Journal Homepage: - www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

ISSN NO. 2320-5407

Article DOI: 10.21474/IJAR01/12478
DOI URL: http://dx.doi.org/10.21474/IJAR01/12478

RESEARCH ARTICLE

THE EFFECTS OF MUSIC ON STRESS

Soma Chaudhuri
Currently Unaffiliated, Kolkata, India.

Manuscript Info

Manuscript History
Received: 15 December 2020
Final Accepted: 18 January 2021
Published: February 2021

Key words:-
Stress, Health, Music, Brain, EEG

Abstract

At the most basic level, stress is our body's response to pressures from a situation or life's event. Although in short occurrence or at optimum level stress may be considered to have positive effects, excess and prolonged stress can cause physiological as well as psychological health disorders. Stress cannot be avoided or omitted, but one can reduce or manage the level of stress using several relaxation techniques. Through age-long research, listening to music has been proven to be a powerful tool for stress reduction. Music has been reported to have direct effects on nervous system, immunological and endocrine system of the human body. Amongst various neuroimaging techniques,electroencephalogram(EEG) is a useful electrophysiological biomarker to monitor the neuronal activities of the human brain with high temporal resolution. In research setting EEG signals are used in mental stress study. The present article attempts to review scientific literature in support of the pivotal role of music on stress reduction. Discussions on stress and its effects on human health are followed by the quantification of stress by EEG for identification and classification of stress. The role of music on stress reduction has been discussed with a light on musical neurofeedback as an effective measure for stress reduction. This comprehensive review would provide theoretical support for claims that music would act as stimuli for stress characterization and also would have its ability to serve as effective and potential measure for stress reduction in everyday life.

Introduction:-

The technological growth in the modern world has thrown challenges to thrive on severe competition which leads to increase in physical as well as mental stress in all humans irrespective of gender, age and profession. As a result, quality of life gets tremendously affected and the work-life balance gets perturbed. The rising trends in hypertension, heart disease, depression, anxiety related disorders are caused by the stress of modern life. Stress has effects on neurotransmitters which is a detriment to good health. It is true that a certain degree of stress is accepted as necessary for performance and productivity, but uncontrolled and prolonged stress appears to be aggressively alarming. Although stress is inescapable in this digital world, people can cope with it strategically to restore the balance of life. Listening to music is one of the coping techniques which helps people feel relaxed, calm and relieved from burden of stress. Much research has been done on establishing the prominent influence of music on the neuronal activities in the brain. Among various neuroimaging techniques, electroencephalogram (EEG) being a

Corresponding Author:- Soma Chaudhuri
Address:- Kolkata, India. E-Mail:-somachaudhuribb7@yahoo.com.

non invasive and cost effective biomarker to monitor and analyze brain waves with high temporal resolution, has been effectively used to characterize stress to study the effects of music on the brain for stress reduction.

This comprehensive review article has aimed at reviewing novel work on effects of music on stress from neurocognitive perspective. The section after describing the methods begins with definitions of stress and stressors followed by the effects of stress on psychosomatic health of humans. Characterization of stress plays a pivotal role in stress management. Detailed attention is paid in contributing to the overview of brain waves and discussing quantification of stress using EEG mentioning different computational methods for stress identification and characterization. Effects of music on brain waves, emotion and the neurotransmitters have been explicitly discussed which corroborate the efficacy of music on stress relief. A short discussion on the selection of music has also been taken into consideration. Neurofeedback or EEG Biofeedback, with a special focus on the alpha and alpha/theta protocol for stress reduction has been discussed along with few studies on musical neurofeedback. The paper concludes with a few suggestions on future work for deeper understanding of the role of music as an effective potential aid to cope with stress.

Methods:-

PubMed and Google Scholar have been used as search engines and Digital Object Identifier (DOI) as the identifier for searching relevant scholarly literature since 1980 to 2020. Papers older than 25 years are cited mainly for providing historic evidences whereas the original research papers and review papers from year 1995 onwards are cited as relevant work references.

Stress and Stressors:

The term “stress” defined by János Hugo Bruno "Hans" Selye, a great Hungarian-Canadian endocrinologist, as the non-specific response of the body to any demand made upon it (Selye, H. 1956, 1973). Stress is a complex reaction pattern that often has psychological, cognitive and behavioural components (Michael, F. et al. 1986). *Eustress* (In Greek, “eu” means “good”) is the healthy stress giving one a feeling of fulfilment like motivation, alertness, challenge and overall well being. *Distress* (commonly known as *stress)* is the persistent stress that is not resolved through coping or adaptation and may lead to anxiety, withdrawal and depressive behaviour imparting negative implications (Selye, H. 1946). Any threatening or challenging situation or event is referred to as a *stressor.* Psychological stressors are social and physical environmental circumstances that challenge the adaptive capabilities and resources of an organism (Monroe, S. M. & Slavich, G. M. 2016). According to The General Adaptation Syndrome (GAS) model proposed by Selye, a stressful event leads to a three-stage bodily response (Selye, H. 1946) as shown in Figure 1. *Alarm* is the first and instantaneous reaction to a stressor in which humans exhibit a “fight or flight” response and stress hormones like cortisol and adrenaline are released into the bloodstream to respond to the danger. In the *Resistance* phase, the body remains on red alert and focuses resources against stressor; stress hormones continue to circulate at high levels and the heart rate, blood pressure and breathing rate increase. Finally in the *Exhaustion* stage, the body’s resistance to stress gradually reduces and collapses as the immune system becomes ineffective resulting in alarming health conditions.

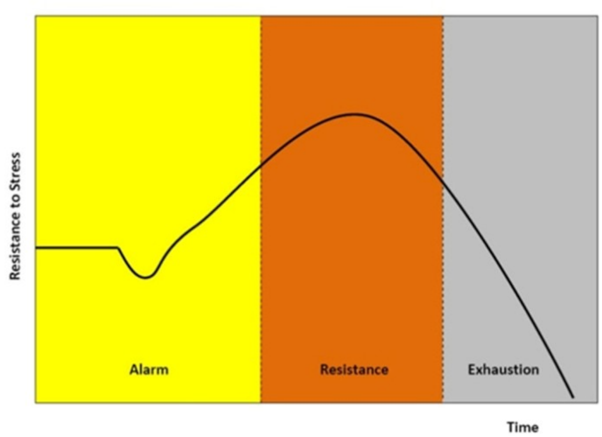

Fig. 1:- Diagram of General Adaptation Syndrome (GAS) Model
(Source:http://commons.wikimedia.org/wiki/File:General_Adaptation_Syndrome.jpg)

Psychosomatic effects of stress:
Stress has detrimental effects upon physical and psychological health of humans. 60-80% of outpatient visits may be related to stress (Avey et al. 2003; Hughes, G. H. et al. 1984). Stress is linked to all leading physical causes of death e.g. heart disease, cancer, stroke (Cohen et al 2007). Significant amount of work on the effects of stress on human physiological health has been done which is summarized in Table 1.

Table1:- Effects of stress on physiological health.

