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Music and medicine: The effects of music on the human being

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Abstract

Music may not only improve quality of life but also effect changes in heart rate (HR) and heart rate variability (HRV). A greater modulation of HR and HRV was shown during musical performance compared to listening to music. Cerebral flow was significantly lower when listening to "Va pensiero" from Verdi's "Nabucco" (70.4±3.3 cm/s) compared to "Libiam nei lieti calici" from Verdi's "La Traviata" (70.2±3.1 cm/s) ($p<0,02$) or Bach's Cantata No. 169 „Gott soll allein mein Herze haben" (70.9±2.9 cm/s) ($p<0,02$). There was no significant influence on cerebral flow in Beethoven's Ninth Symphony during rest (67.6±3.3 cm/s) or music (69.4±3.1 cm/s). Music significantly decreases the level of anxiety for patients in a preoperative setting compared to midazolam (STAI-X-1 score 36) ($p<0.001$). Listening to music while resting in bed after open-heart surgery leads to significant differences in cortisol levels between the music (484.4 mmol/l) and the non-music group (618.8 mmol/l) ($p<0.02$).

Key words: music performance, music perception, quality of life, music therapy, cardiovascular system

Introduction

Listening to music, whether a Mozart symphony or to Antonio Vivaldi's "the four seasons" may not only help to unwind at the end of a stressful day. It could also lower blood pressure, heart rate and improve heart rate variability. The idea that music has an effect on heart rate, blood pressure and cardiovascular system has been reported in 1918 by Hyde and Scalapino (1). They reported that minor tones increased heart rate and lowered blood pressure, whereas "stirring" music increased both blood pressure and heart rate. There are several individual reactions to music that are dependent on individual preferences, mood or emotions (2). It has been reported that music showed consistent cardiovascular and respiratory responses with different styles in most subjects, in whom responses were related to tempo and were associated with faster breathing (3,4). Fast music caused increases in blood pressure, heart rate and breathing rate, and reduced baroreflex sensitivity. Slow music, on the other hand, caused a significant fall in heart rate and breathing frequency compared with the baseline. The responses were qualitatively similar in musicians and nonmusicians and apparently were not influenced by musical preferences, although musicians did respond more (5).

In recent years, music has been increasingly used as a therapeutic tool in the treatment of different diseases (6-8). It has been shown that music therapy not only reduced

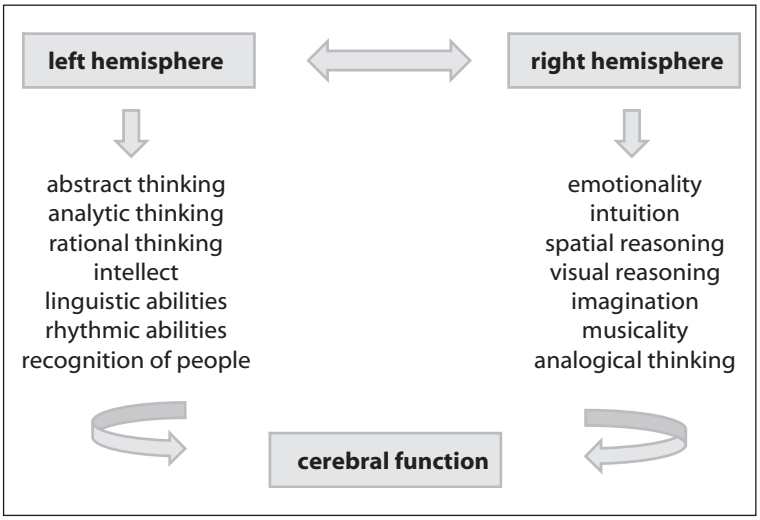

Figure 1: Brain association areas. Localization of different functional areas in the left or right brain hemisphere

blood pressure, heart rate and patient anxiety but had a significant effect on future events, including reinfarction and death, in acute coronary syndrome patients who underwent revascularization (Dr. Predrag Mitroviv, ESC congress 2009, Barcelona, personal communication). Miller et al showed that music also affects endothelial function and in this study brachial artery flow mediated dilation increased 26% during music phase that evoked joy compared to baseline ($p<0,002$)(9). The purpose of the present manuscript is to summarize the different effects of music on health, cardiovascular parameters, anxiety, pain and to describe what kind of music is helpful for whom and what kind of music is probably dangerous.

