and attention

processes, essential in the brain plasticity process. The neurotransmitter serotonin also plays a vital role in brain plasticity. Serotonin increases significantly when a person listens to pleasant music [33].

Music can activate the stored memory. Brain imaging shows neural activity associated with listening to music extending from the auditory cortex to the bilateral frontal, temporal, parietal, and subarachnoid pathways [34]. Information processing starts from sensory memory, which captures all the information, then it is identified by the human sensory system. Information that has been stored in sensory memory will undergo encoding, retrieval of information and transformed into a meaningful mental form. The encoding results are then sent to short-term memory, which is limited in capacity so that only part of this sensory memory will be processed. Information on short-term memory depends on the attention given. With the effort to recall, this information will enter into long-term memory. Music will affect the encoding process. Positive emotions obtained when listening to music will encourage the improvement of cognitive functions [35].

Listening to pleasant music significantly increases cerebral blood flow (CBF) of the mesolimbic system, ventral striatum (nucleus accumbens and mesencephalon), as well as various other structures such as the thalamus, cerebellum, insula, anterior cingulated cortex (ACC) and orbitofrontal cortex (OFC). Increased brain vascularization will trigger brain plasticity that can improve cognitive function [1].

A study using functional MRI showed activation of NAc and VTA when listening to pleasant music. The relationship between NAc and VTA is known to regulate the autonomic system, emotional, and cognitive function. The insula becomes active because it is associated with NAc and plays a role in addictive behavior to something. Improvement of cognitive function with listening to music is due to the relationship between OFC and mesocorticolimbic dopaminergic circuits. Dopaminergic NT in neuronal pathways plays an important role in the brain's ability to process the heard music [1].

We summarize the impact of music therapy in cognitive function and critically ill patients in **Figure 1** below.

5.1 Author findings regarding music and cognitive function

The author and team conducted an experimental study in 2017 to determine the improvement in cognitive function and an increase in serum dopamine in the elderly after listening to Balinese flute music as the main instrument. Instrumental music was used in the study. It is the type of music that does not use vocals. Based on previous studies, instrumental, low-pitched music with a harmonious slow rhythm (60–80 beats per minute) is pleasing to the listener and can affect body physiology, slow down breathing rate and heart rate, and influence emotions via the limbic system [11].

The study by Laksmidewi et al. used music from the Balinese bamboo flute as its main instrument, which was composed with modern music and played by Balinese artist Agus Teja Sentosa, S.Sn. The song that was played entitled "Morning Happiness", with a tempo of 70–90 beats per minute and a frequency of 440 Hz. Classical music was also used in the study, namely Spring by Antonio Lucio Vivaldi. Listening to classical music can produce a positive effect called the Mozart effect or Vivaldi effect [36].

The study used an experimental pretest-posttest control group design. Subjects were 32 healthy geriatrics aged 60–74 years. Subjects were divided into 2 groups, namely the control and intervention groups. Subjects in the control group listened to western classical music entitled "Spring", while the intervention group listened to classical music "Spring" coupled with the Balinese instrumental "Morning