Author	Area of Work
Pickering, T. G. 2001; Lederbogen, F. et al. 2011; Allen, A. P. et al. 2014; Ursin,H. & Eriksen, H. R. 2004	Hypertension, cardiovascular disease
Holmes, S. D. et al. 2006	Coronary artery disease
Khorana, S. 1983.	Peptic ulcers & ulcerative colitis
Garg, A. et al. 2001	Skin disorders like Eczema
Valsamakis, G. et al. 2019	Female reproductive dysfunction
Joachim, R. A. et al. 2003	Respiratory ailments like asthma
Mönnikes, H. et al 2001	Gastroesophageal reflux disease (GERD)
Kruk, J. et al. 2019	Cancer
Stojanovich, L. &Marisavljevich, D. 2008	Autoimmune disease
Dragoş, D. &Tănăsescu, M. D 2010	Defense system
Aschbacher, K. et al. 2014	obesity

Prolonged Stress is associated with development of most major mental health problems like depression, post-traumatic stress disorder (PTSD), pathologic aging (Marin, et al. 2011) and anxiety disorders (Karthikeyan, P. et al. 2011). During stress, the hypothalamic-pituitary-adrenal (HPA) axis activates the release of glucocorticoids with consequent increases in heart rate, blood pressure, and metabolism which are associated with stress related disorders like depression (Chida, Y. & Steptoe, A. 2009). Neuroimaging studies have revealed positive correlation between the depressive persons' plasma cortisol, a stress hormone in humans, with the activity of the left amygdala (Drevets, WC. et al. 2002). Increased secretion of major cortisol leads to impairments in attention, memory and emotion processing in humans (Lupien, S. J. et al. 2005). When subjected to stress, the healthy brain regulates the nervous, endocrine and the immune system to maintain allostasis, an organism's ability to "achieve stability through change" (McEwen, B. S. 1998). Even low stress intensity can lead to allostatic overload resulting in brain damage (McEwen, B. S. 2012). Cognitive decline was almost 30% faster in individuals experiencing distress compared to those with no distress (Han, B. et al. 2016).

Brain waves and stress quantification by EEG signals:
Stress quantification is very important for clinical intervention and disease prevention. As Stress is originated from brain, neurological signals have significant importance in measuring mental stress. Brain (or neural) oscillations refer to the rhythmic and/or repetitive electrical activity generated spontaneously and in response to stimuli by neural tissue in the central nervous system (Başar, E. 2013). Human brain consists of billions of neurons, which all generate electrical impulses. When these neurons work in synchrony, tiny alternating electrical potentials occurs at the synapses. The more the neurons work, the larger the potential of the electrical oscillations measured in micro volts. The faster the neurons work together, the higher the frequency of the oscillations measured in hertz (Hz). Based on their frequency, brainwaves are of five categories which correspond to different states of thought or experience (Figure 2, Table 2).

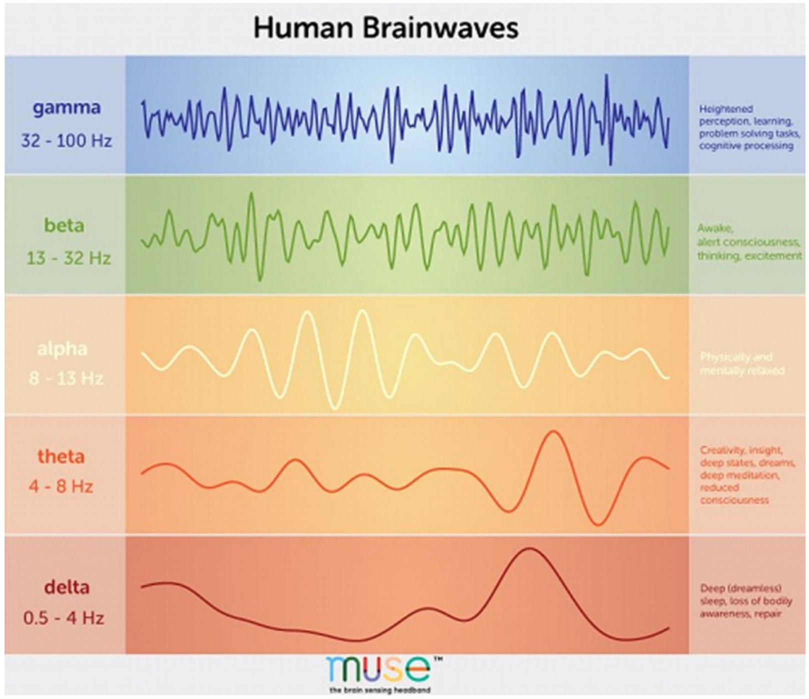

Fig 2:- Diagram illustrating different brain waves bands characterized by frequency (Hz); (Source: http://choosemuse.com 2018).

Table 2:- Human brain waves: Frequency (Hz) and Amplitude (microvolt) range.

Name of waves	Frequency (Hz)	Amplitude (microvolt)
Delta	0.5-4	100-200
Theta	4-8	Higher than 30
Alpha	8-13	30-50 or higher
Beta	13-32	2-20 or higher
Gamma	32-100	3-5 or higher

In a stressful situation, the sympathetic nervous system dominates and the brain's natural response is to accelerate from slow alpha and theta waves to fast beta frequencies (Hoffmann, E. 2005). Both decreased and increased in alpha and beta power have been found as a sign of mental stress (Puterman, E. et al. 2011). During rest and relaxation, the parasympathetic nervous system dominates and as a result the brain waves are slowed down from beta to alpha wave frequencies and during excessive parasympathetic activity to theta waves (Hoffmann, E. 2005).

Considering factors like temporal or spatial resolution, specificity and coverage in selecting non-invasive neurological methods for stress measurement, Electroencephalogram (EEG) is an important tool for studying the transient dynamics of the human brain's large-scale neuronal circuits. It is one of the most common quantifiable measures to identify and classify human stress using real-time digital technology to record electrical activity of the brain with high temporal resolution in millisecond scale (Berka, C. et al 2004). The changes in autonomous nervous system can be effectively represented by EEG signals (Seo, S. H. et al. 2010). Long-term stress has been classified with machine learning algorithms using resting state EEG signal recordings (Saeed, S. 2020). The ratio of power spectral densities of alpha and beta bands has been computed for the analysis of physical stress (N H A Hamid et al. 2010). The changes in EEG absolute power and other connectivity measures such as coherence have been observed to analyze stress (Alonso, J. F. et al. 2015). For stress identification and stress state classification using EEG, different computational methods are used (Table 3). Activities in the right hemisphere of the brain dominate the activities in the left hemisphere of the brain during negative emotions (Horlings, R. et al. 2008) which indicates the area for stress detection. Rapid beta wave frequencies are considered as the characteristic indicators of stress (Lin, T. A. & John, L. R. 2006). Stress pattern can be indicated by high Beta power and low Alpha power on anterior side of human brain (Seo, S. H. et al. 2010). Slope of EEG linear regression has been a feature to determine the relaxation level of an individual (Teplan, M. et al. 2006) and a combination of EEG Asymmetry and Spectral Centroids techniques has also been used as a feature to detect unique patterns of human stress (N Sulaiman, et al. 2011).

Table 3:- Different computational methods used for identification and classification of stress.

Computational methods	Researchers
Decision trees	Dharmawan, Z. & Rothkrantz, LJM 2007
Artificial Neural Network (ANN)	Alić, B. et al. 2016
Support Vector Machines (SVM)	Sani, M. M. et al. 2014
Random Forest	Haouij, Neska. et al. 2018
Bayesian classifiers	Horlings, R. et al. 2008
K-nearest neighbors	Khosrowabadi, R. et al. 2011
EEG eigenvalue decomposition	Paul, M. P. et al. 2013
Brain Wave Balancing Index (BBI)	Adnan, N. et al. 2012
Discrete Wavelet Transform (DWT)	Murugappan, M. et al 2010

Coping with stress using music:

Lazarus and Folkman have defined coping as "the process of managing demands (external or internal) that are appraised as taxing or exceeding the resources of the person" (Lazarus, R. S. & Folkman, S. 1984). Coping models may be of two types: *instrumental* and *palliative* (Hanser, S. 1985). The instrumental model implies direct action in an attempt to change the troubled transaction. The regulation of emotions associated with stress constitutes the palliative approach. Music being the language of emotions (Langer, S. K. 1957) is best classified as emotion-based palliative coping strategy that involves the use of music in order to reduce stress and its allied physiological and psychological ailments. Music is a powerful inducer of emotions and mood arousal (Ilie et al. 2002) and has an effect on activity in the brain's emotional core (Blood, A. J. & Zatorre, R. J. 2001; Juslin, P. N. &Vastfjall, D. 2008; Koelsch, S. 2010; Menon, V. & Levitin, D. J. 2005; Panksepp, J. & Bernatzky, G. 2002; Sloboda, J. A. & Juslin, P. N. 2010). According to American Psychological Association's survey (Stress in America, 2014) listening to music has been identified as one of the major stress coping techniques.