Effects of music on the cardiovascular pathophysiology in the pregnant woman

It is well known that music, as a stimulus, can be recognized as early as the twentieth week of fetal development. The unborn baby will recognize all sounds and will "learn" music in this way (10,11). This is the first sensory impression for the child. There is general agreement that soft sounds with regular and low rhythms ("lullabies") are ideal for the unborn baby or even in children born before the regular date of birth. This is a well known interaction between the baby and the mother and will help to avoid colic in newborns. In addition, music is also helpful for the mother prior to delivery. Yang et al (12) studied the effect of music on anxiety alleviation in 120 antepartal women on bed rest. These women received music therapy for 30 min on 3 consecutive days. Music was selected according to the women's own preferences. Usual care participants had a 30 minute rest on 3 consecutive days. Variables included anxiety (State-Trait Anxiety Inventory), and physiological responses like vital signs and fetal heart rate. Anxiety levels decreased and physiological responses improved significantly in the women with music therapy while on bed rest. In another study by Kim et al (13) it was suggested to play music for women during pregnancy, birth and nursing. Increased sympathetic activity during pregnancy has been proposed as a mechanism for increased incidence of arrhythmias and, therefore, music may help to avoid them (14,15). Occurrence of cardiac tachyarrhythmias may also be related to physiologic changes occurring during pregnancy, such as increased heart rate, decreased peripheral resistance and increased stroke volume. Music with slow rhythms, soft sounds and particularly music

from Mozart is beneficial in these circumstances and opens new possibilities for unborn (and born) babies as well as for the mother. It seems possible to prevent cardiac arrhythmias for both mother and the unborn child as well as to prevent sudden infant death. In addition to these cardiovascular effects, there is a significant improvement in cognitive function (Binet intelligence scale) when listening to Mozart's music (score 57.56) compared to relaxation (score 54.61) or silence (score 54.00) ($p<0.002$). In relation to each other, the relaxation and silence conditions did not differ ($p=0.43$) (16). Music can also be helpful in instances of depression and more specifically postpartum depression (17). It seems that Mozart has benefitial effects on energy expenditure in growing preterm infants (18).

Effects of music on the pathophysiology and the cardiovascular system

Bernardi et al. (19) studied 24 young, healthy subjects (12 chorists and 12 nonmusician control subjects) who listened in random order to music with vocal (Puccini's "Turandot") or orchestral (Beethoven's Ninth Symphony adagio) progressive crescendos, more uniform emphasis (Bach's Cantata BWV 169 "Gott soll allein mein Herz haben"), 10-second period rhythmic phrases (Verdi's arias "Va pensiero" and "Libiam nei lieti calci") or silence while heart rate, respiration, blood pressure, middle cerebral artery flow velocity, and skin vasomotion were recorded. Common responses were recognized by averaging instantaneous cardio respiratory responses regressed against changes in musical profiles and by coherence analysis during rhythmic phrases. Vocal and orchestral crescendos produced significant correlations between cardiovascular or respiratory signals and musical profile, particularly skin vasoconstriction and blood pressures, proportional to crescendo, in contrast to uniform emphasis, which induced skin vasodilation and reduction in blood pressure ($p<0.05$). Correlations were significant both in individual and group-averaged signals ($p<0.05$). Phrases at 10-second intervals by Verdi entrained the cardiovascular autonomic variables. It is important to note that no qualitative differences were observed in recorded measurements between musicians and nonmusicians. In this study cerebral flow was significantly lower when listening to "Va pensioero" (70.4±3.3 cm/s) compared to "Libiam nei lieti calici (70.2±3.1 cm/s) ($p<0,02$) or Bach (70.9±2.9 cm/s) ($p<0,02$). There was no significant influence on cerebral flow in Beethoven's Ninth Symphony during rest (67.6±3.3 cm/s) or music (69.4±3.1 cm/s). The data by Bernardi et al. (19) also demonstrate that in addition to conscious chills, which typically are experienced by a minority of subjects, there is a common pattern of unconscious response when different subjects listen to the same music. These autonomic responses were more apparent with lyrical responses from an operatic aria or a typical exciting orchestral phrase than with more "intellectual" solo singing from a Bach cantata. The extent of the responses appeared to be dependent on the specific pattern of the musical profile. When a sudden crescendo was spaced adequately, or the musical profile exhibited a regular or slow change, then the cardiovascular system tracked the musical profile, and skin vasomotion was evident. When the musical profile changed very rapidly, the overall effect was opposite. Skin vasomotion and a reduction in blood pressure by general relaxation were observed (19). It has been shown in other studies by Yoshie et al. (20) and Nakahara et al. (21) that music will have beneficial effects on heart rate, heart rate variability and anxiety levels in not only skilled pianists but also nonmusicians during both performance of and listening to music. The findings of these studies suggest, though, that musical performance has a greater effect on emotion-related modulation in cardiac autonomic nerve activity than musical perception (22,23).