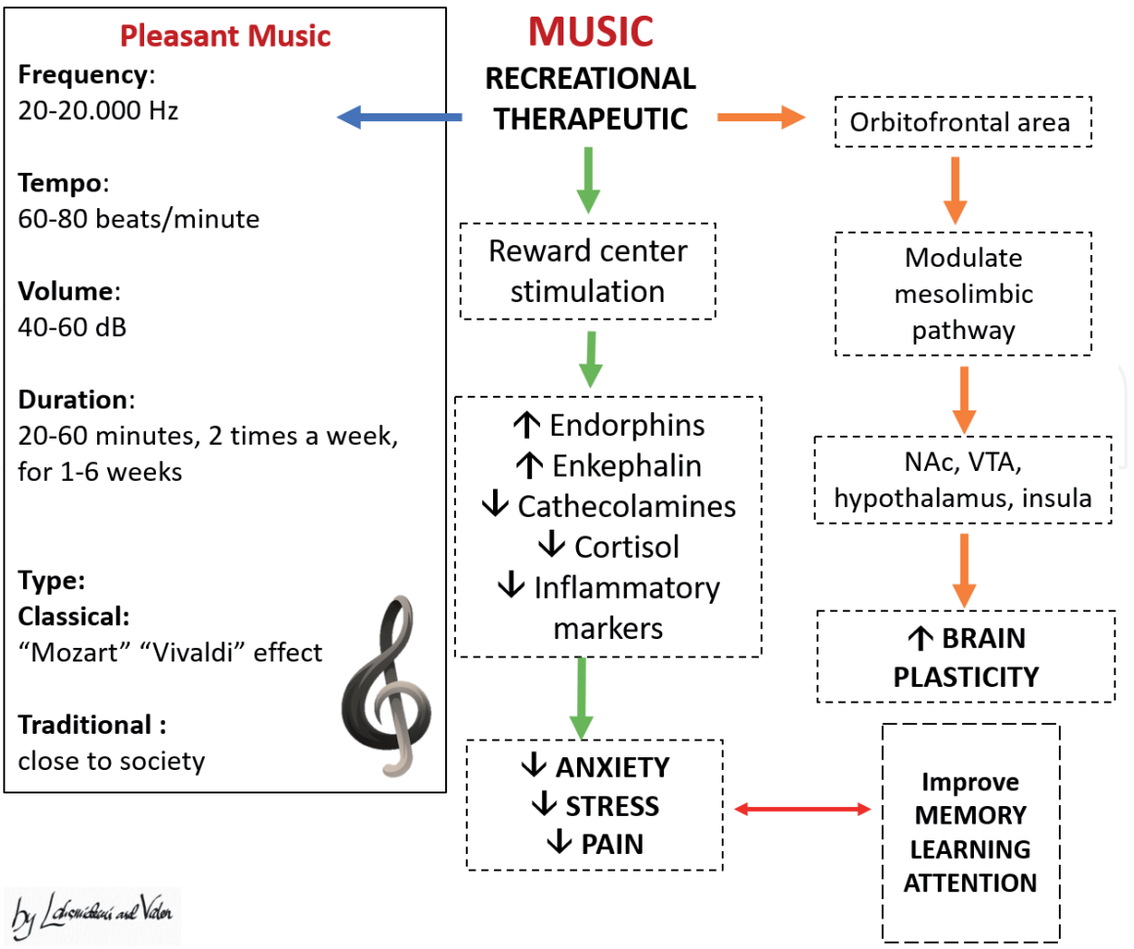

Figure 1.
Impact of music therapy in cognitive function and critically ill patients.

Happiness". Each song was played for 20 minutes every morning before the subjects carried out their daily activities. Cognitive function assessments with the Montreal Cognitive Assessment-Indonesian version (MoCA-Ina) were carried out before the intervention and 21 days after the intervention. Serum dopamine tests were also performed before the intervention and 21 days after the intervention.

The study results showed that the mean increase in cognitive function was higher in the intervention group (5.22; $p < 0.001$) than the control group (4.67; $p < 0.001$). The improvement in the MoCA-Ina score between the two study groups was not statistically significant with $p > 0.05$. The mean increase in dopamine levels in the control group (3.60) was greater than the intervention group (3.56). However, the mean increase was not statistically significant ($0 = 0.085$). This study concludes that there is a significant relationship between listening to Balinese flute instrumental music and improvement in cognitive function, especially in the memory domain in all subjects. However, the mean increase in cognitive function and serum dopamine levels did not reach statistical significance between the two study groups [36].

6. Conclusion

Music therapy has a significant role in cognitive function, brain plasticity, stress and anxiety management. Increased vascularization of various mesocorticolimbic structures and activation of dopaminergic neurotransmitters regulate the autonomic system, emotion and cognitive function. Besides classical music that was previously known to have a positive effect in the brain with the Mozart or Vivaldi

effect, traditional music is also being studied. Traditional music grows and develops over a long period of time in society, this type of music has great potential in improving cognitive function, especially in the elderly. Further studies are needed to optimize the selection of appropriate music therapy for patients both in critical care settings and to improve cognitive function.

Conflict of interest

The authors declare no conflict of interest.

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