Music on brain:

From ample research on music and the brain, it is manifested that music has a biological basis and the brain has a functional organization for music (Weinberger, N. M. 2004). Listening to music is reported to influence varied regions in the brain, including multiple cortices (auditory, visual, motor), the cerebellum along with the deeper emotional area (amygdala, orbitofrontal, anterior cingulate cortex), memory (hippocampus), mesolimbic reward structures and dopaminergic neural networks (Koelsch, S. & Siebel, W. A. 2005; Koelsch, S. 2010) and also to alter the dynamical brain responses, i.e. oscillatory component(s) of the EEG signals, particularly theta frequency band. Music-induced chills produce reduced activity in brain structures associated with anxiety (Blood and Zatorre, 2001). Mainly two types of brain waves responsible for mental relaxation and stress reduction are the alpha wave (8–13 Hz) during relaxation and theta wave (4–8 Hz) during deep relaxation. Studies have found that brain waves can be altered by music (Levitin, D. J. & Tirovolas, A. K. 2009). Alpha and theta brain waves increase either by relaxing music or by other relaxation techniques (Jacobs, G. D. & Friedman, R. 2004). Different types of music (Light, Country, Jazz, Rock) have been reported to cause the decline of the energy intensity of the waves from different areas which strongly supports the hypothesis that different types of music will have different impact on the human brain and EEG waves (Sun, C. et al. 2013). The first neuroscientific study of the effect of listening to archaic sounds (monochord) was done in patients demonstrating the changes in complexity in brain oscillation patterns in comparison with progressive muscle relaxation (PMR) (Bhattacharya, J. & Lee, E. J. 2016). Studies on the effects of music on alpha and theta waves are summarized in Table 4.

Table 4:-Effect of music on alpha and theta waves.

Researchers	Area of Work
Kabuto, M. et al. (1993)	The relaxation effects of music are also reported to be associated with a change in the total theta power.
Sakharov, D. S. et al. (2005); Sammler, D. et al.(2007)	Pleasant music would elicit an increase of Frontal midline (Fm) theta power.
	Pleasant music is observed to produce a decrease in the

Sammler, D. et al. (2007)	alpha power at the left frontal lobe and unpleasant music a decrease in the alpha power at the right frontal lobe.
Chan A S et al. (2008)	Fm theta power is related to heightened mental effort and the subjective scores of the pleasantness of the emotional experience and an increase in posterior theta power is shown while listening to classical music.

A frontal asymmetry in the lower alpha-band has been found (Mikutta, C. et al. 2012) which may be associated with activations of subcortical limbic structures during periods of high arousal in music as shown in other studies (Davidson, R. J. 2004). Although mood induction and emotion regulation are not exactly the same because moods are affective states lower in intensity than emotions (Juslin, P. N. & Sloboda, J. A. 2010) yet mood induction is of high concern in stress reduction.

Music on stress relief:
Numerous studies on the effect of music listening on stress and anxiety have shown the ability of music to improve an individual's emotional as well as physical health by reducing the stress level (Koelsch, S. and Stegemann, T. 2012; Krause, A. E. et al. 2015). It is one of the most convenient approaches for stress relief and relaxation in everyday life. The structural features of music not only help convey an emotional message to the listener, but also express and create emotion in the listener (Bhatti, A. M. et al. 2016) which shows beneficial effects on stress related physiological and emotional processes. Music has been shown to be effective for the reduction of anxiety (Koelsch, S. and Stegemann, T. 2012) both in the laboratory settings (Knight, W. E. J. & Rickard, N. S. 2001) and in out-of-lab experiments (Ventura, T. et al. 2012). Listening to slow, quiet classical music has shown a decline in the perceived level of psychological stress and an increase in the stress coping ability of an individual (Ventura, T. et al. 2012). Music can reduce depression (Aalbers, S. et al. 2017), blood pressure (Sutoo, D. & Akiyama, K. 2004), heartbeat (Cervellin, G. & Lippi, G. 2011) and stabilize people’s psychological and physiological state with visible positive effects on heart diseases (Bradt, J. et al. 2013), stroke (Magee, W. L. et al. 2017) dementia and Alzheimer’s disease (Svansdottir, H. B. & Snædal, J. 2006), schizophrenia (Tseng, P. T et al. 2016). Many studies have shown that background music has its positive impact toward patients with moderate stressful conditions (Wang, Kun. et al. 2016).

The effect of music on human subjects under mental stress has been studied (Nawaz, R. et al. 2018) in three different stress levels: low, high and moderate (using congruent, incongruent and mix stroop color test); with and without background music and the corresponding EEG has been recorded. For congruent and mix stroop test higher alpha power is observed in the presence of music indicating a positive effect of music under low and moderate stress conditions whereas for incongruent case the alpha power is reduced in the presence of music indicating the negative effect of music under high stress. The stress behavior of females is reported to be more sensitive to music as compared to males (Asif, A. et al. 2019). Listening to a piece of classical piano music has been reported to evoke activity changes in the amygdala and the orbitofrontal cortex (Koelsch, S. 2014) which plays a pivotal role in stress reduction in daily life. According to the study of Frances H Rauscher and his team (Rauscher, F. H. 1993), significantly better spatial reasoning skills were observed on normal subjects after listening to Mozart's sonata for two pianos (K448) for 10 minutes than after periods of listening to relaxation instructions designed to lower blood pressure or silence (Jenkins, J. S. 2001).

The controlled use of a specific kind of music and its ability to influence behavioral, emotional, and psychological changes in a human being during the treatment of a disability or illness is usually referred to as music therapy (Watkins, G. R. 1997). Many literatures have reported music therapy as a well-established, non-invasive, safe and inexpensive measure with its ability to exhilarate positive emotions promoting calmness and a feeling of relaxation in mental stress related problems (Archie, P. et al. 2013; Burrai, F. et al. 2019; Mondanaro, J. F. et al. 2017; Raglio, A. et al. 2015). The stress response of terminally ill cancer survivor to a music therapy intervention has been studied in a randomized controlled trial and a positive emotional effect along with a significant decrease in tiredness, anxiety and breathing difficulties as well as an increase in levels of overall well being have been reported (Ramirez, R. et al. 2018). The effects of Indian Hindustani classical raga Desi-Todi (played on flute) on three physiological (alpha EEG frequency, systolic and diastolic blood pressure and heart rate), three psychological (depression, state and trait anxiety), and four components of anxiety (somatic, cognitive, behavioral and affective) have shown a significant increase in the alpha EEG frequency and a significant decrease in the scores on depression and the four components of anxiety (Gupta, U. & Gupta, B. S. 2005). Music Therapy has been observed as an evidence-based novel therapeutic tool to reduce stress elating the cognitive, sensory, communicative and emotional domains.

Music on neurotransmitters and immunological stress markers:

Studies (Table 5) suggest that pleasant music releases dopamine, the main neurotransmitter in the reward system. Different music has its effects on the levels of other neurotransmitters like norepinephrine, serotonin, endorphin and cortisol (Table 6). Stress induces major changes in the immune system (Koelsch, S. & Siebel, W. A. 2005). The study of Brennan and Charnetski (Brennan, F. X. & Charnetski, C. J. 2000) indicated that there is a positive relationship between relaxing music and immunological stress markers. Listening to and playing music are reported to modify the level of certain immunological components such as immunoglobulin A (IgA) and natural killer cells (Enk, R. et al. 2008) and to elevate level of stress markers like cytokine IL-6 level and IL-10 improving mood (Wachi, M. et al. 2007). Some of the relaxing properties of music are also reported to elicit biochemical measurable stress-reducing effects, such as reduction of inflammatory markers (Wachi, M. et al. 2007).

Table 5:- Study of dopamine and opioids to musical pleasure (Source: Chanda, M. L. & Levitin, D. J. 2013).