It has been shown that the structure of a piece of music has a constant dynamic influence on cardiovascular and respiratory responses, which correlates with musical profiles (24,25). Specific musical phrases (frequently at a rhythm of 6 cycles/min in famous arias by Verdi) can synchronize inherent cardiovascular rhythms, thus modulating cardiovascular control. This occurred regardless of respiratory modulation, which suggests the possibility of direct entrainment of such rhythms and led to the speculation that some of the psychological and somatic effects of music could be mediated by modulation or entrainment of these rhythms (26). Music as therapy is an option for all since it has been reported that musicians and nonmusicians alike showed similar qualitative responses (cardiovascular and respiratory system). This suggests that "active" playing of music is not essential to induce synchronization with music. However, it was pointed out that musicians appeared to show higher cardiovascular and respiratory modulation induced by music. They also tended to respond more than nonmusicians to more "intellectual" music like that of Bach or Mozart (27-29).

Effect of music during cardiac catheterization

Argstatter et al. (30) analyzed the role of music in 90 patients who underwent cardiac catheterization. There were three randomized groups: Group I represented patients with "music only" during catheterization procedures, Group II patients had both music during catheterization and extended information prior to the procedure and Group III patients served as controls. In all groups the anxiety score was evaluated with the categories "minimal anxiety – minimal stress" or "severe anxiety – severe stress". It was becoming clear that the behavior during the procedures was significantly better in Group I and Group II patients in contrast to controls ($p<0.05$). However, there were no significant differences in heart rate and blood pressure between the three groups. In addition similar drug regimens were used prior to and after the procedure. Recently, in the Almut-study the effect of different types of music during cardiac catheterization procedures was analyzed by an anxiety score system between patients who had music during the procedure compared to those who did not (31). In addition to the anxiety score, heart rate and blood pressure were recorded. There were patients who listened to classical music, meditation music, Jazz or silence. In patients who were not able to select their own music, the most beneficial effect was seen in those who had classical music. In patients who selected their own music, meditation music was most powerful. Although there were significant differences in the anxiety index between patients with or without music ($p<0.05$), no significant differences among the two groups were observed in heart rate or blood pressure.

Effect of music on the cardiopulmonary pathophysiology prior to and after cardiac surgery

The influence of music was studied prior to bypass grafting or valve replacement in 372 patients wherein a portion of the group received midazolam (0.05-0.1 mg/kg) according to the STAI-X-1 anxiety score (32). Of the 372 total patients, there were 177 patients who had music prior to surgery and 195 patients who received midazolam. There were significant differences in the anxiety scores prior to and after surgery between both groups: in the "music group" prior to and after surgery the score was 34 and 36 respectively, whereas the score was 30 and 34 in the midazolam group ($p<0.001$). Nilsson et al. (33) analyzed 40 patients who underwent bypass grafting or aortic valve replacement and in these patients oxytocin, heart rate, blood pressure, PaO_2 and oxygen saturation SaO_2 were studied in two groups: one group

had music, the other group served as controls. As pointed out by the authors there were significantly better values of oxytocin (increased) and PaO_2 (increased) in the music group compared to controls ($p<0.05$). No significant differences were observed regarding heart rate, blood pressure and SaO_2. In another study, Nielsson et al. (34) analyzed the follow-up of 58 patients after cardiac surgery. These patients underwent musical therapy (30 min music exposure one day after surgery) compared to controls. Evaluation of cortisol, heart rate, ventilation, blood pressure, SaO_2, pain and anxiety indices was performed. There were significantly lower cortisol levels in the music group (484.4 mmol/l) compared to patients without music (618,8 mmol/l) ($p<0.02$). There were no significant differences in heart rate, blood pressure, respiration and oxygen saturation between both groups. Similar effects have been reported by Antonietti in patients who underwent rehabilitation after surgery (35).