Author	Outcome measures	Conditions	Participants	Observations
Blood, A. J. and Zatorre, R. J. (2001)	rCBF using PET; self-reported chills	self-selected music, neutral music, noise, and rest	Music students	Chills increase rCBF in ventral striatum and midbrain
Brown, S. et al. (2004)	rCBF using PET; self-reported musical pleasure	Experimenter-selected music Vs rest	Non-musicians	Music increases rCBF in NAc, insula, hippocampus
Menon, V. and Levitin, D. J. (2005)	rCBF using fMRI, network connectivity; self-reported pleasantness	Experimenter-selected music Vs scrambled versions of same	Non-musicians	Music increases rCBF in NAc, VTA and insula; strong connectivity of NAc, VTA, hypothalamus and insula
Koelsch, S. et al. (2006)	rCBF using fMRI; self-reported pleasantness	Experimenter-selected music, pleasant Vs unpleasant	Non-musicians	Pleasant music increases CBF in ventral striatum; # rCBF in amygdala, hippocampus, parahippocampal gyrus and temporal poles
Salimpoor, V. N. et al. (2011)	D2 binding using ligand-based PET; self-reported chills	Self-selected Vs neutral music	Unselected for musical ability	Chills increase D2 binding in NAc; Anticipation " D2 binding in caudate

Abbreviations: D2, dopamine D2 receptor; mPFC, medial prefrontal cortex; NAc, nucleus accumbens; PET, positron emission tomography; rCBF, regional cerebral blood flow; VTA, ventral tegmental area.

Table 6:- Studies of different music on different neurotransmitters.

Researchers	Music Type	Neurotransmitters	Study Outcome (Increase/decrease)
Yamamoto, T. et al. 2003	Slow music	Norepinephrine	Decrease in the level
Evers, S. & Suhr, B. 2000	Pleasant music	Serotonin	Increase in the level
	Unpleasant music		Decrease in the level
Gerra, G. et al. 1998	Pleasant music	Endorphin	Increase in the level
	Techno Music	Cortisol	Increase in the level
Khalfa, S. et al. 2003	Relaxing music	Cortisol	Decrease in the level
Kreutz, et al. 2004	Classical choral song	Cortisol	Decrease in the level
Suda, M. et al. 2008	Major music (Mozart's	Cortisol	Decrease in the level

	Allegro con spirito, K448		

Selection of music:
Selection of appropriate music is of huge significance and the effects of different music genres on reducing stress have been explored in several studies. Classical music is found to be more stress relieving than non-classical music such as heavy metal and hard rock (Labbé, E. et al. 2007). Sedative music or silence reduces tension and has a relaxing effect, as compared to stimulative music or noise (Lingham, J. et al. 2009). Listening to self selected music while being in curative radiation therapy has been reported to lower anxiety and treatment-related distress (Clark, M. et al 2006). A meta-analysis of the effectiveness of music use of stress reduction revealed the importance of preferred music in a decrease of arousal due to stress (Pelletier, C. L. 2004). Relaxing music which is specially formulated music with binaural beats (alpha brainwave range, 8–13 Hz) for relaxation (alpha state) has been reported (Phneah, S. W. & Nisar, H. 2017) to produce more alpha brainwaves hence higher alpha power causing a better soothing effect on the participants compared to the participants' favourite music.

Musical neurofeedback in stress reduction:
Neurofeedback, also known as EEG biofeedback, involves utilizing EEG signals to measure brain wave activity with the use of audio or visual signals to reorganize or retrain these brain signals. Musical Neurofeedback has become frequently used technique for treating stress related disorders. (Álvaro J. Bocanegra-Pérez, et al. 2020). It teaches self-control of brain functions to subjects by measuring brain waves and providing a feedback signal. Over the past decade, neurofeedback has been found to be effective in producing significant improvements in medical conditions related to stress such as depression (Hammond, D. C. 2004), anxiety (Kerson, C. et al. 2009), migraine (Walker, J. E. 2011).

The most commonly used neurofeedback protocols in treating stress and emotional disorders are alpha, theta, and alpha/theta ratio. The upper alpha frequency band has been examined as a neurofeedback criterion (Zoefel, B. et al. 2011) and shown to modulate amygdala complex connectivity associated with post-traumatic stress disorder (PTSD), leading to symptom reduction (Nicholson, A. A. et al. 2016) and relaxation to the anxiety patients (Rice, K. M. et al. 1993). Increasing of alpha power at the right frontal cortex has been reported to reduce negative emotion and anxiety symptom (Mennella, et al. 2017). Theta treatment reduces anxiety, depression, emotional disorders (Vernon, D. J. 2005). Alpha/theta protocol of neurofeedback has been studied (Gruzelier, J. 2009) for raising the theta–alpha ratio which showed reduction of depression and anxiety in alcoholism and resolved post traumatic stress disorder (PTSD).

The potential benefits of combining music, neurofeedback and emotion detection have been investigated by Rafael Ramirez and his team (Ramirez, R. et al. 2015) for improving elderly people's mental health with a goal to investigate the emotional reinforcement capacity of automatic music neurofeedback systems and its effects for improving depression in elderly people. The study (Ramirez, R. et al. 2015) proposed a new neurofeedback approach which allowed users to manipulate expressive parameters in musical performances using their emotional state which had been characterized by a coordinate in the arousal-valence plane decoded from their EEG activity. The positive results of their clinical experiment suggested a new research with the proposed musical neurofeedback approach. A combination of music therapy with the real-time EEG-based human emotion recognition algorithm has been proposed by Olga Sourina and her team (Sourina, O. et al. 2012) by which the user's current emotional state could be identified and based on such neurofeedback the music therapy could be adjusted to the patient's needs. A pilot study has been conducted by Alexander Ivanovich Fedotchev (Fedotchev, A. 2018) with an aim to examine the efficiency of music stimulation online controlled by feedback signals from patient's EEG oscillators for the correction of stress-induced functional disturbances. The result showed normalization of the EEG, reduction of stress sensations, and positive shifts in mental and emotional status of the patients.

Conclusion:-
Stress has been identified as a serious and escalating issue having severe impacts on both individuals and society. Growing experimental evidences show that the effects of music on human brain with precise identification and classification of stress by EEG monitoring could be a potential clinical method to manage and treat the stress related health hazards. Music being a cost effective subjective stimulus, it is quite evident from studies that properly selected music would be beneficial as a therapeutic to the common people suffering from stress related health problems. Musical Neurofeedback training would also cast a new light on stress research.

A preliminary literature support has been attempted through this review paper to provide the evidences for the effects of music to facilitate stress relief. But there is an absolute need of more focused neuroscientific research to explore the clinical efficacy of music interventions on stress with more detailed insights.The author would have liked to suggest a few ideas where future research needs to be looking next. As levels of stress may vary from mild to moderate to severe, more work is required on the identification of different levels of stress and the effects of music should be observed accordingly for detailed characterization. Comparative studies can also be done with instrumental and vocal music for finding the better option of minimizing stress levels in humans. The review conclusively suggests that on precise identification and classification of stress, music can be considered as a prospective aid to cope with stress. Future investigations would certainly validate the conclusions by exploring exclusive association of music with human brain which would help in achieving a deeper understanding of beneficial effects of music on stress.

References:-

1. Aalbers, S., Fusar-Poli, L., Freeman, R. E. et al. (2017) Music therapy for depression. The Cochrane database of systematic reviews, 11(11), CD004517. https://doi.org/10.1002/14651858.CD004517.pub3
2. Alić, B, Sejdinović D, Gurbeta L et al (2016, June) Classification of stress recognition using artificial neural network. In 2016 5th Mediterranean Conference on Embedded Computing (MECO) (pp. 297-300). IEEE. doi: 10.1109/MECO.2016.7525765.
3. Allen, A. P., Kennedy, P. J., Cryan, J. F. et al. (2014) Biological and psychological markers of stress in humans: focus on the Trier Social Stress Test. Neuroscience &Biobehavioral Reviews, 38, 94-124. https://doi.org/10.1016/j.neubiorev.2013.11.005
4. American Psychological Association. (2015, January 11). Paying with our health. http://www.apa.org/news/press/releases/stress/2014/financial-stress
5. Alonso, J. F., Romero, S., Ballester, M. R. et al. (2015) Stress assessment based on EEG univariate features and functional connectivity measures. Physiological measurement, 36(7), 1351–1365. https://doi.org/10.1088/0967-3334/36/7/1351
6. Álvaro, J. Bocanegra-Pérez, Jose L. Velasquez-Perez, L. Valentina Martinez-Diaz et al. (2020) Music-based neurofeedback system for stress regulation and memory stimulation. Proc. SPIE 11583, 16th International Symposium on Medical Information Processing and Analysis, 115830U. https://doi.org/10.1117/12.2576711
7. Archie, P., Bruera, E., & Cohen, L. (2013) Music-based interventions in palliative cancer care: a review of quantitative studies and neurobiological literature. Supportive care in cancer : official journal of the Multinational Association of Supportive Care in Cancer, 21(9), 2609–2624. https://doi.org/10.1007/s00520-013-1841-4
8. Aschbacher, K., Kornfeld, S., Picard, M. et al. (2014) Chronic stress increases vulnerability to diet-related abdominal fat, oxidative stress, and metabolic risk. Psychoneuroendocrinology, 46, 14-22. https://doi.org/10.1016/j.psyneuen.2014.04.003
9. Asif, A., Majid, M., & Anwar, S. M. (2019) Human stress classification using EEG signals in response to music tracks. Computers in biology and medicine, 107, 182–196. https://doi.org/10.1016/j.compbiomed.2019.02.015
10. Avey, H., Matheny, K. B., Robbins, A. & Jacobson, T. A. (2003) Health care providers' training, perceptions, and practices regarding stress and health outcomes. Journal of the National Medical Association, 95(9), 833. PMID: 14527051
11. Başar, E. (2013). Brain oscillations in neuropsychiatric disease. Dialogues in clinical neuroscience, *15*(3), 291–300. doi: 10.31887/DCNS.2013.15.3/ebasar
12. Berka, C., Levendowski, D. J., Cvetinovic, M. M. et al.(2004) Real-time analysis of EEG indexes of alertness, cognition, and memory acquired with a wireless EEG headset. International Journal of Human-Computer Interaction, vol. 17, pp. 151-170. https://doi.org/10.1207/s15327590ijhc1702_3
13. Bhattacharya, J. & Lee, E. J. (2016) Modulation of EEG theta band signal complexity by music therapy. International Journal of Bifurcation and Chaos, 26(01), 1650001. https://doi.org/10.1142/S0218127416500012
14. Bhatti, Adnan., Majid, Muhammad., Anwar, Syed. et al. (2016) Human emotion recognition and analysis in response to audio music using brain signals. Computers in Human Behavior. 65. 267-275. DOI: 10.1016/j.chb.2016.08.029
15. Blood, A. J. & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. Proceedings of the National Academy of Sciences of the United States of America, 98(20), 11818–11823. https://doi.org/10.1073/pnas.191355898

16. Bradt, J., Dileo, C. & Potvin, N. (2013) Music for stress and anxiety reduction in coronary heart disease patients. The Cochrane database of systematic reviews, (12), CD006577. https://doi.org/10.1002/14651858.CD006577.pub3
17. Brennan, F. X. & Charnetski, C. J. (2000) Stress and immune system function in a newspaper's newsroom. Psychological reports, 87(1), 218–222. https://doi.org/10.2466/pr0.2000.87.1.218
18. Brown, S., Martinez, M. J. & Parsons, L. M. (2004) Passive music listening spontaneously engages limbic and paralimbic systems. Neuroreport, 15(13), 2033–2037. https://doi.org/10.1097/00001756-200409150-00008
19. Burrai, F., Lupi, R., Luppi, M. et al. (2019) Effects of Listening to Live Singing in Patients Undergoing Hemodialysis: A Randomized Controlled Crossover Study. Biological research for nursing, 21(1), 30–38. https://doi.org/10.1177/1099800418802638
20. Cervellin,G. & Lippi, G. (2011) From music-beat to heart-beat: a journey in the complex interactions between music, brain and heart. European journal of internal medicine, 22(4), 371–374. https://doi.org/10.1016/j.ejim.2011.02.019
21. Chan, A. S., Han, Y.M. & Cheung, M. C. (2008) Electroencephalographic (EEG) measurements of mindfulness-based Triarchic body-pathway relaxation technique: a pilot study. Applied Psychophysiology and Biofeedback, 33(1), 39-47. https://doi.org/10.1007/s10484-008-9050-5
22. Chanda, M. L. & Levitin, D.J. (2013) The neurochemistry of music. Trends in cognitive sciences, 17(4), 179–193. https://doi.org/10.1016/j.tics.2013.02.007
23. Chida,Y. & Steptoe, A. (2009) Cortisol awakening response and psychosocial factors: a systematic review and meta-analysis. Biological psychology, 80(3), 265–278. https://doi.org/10.1016/j.biopsycho.2008.10.004
24. Clark,M., Isaacks-Downton, G., Wells, N. et al (2006) Use of preferred music to reduce emotional distress and symptom activity during radiation therapy. Journal of music therapy, 43(3), 247–265. https://doi.org/10.1093/jmt/43.3.247
25. Cohen,S., Janicki-Deverts, D. & Miller, G.E. (2007) Psychological stress and disease. Jama, 298(14), 1685-1687. doi:10.1001/jama.298.14.1685
26. Davidson, R. J. (2004) What does the prefrontal cortex "do" in affect: perspectives on frontal EEG asymmetry research. Biological psychology, 67(1-2), 219–233. https://doi.org/10.1016/j.biopsycho.2004.03.008
27. Dharmawan, Z. & Rothkrantz, LJM (2007) Analysis of computer game player stress level using EEG data. In Q. Mehdi, P. Estrailler, & M. Eboueya (Eds.), CGAMES'2007 (pp. 111-124). The University of Wolverhampton.
28. Dragoş, D. & Tănăsescu, M. D. (2010) The effect of stress on the defense systems. Journal of medicine and life, 3(1), 10. PMID: 20302192
29. Drevets, WC., Price, JL., Bardgett, ME., et al.(2002) Glucose metabolism in the amygdala in depression: relationship to diagnostic subtype and plasma cortisol levels. Pharmacol Biochem Behav; 71:431–447. https://doi.org/10.1016/S0091-3057(01)00687-6
30. Enk, R., Franzke, P., Offermanns, K. et al. (2008) Music and the immune system. International Journal of Psychophysiology,69,207–241.DOI: 10.1016/j.ijpsycho.2008.05.039
31. Evers, S., & Suhr, B. (2000) Changes of the neurotransmitter serotonin but not of hormones during short time music perception. European archives of psychiatry and clinical neuroscience, 250(3), 144–147. https://doi.org/10.1007/s004060070031
32. Fedotchev, A. (2018) Stress Coping Via Musical Neurofeedback. Advances in mind-body medicine, 32(2), 17–20. PMID: 31370040.
33. Garg, A., Chren, M. M., Sands, L. P., et al. (2001) Psychological stress perturbs epidermal permeability barrier homeostasis: implications for the pathogenesis of stress-associated skin disorders. Archives of dermatology, 137(1), 53-59. PMID: 11176661; DOI: 10.1001/archderm.137.1.53
34. Gerra, G., Zaimovic, A., Franchini, D. et al. (1998) Neuroendocrine responses of healthy volunteers to 'techno-music': relationships with personality traits and emotional state. International journal of psychophysiology: official journal of the International Organization of Psychophysiology, 28(1), 99–111. https://doi.org/10.1016/s0167-8760(97)00071-8
35. Gruzelier, J. (2009) A theory of alpha/theta neurofeedback, creative performance enhancement, long distance functional connectivity and psychological integration. Cognitive Processing, 10(1), 101-109. https://doi.org/10.1007/s10339-008-0248-5
36. Gupta, U. & Gupta, B. S. (2005) Psychophysiological responsivity to Indian instrumental music. Psychology of Music, 33(4), 363–372. https://doi.org/10.1177/0305735605056144
37. Hammond,D.C. (2004) Neurofeedback treatment of depression and anxiety. J. Adult Dev. 4, 45–56. DOI: 10.1007/s10804-005-7029-5