Effects of music on intensive care patients, geriatric and terminally ill patients

It is well known that soft and not loud sounds have beneficial effects on patients while treated in intensive care medicine and will reduce pain and stress significantly (36). Soft, silent or quiet classical or meditation music is associated with the reduced need for sedative drugs and reduced perception of pain. Despite the well known effects of music in intensive care medicine this kind of "therapy" is observed rarely in daily practice. In addition to this, there are many psychological effects: music from the youth of the patient will lead to improved mood, concentration and motivation, all of which are essential for the intensive care patient. There are spectacular effects of music in geriatric patients: music from the youth and music from "better days" will lead to improved mood, motivation, increased vitality and will also encourage social contacts (36). This is important in geriatrics and in patients with depressive syndromes. Chan et al. (37) performed a randomized study in 47 people under the age of 65 who underwent music therapy compared to 24 controls. In the music group, there were statistically significant decreases in depression scores ($p<0.001$), blood pressure ($p<0.001$), and heart rate ($p<0.001$) after one month ($p<0.001$). The implication of this observation is that music can be an effective intervention for older and/or patients suffering from depressive syndromes. Particularly older patients with Alzheimer diseases will profit from music therapy. We all know that the terminal patient presents a unique situation. It has been reported that these patients will continue hearing although some other organ functions have been lost. Therefore, music plays an important role in this situation and music from the patient's youth has the most impact. This music might prove to be the last source of aesthetic enjoyment and simple happiness for the dying patient (38,39).

What types of music are good for health – which are not?

The most beneficial music for the health of a patient is *classical music*, which holds an important role in music therapy (40). It has been shown that music composed by Bach, Mozart and Italian composers is the most powerful in "treating" patients. It is possible to select the "ideal" therapy for cardiovascular disturbances, recreation and refreshment of the immune system, improvement of concentration and help with depression. The beneficial effects of Bach's music is possibly caused by his "mathematical" compositions avoiding sudden changes (Fig. 2,3). Patients who would receive the most benefit from classical music include those with anxiety, depressive syndromes, cardiovascular disturbances and those suffering from pain, stress or sleep disturbances. *Popular music* is an "eye-opener". This music incorporates harmonic melodies that will lead to buoyant spirit, good mood leading to lift in mood, in-

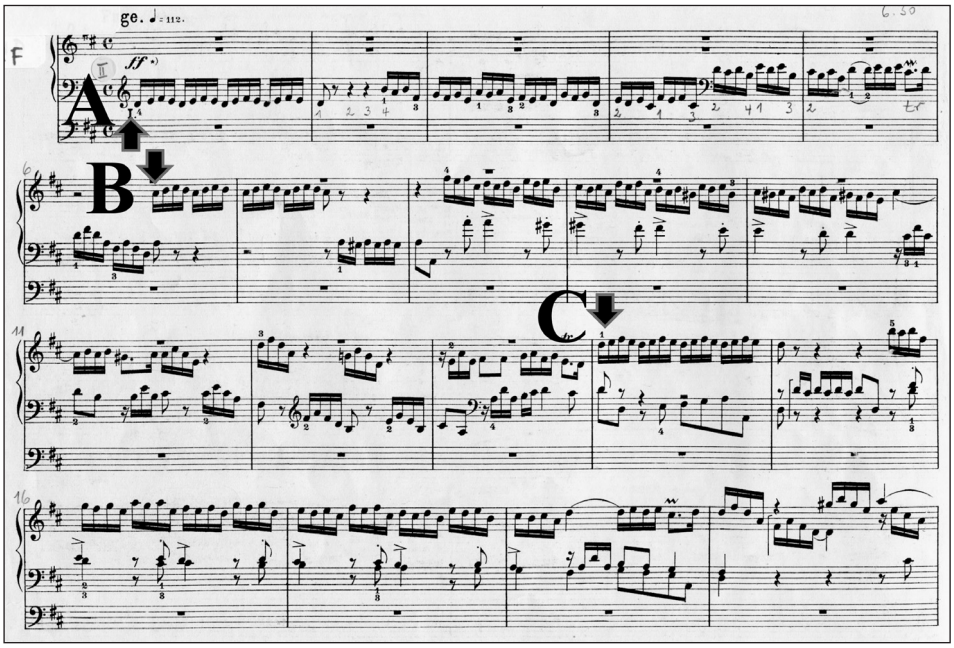

Figure 2: Johann Sebastian Bach (1685-1750): Fuga in D major (BWV 532) for organ solo. This is a typical example of Bach's music. The theme is conduced in the same manner four times ("A" – "D"). This explains the typical "Bach effect" avoiding sudden changes in tempo and dynamics (measure 1-19).