38. Han, B., Yu. L., Geng, Y. et al. (2016) Chronic Stress Aggravates Cognitive Impairment and Suppresses Insulin Associated Signaling Pathway in APP/PS1 Mice. Journal of Alzheimer's disease : JAD, 53(4), 1539–1552. https://doi.org/10.3233/JAD-160189
39. Hanser, Suzanne, B. (1985) Music Therapy and Stress Reduction Research. **Journal of Music Therapy**, Volume 22, Issue 4, Winter 1985, Pages 193–206, https://doi.org/10.1093/jmt/22.4.193
40. Haouij, Neska. & Poggi, Jean-Michel. & Ghozi, Raja. et al (2018) Random forest-based approach for physiological functional variable selection for driver's stress level classification. Statistical Methods & Applications. 28. DOI: 10.1007/s10260-018-0423-5
41. Hoffmann, E. (2005) Brain training against stress: Theory, methods and results from an outcome study. Stress Report, 4(2), 1-24. completebraincare.com
42. Holmes, S. D., Krantz, D. S., Rogers, H. et al. (2006) Mental stress and coronary artery disease: a multidisciplinary guide. Progress in cardiovascular diseases, 49(2), 106–122. https://doi.org/10.1016/j.pcad.2006.08.013
43. Horlings, R., Datcu, D. & Rothkrantz, L. J. (2008, June). Emotion recognition using brain activity. In Proceedings of the 9th international conference on computer systems and technologies and workshop for PhD students in computing (pp. II-1). 6. DOI: 10.1145/1500879.1500888
44. Hughes, G. H., Pearson, M. A. & Reinhart, G. R. (1984) Stress: sources, effects, and management. Family & Community Health: The Journal of Health Promotion &Maintenance.7(l), 47-55. PMID: 10265755
45. Ilie, Gabriela. & Thompson, William. &Schellenberg, E. (2002) Effects of Musical Tempo and Mode on Arousal, Mood, and Spatial Abilities. Music Perception..2002.20.2.151. DOI: 10.1525/mp.2002.20.2.151
46. Jacobs, G. D., & Friedman, R. (2004) EEG spectral analysis of relaxation techniques. Applied psychophysiology and biofeedback, 29(4), 245–254. https://doi.org/10.1007/s10484-004-0385-2
47. Jenkins, J. S. (2001) The Mozart Effect. Journal of the Royal Society of Medicine, 94(4), 170–172. https://doi.org/10.1177/014107680109400404
48. Joachim, R. A., Quarcoo, D., Arck, P. C., Herz, U., Renz, H., & Klapp, B. F. (2003). Stress enhances airway reactivity and airway inflammation in an animal model of allergic bronchial asthma. *Psychosomatic medicine*, *65*(5), 811–815. https://doi.org/10.1097/01.psy.0000088582.50468.a3
49. Juslin, P. N. & Västfjäll, D. (2008) Emotional responses to music: the need to consider underlying mechanisms. The Behavioral and brain sciences, 31(5), 559–621. https://doi.org/10.1017/S0140525X08005293
50. Juslin, P. N. & Sloboda, J. A. (2010) Introduction: Aims, organization, and terminology. In P. Juslin& J. Slodoba (Eds.), Handbook on music and emotions: Theory, research, applications (pp. 3–12). Oxford: Oxford University Press
51. Kabuto, M., Kageyama, T. & Nitta, H. (1993) EEG power spectrum changes due to listening to pleasant music and their relation to relaxation effects. Nihon eiseigakuzasshi. Japanese journal of hygiene, 48(4), 807–818. https://doi.org/10.1265/jjh.48.807
52. Karthikeyan, P., Murugappan, M. &Yaacob, S. (2011, March) A review on stress inducement stimuli for assessing human stress using physiological signals. In 2011 IEEE 7th International Colloquium on Signal Processing and its Applications (pp. 420-425). IEEE.
53. Kerson, C., Sherman, R. A. & Kozlowski, G. P. (2009) Alpha suppression and symmetry training for generalized anxiety symptoms. Journal of Neurotherapy, 13(3), 146–155. https://doi.org/10.1080/10874200903107405
54. Khalfa, S., Bella, S. D., Roy M. et al. (2003) Effects of relaxing music on salivary cortisol level after psychological stress. Annals of the New York Academy of Sciences, 999, 374–376. DOI: 10.1196/annals.1284.045
55. Khorana, S. (1983) A study of psychological factors and psychotherapy on ulcerative colitis. Indian Journal of Clinical Psychology **10**(2), 459–468.
56. Khosrowabadi, R., Quek, C., Ang, K. K. et al. (2011, July) A Brain-Computer Interface for classifying EEG correlates of chronic mental stress. In The 2011 International Joint Conference on Neural Networks (pp. 757-762). IEEE
57. Knight, W. E. J. & Rickard, N. S. (2001) Relaxing music prevents stress-induced increases in subjective anxiety, systolic blood pressure, and heart rate in healthy males and females. Journal of music therapy, 38(4), 254–272. https://doi.org/10.1093/jmt/38.4.254
58. Koelsch, S. (2010) Towards a neural basis of music-evoked emotions. Trends in cognitive sciences, 14(3), 131–137. https://doi.org/10.1016/j.tics.2010.01.002
59. Koelsch, S. (2014) Brain correlates of music-evoked emotions. Nat Rev Neurosci **15,** 170–180 https://doi.org/10.1038/nrn3666

60. Koelsch, S. & Siebel, W. A. (2005) Towards a neural basis of music perception. Trends in cognitive sciences, 9(12), 578–584. https://doi.org/10.1016/j.tics.2005.10.001
61. Koelsch, S. & Stegemann, T. (2012) The brain and positive biological effects in healthy and clinical populations. In R. A. R. MacDonald, G. Kreutz, & L. Mitchell (Eds.), Music, health, and wellbeing (p. 436–456). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199586974.003.0029
62. Koelsch, S., Fritz, T., v Cramon, D. Y. et al (2006) Investigating emotion with music: an fMRI study. Human brain mapping, 27(3), 239–250. https://doi.org/10.1002/hbm.20180
63. Krause, A. E., North, A. C. & Hewitt, L. Y. (2015) Music-listening in everyday life: Devices and choice. Psychology of Music, 43(2), 155–170. https://doi.org/10.1177/0305735613496860
64. Kreutz, G., Bongard, S., Rohrmann, S., Hodapp, V., & Grebe, D. (2004) Effects of choir singing or listening on secretory immunoglobulin A, cortisol, and emotional state. Journal of behavioral medicine, 27(6), 623-635. https://doi.org/10.1007/s10865-004-0006-9
65. Kruk, J., Aboul-Enein, B. H., Bernstein, J. et al. (2019) Psychological Stress and Cellular Aging in Cancer: A Meta-Analysis. Oxidative medicine and cellular longevity, 2019, 1270397. https://doi.org/10.1155/2019/1270397
66. Labbé, E., Schmidt, N., Babin, J. et al. (2007) Coping with stress: the effectiveness of different types of music. Applied psychophysiology and biofeedback, 32(3-4), 163–168. https://doi.org/10.1007/s10484-007-9043-9
67. Langer, S. K. (1957) Philosophy in a new key. Massachusetts: Harvard University Press
68. Lazarus, R. S., & Folkman, S. (1984) Stress, appraisal, and coping. Springer publishing company, p. 283
69. Lederbogen, F., Kirsch, P., Haddad, L. et al. (2011) City living and urban upbringing affect neural social stress processing in humans. Nature, 474(7352), 498-501. DOI: 10.1038/nature10190
70. Levitin, D. J., &Tirovolas, A. K. (2009) Current advances in the cognitive neuroscience of music. Annals of the New York Academy of Sciences, 1156, 211–231. https://doi.org/10.1111/j.1749-6632.2009.04417.x
71. Lin, T. A., & John, L. R. (2006, June) Quantifying Mental Relaxation with EEG for use in Computer Games. In International conference on internet computing (pp. 409-415). https://doi.org/10.1007/978-3-642-02315-6_15
72. Lingham, Joseph. & Theorell, Töres. (2009) Self-selected "favourite" stimulative and sedative music listening – how does familiar and preferred music listening affect the body?Nordic Journal of Music Therapy. 18. 150-166. DOI: 10.1080/08098130903062363
73. Lupien, S. J., Fiocco, A., Wan, N. et al. (2005) Stress hormones and human memory function across the
74. lifespan. Psychoneuroendocrinology, 30(3), 225-242. DOI: 10.1016/j.psyneuen.2004.08.003
75. Magee, W. L., Clark, I., Tamplin, J. et al., (2017) Music interventions for acquired brain injury. The Cochrane database of systematic reviews, 1(1), CD006787. https://doi.org/10.1002/14651858.CD006787.pub3
76. Marin, M. F., Lord, C., Andrews, J. et al. (2011) Chronic stress, cognitive functioning and mental health. Neurobiology of learning and memory, 96(4), 583-595. https://doi.org/10.1016/j.nlm.2011.02.016
77. McEwen, B. S. (1998). Protective and damaging effects of stress mediators. The New England journal of medicine, 338(3), 171–179. https://doi.org/10.1056/NEJM199801153380307.
78. McEwen, B S (2012) Brain on stress: how the social environment gets under the skin. Proceedings of the National Academy of Sciences, 109(Supplement 2), 17180-17185. https://doi.org/10.1073/pnas.1121254109
79. Mennella, R., Patron, E. & Palomba, D. (2017) Frontal alpha asymmetry neurofeedback for the reduction of negative affect and anxiety. Behaviour research and therapy, 92, 32–40 https://doi.org/10.1016/j.brat.2017.02.002
80. Menon, V. & Levitin, D. J., (2005) The rewards of music listening: response and physiological connectivity of the mesolimbic system. NeuroImage, 28(1), 175–184. https://doi.org/10.1016/j.neuroimage.2005.05.053
81. Michael, F., Labbé, E. E. & Kuczmierczyk, A. R. (1986) Health psychology: A psychobiological perspective. Springer Science & Business Media.
82. Mikutta, C., Altorfer, A., Strik, W. et al. (2012) Emotions, arousal, and frontal alpha rhythm asymmetry during Beethoven's 5th symphony. Brain topography, 25(4), 423–430. https://doi.org/10.1007/s10548-012-0227-0
83. Mondanaro, J. F., Homel, P., Lonner, B. et al. (2017) Music Therapy Increases Comfort and Reduces Pain in Patients Recovering From Spine Surgery. American journal of orthopedics (Belle Mead, N.J.), 46(1), E13–E22. PMID: 28235116
84. Mönnikes, H., Tebbe, J. J., Hildebrandt, M. et al. (2001) Role of stress in functional gastrointestinal disorders. Evidence for stress-induced alterations in gastrointestinal motility and sensitivity. Digestive diseases (Basel, Switzerland), 19(3), 201–211. https://doi.org/10.1159/000050681

85. Monroe, S. M. & Slavich, G. M. (2016). Psychological Stressors. 10.1016/B978-0-12-800951-2.00013-3. https://doi.org/10.1016/B978-0-12-800951-2.00013-3
86. Murugappan, M., Ramachandran, N., & Sazali, Y. (2010) Classification of human emotion from EEG using discrete wavelet transform. Journal of Biomedical Science and Engineering, 03, 390-396. DOI: 10.4236/jbise.2010.34054
87. Muse (June 25, 2018) A Deep Dive into Brainwaves: Brainwave Frequencies Explained. Retrieved from https://choosemuse.com/blog/a-deep-dive-into-brainwaves-brainwave-frequencies-explained-2/
88. N H A, Hamid., N. Sulaiman., S A M, Aris. et al. (2010, May) Evaluation of human stress using EEG power spectrum. In 2010 6th International Colloquium on Signal Processing & its Applications (pp. 1-4). IEEE., doi: 10.1109/CSPA.2010.5545282.
89. N. Adnan., Z. H. Murat., R. S. S. Abdul Kadir and Noradibah Hj Mohamad Yunos, "University students stress level and brainwave balancing index: Comparison between early and end of study semester," 2012 IEEE Student Conference on Research and Development (SCOReD), Pulau Pinang, 2012, pp. 42-47, doi: 10.1109/SCOReD.2012.6518608.
90. N Sulaiman, M N Taib, S Lias et al (2011) EEG-based Stress Features Using Spectral Centroids Technique and k-Nearest Neighbor Classifier.UkSim 13th International Conference on Computer Modelling and Simulation, Cambridge, 2011, pp. 69-74, doi: 10.1109/UKSIM.2011.23.
91. Nawaz, R., Nisar, H. &Voon, Y. V. (2018) The Effect of Music on Human Brain; Frequency Domain and Time Series Analysis Using Electroencephalogram. IEEE Access, 6, 45191-45205. **DOI:** 10.1109/ACCESS.2018.2855194
92. Nicholson, A. A., Ros, T., Frewen, P. A. et al. (2016) Alpha oscillation neurofeedback modulates amygdala complex connectivity and arousal in posttraumatic stress disorder. NeuroImage. Clinical, 12, 506–516. https://doi.org/10.1016/j.nicl.2016.07.006
93. Panksepp, J. & Bernatzky, G. (2002) Emotional sounds and the brain: the neuro-affective foundations of musical appreciation. Behavioural processes, 60(2), 133–155. https://doi.org/10.1016/s0376-6357(02)00080-3
94. Paul, Murugesa Pandiyan., Sazali, Yaacob. (2013) Mental stress level classification using eigenvector features and principal component analysis, Communications in Information Science and Management Engineering 3 (5) 254
95. Pelletier, C. L. (2004) The effect of music on decreasing arousal due to stress: a meta-analysis. Journal of music therapy, 41(3), 192–214. https://doi.org/10.1093/jmt/41.3.192
96. Phneah, S. W. &Nisar, H. (2017) EEG-based alpha neurofeedback training for mood enhancement. Australasian physical & engineering sciences in medicine, 40(2), 325–336. https://doi.org/10.1007/s13246-017-0538-2
97. Pickering, T. G. (2001) Mental stress as a causal factor in the development of hypertension and cardiovascular disease. Current hypertension reports, 3(3), 249-254. DOI: 10.1007/s11906-001-0047-1
98. Puterman, E., O'Donovan, A., Adler, N. E., et al. (2011). Physical activity moderates effects of stressor-induced rumination on cortisol reactivity. Psychosomatic Medicine, vol. 73, pp. 604-611, 2011. doi: 10.1097/PSY.0b013e318229e1e0.
99. Raglio, A., Attardo, L., Gontero, G. et al. (2015) Effects of music and music therapy on mood in neurological patients. World journal of psychiatry, 5(1), 68–78. https://doi.org/10.5498/wjp.v5.i1.68
100. Ramirez, R., Palencia-Lefler, M., Giraldo, S. et al. (2015) Musical neurofeedback for treating depression in elderly people. Frontiers in neuroscience, 9, 354. http://doi.org/10.3389/fnins.2015.00354
101. Ramirez, R., Planas, J., Escude, N. et al (2018) EEG-Based Analysis of the Emotional Effect of Music Therapy on Palliative Care Cancer Patients. Frontiers in psychology, 9, 254. https://doi.org/10.3389/fpsyg.2018.00254
102. Rauscher, FH., Shaw, GL. & Ky CN. (1993) Music and spatial task performance. Nature **365,** 611. DOI: 10.1038/365611a0
103. Rice, K. M., Blanchard, E. B. & Purcell, M. (1993) Biofeedback treatments of generalized anxiety disorder: preliminary results. Biofeedback and self-regulation, 18(2), 93–105. https://doi.org/10.1007/BF01848110
104. Saeed, S., Anwar, S. M., Khalid, H., Majid, M., & Bagci, A. U. (2020). EEG based Classification of Long-term Stress Using Psychological Labeling. *Sensors (Basel, Switzerland)*, *20*(7), 1886. https://doi.org/10.3390/s20071886
105. Sakharov, D. S., Davydov, V. I. &Pavlygina, R. A. (2005) Intercentral relations of the human EEG during listening to music. Human Physiology, 31(4), 392–397. PMID: 16122031
106. Salimpoor, V.N., Benovoy, M., Larcher, K. et al. (2011) Anatomically distinct dopamine release during anticipation and experience of peak emotion to music. Nature neuroscience, 14(2), 257–262. https://doi.org/10.1038/nn.2726

107. Sammler, D., Grigutsch, M., Fritz, T. et al (2007) Music and emotion: Electrophysiological correlates of the processing of pleasant and unpleasant music. J Psychophysiology, 44, 293–304. doi: 10.1111/j.1469-8986.2007.00497.x.
108. Sani, M. M., Norhazman, H., Omar, H A. et al. (2014, December) Support vector machine for classification of stress subjects using EEG signals. In 2014 IEEE Conference on Systems, Process and Control (ICSPC 2014) (pp. 127-131). IEEE. doi:10.1109/spc.2014.7086243
109. Selye, H. (1946) The general adaptation syndrome and the diseases of adaptation. The Journal of clinical endocrinology and metabolism, 6, 117–230. https://doi.org/10.1210/jcem-6-2-117
110. Selye, H. (1956) The stress of life. New York: McGraw Hill
111. Selye, H. (1973) The Evolution of the Stress Concept: The originator of the concept traces its development from the discovery in 1936 of the alarm reaction to modern therapeutic applications of syntoxic and catatoxic hormones. American Scientist, 61(6), 692-699. Retrieved November 23, 2020, from http://www.jstor.org/stable/27844072
112. Seo, S. H., Lee, J. T. & Crisan, M. (2010) Stress and EEG. Convergence and hybrid information technologies, 1(1), 413-424. DOI: 10.5772/9651
113. Sloboda, J. A. & Juslin, P. N. (2010) At the interface between the inner and outer world: Psychological perspectives. In P. N. Juslin& J. A. Sloboda (Eds.), Series in affective science. Handbook of music and emotion: Theory, research, applications (p. 73–97). Oxford University Press.
114. Sourina, O., Liu, Y. & Nguyen, M. K. (2012) Real-time EEG-based emotion recognition for music therapy. J Multimodal User Interfaces **5,** 27–35. https://doi.org/10.1007/s12193-011-0080-6
115. Stojanovich, L. & Marisavljevich, D. (2008) Stress as a trigger of autoimmune disease. Autoimmunity
116. reviews, 7(3), 209–213. DOI: 10.1016/j.autrev.2007.11.007
117. Suda, M., Morimoto, K., Obata, A. et al. (2008) Emotional responses to music: towards scientific perspectives on music therapy. Neuroreport, 19(1), 75–78. https://doi.org/10.1097/WNR.0b013e3282f3476f
118. Sun, Chenbing., Bao, Yimin., Xu, Jiatuo. et al. (2013) The Effects of Different Types of Music on Electroencephalogram.IEEE International Conference on Bioinformatics and Biomedicine. DOI Bookmark:10.1109/BIBM.2013.6732586
119. Sutoo, D. & Akiyama, K. (2004) Music improves dopaminergic neurotransmission: demonstration based on the effect of music on blood pressure regulation. Brain research, 1016(2), 255–262. https://doi.org/10.1016/j.brainres.2004.05.018
120. Svansdottir, H. B. & Snædal, J. (2006) Music therapy in moderate and severe dementia of Alzheimer's type: a case–control study. International psychogeriatrics, 18(4), 613-621. DOI: https://doi.org/10.1017/S1041610206003206
121. Teplan, M., Krakovská, A. & Stolc, S. (2006) EEG responses to long-term audio-visual stimulation. International journal of psychophysiology : official journal of the International Organization of Psychophysiology, 59(2), 81–90. https://doi.org/10.1016/j.ijpsycho.2005.02.005
122. Tseng, P. T., Chen, Y W., Lin, P Y. et al. (2016) Erratum to: Significant treatment effect of adjunct music therapy to standard treatment on the positive, negative, and mood symptoms of schizophrenic patients: a meta-analysis. BMC psychiatry, 16(1), 1-4. https://doi.org/10.1186/s12888-016-0718-8
123. Ursin, H. & Eriksen, H. R. (2004) The cognitive activation theory of stress. Psychoneuroendocrinology, 29(5), 567-592. https://doi.org/10.1016/S0306-4530(03)00091-X
124. Valsamakis, G., Chrousos, G., & Mastorakos, G. (2019) Stress, female reproduction and pregnancy. Psychoneuroendocrinology, 100, 48-57.
125. Ventura, T., Gomes, M. C. & Carreira, T. (2012) Cortisol and anxiety response to a relaxing intervention on pregnant women awaiting amniocentesis. Psychoneuroendocrinology, 37(1), 148–156. https://doi.org/10.1016/j.psyneuen.2011.05.016
126. Vernon, D. J. (2005) Can neurofeedback training enhance performance? An evaluation of the evidence with implications for future research. Applied psychophysiology and biofeedback, 30(4), 347–364. https://doi.org/10.1007/s10484-005-8421-4
127. Wachi, M., Koyama, M., Utsuyama, M. et al. (2007) Recreational music-making modulates natural killer cell activity, cytokines, and mood states in corporate employees. Medical science monitor: international medical journal of experimental and clinical research, 13(2), CR57–CR70. PMID: 17261984
128. Walinga, J. and Stangor, C. (2014) Introduction to Psychology – 1st Canadian Edition. Victoria, B.C.: BCcampus. . Retrieved from https://opentextbc.ca/introductiontopsychology/chapter/15-2-stress-and-coping/. accessed on November 2020

129. Walker, J. E. (2011) QEEG-guided neurofeedback for recurrent migraine headaches. Clinical EEG and neuroscience, 42(1), 59–61. https://doi.org/10.1177/155005941104200112
130. Wang, Kun. & Wen, Wanhui & Liu, Guang-Yuan (2016) The autonomic nervous mechanism of music therapy for dental anxiety. 289-292. DOI: 10.1109/ICCWAMTIP.2016.8079858
131. Watkins, G. R. (1997) Music therapy: proposed physiological mechanisms and clinical implications. Clinical nurse specialist CNS, 11(2), 43–50. https://doi.org/10.1097/00002800-199703000-00003
132. Weinberger, N. M. (2004). Music and the brain. *Scientific American*, *291*(5), 88-95. DOI: 10.1038/scientificamerican1104-88
133. Wikimedia Commons. A diagram of the General Adaptation syndrome model by David G. Myers (http://commons.wikimedia.org/wiki/File:General_Adaptation_Syndrome.jpg) used under the CC-BY 3.0 (http://creativecommons.org/licenses/by/3.0/deed.en).
134. Yamamoto, T., Ohkuwa, T., Itoh, H. et al. (2003) Effects of pre-exercise listening to slow and fast rhythm music on supramaximal cycle performance and selected metabolic variables. Archives of physiology and biochemistry, 111(3), 211–214. https://doi.org/10.1076/apab.111.3.211.23464
135. Zoefel, B., Huster, R. J. & Herrmann, C. S. (2011) Neurofeedback training of the upper alpha frequency band in EEG improves cognitive performance. NeuroImage, 54(2), 1427–1431. https://doi.org/10.1016/j.neuroimage.2010.08.078.