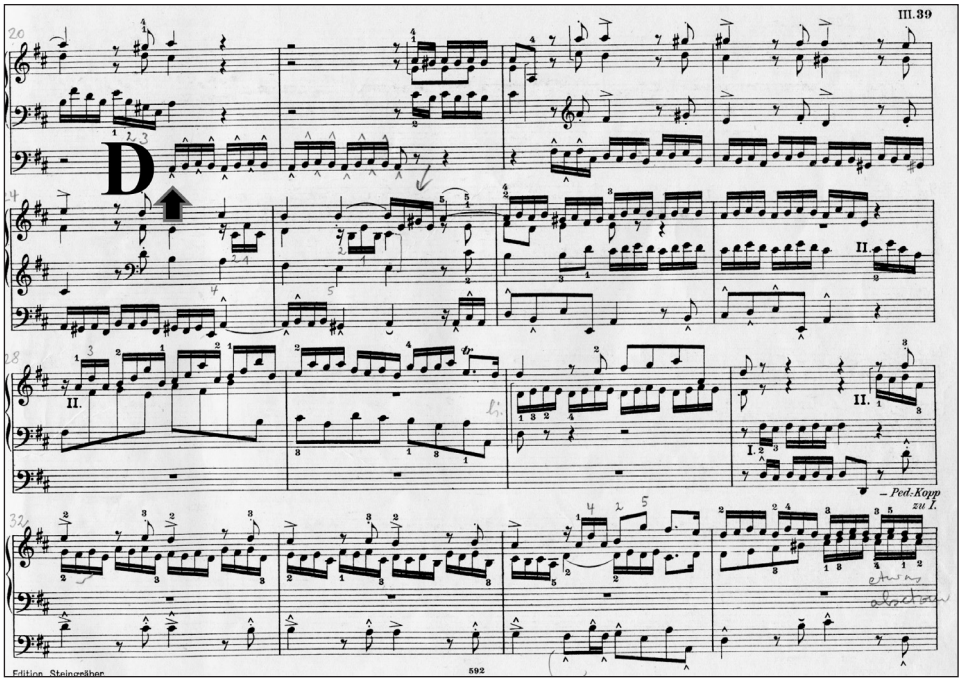

Figure 3: Johann Sebastian Bach (1685-1750): Fuga in D major (BWV 532) for organ solo. This is a typical example of Bach's music. The theme is conduced in the same manner four times ("A" – "D"). This explains the typical "Bach effect" avoiding sudden changes in tempo and dynamics (measure 20-35).

creased motivation and general stimulation. *Meditation music* has sedative effects. Sounds are slow and rhythms few. This kind of music generates spiritual reflection and, as such, is utilized in Yoga and Tai Chi. *Heavy metal* and *techno* are ineffective or even dangerous. This music encourages rage, disappointment, and aggressive behavior while causing both heart rate and blood pressure to increase. Breastfeeding mothers should avoid this music because there is a negative influence on milk flow. In addition, plants have been shown to slow their growth or even die when exposed to this kind of music on a permanent basis. *Hip Hop* and *Rap* are less frequently effective due to the sounds, but can often have effect due to their words – the important element of which is the rhyme structure. *Jazz* appeals to all senses, but a high degree of concentration is necessary when listening to Jazz. There are few studies of the effect of Jazz on health. *Latin-American* music like samba, tango, cha-cha-cha, rumba, reggae or mambo is very rhythmic. This music leads to positive mood and buoyant spirit and induces movement. It increases motivation and stimulates activity. *Folk* is music with a socio-cultural background. It is enriching for intellectual work, leads to confidence and emphasizes protection. However, if folklore is "unusual" in character it can have a negative effect. *Schlager music* are songs to sing alone with, have simple structures but frequently have "earworm-character". This kind of music is inappropriate for influencing health.

When is music not useful?

More recently, several reports have indicated the usefulness of music therapy in managing psychiatric disorders (41,42). Music has been used in the treatment of psychosis and neurosis and now is being used in addressing organic disorders such as dementia. It plays a useful role in allaying anxiety and relaxing patients in critical care. Music therapy has been used effectively in both adults and children with psychiatric disorders. It has been used to modify the behavior of children with autism and pervasive developmental disorders with moderate success. It has been used to reduce agitation in patients with dementia by soothing them and eliminating the social isolation of these patients (43,44). Music therapy has been used in patients with Parkinson's disease to improve motor skills and to deal with emotional problems (45). There is ample evidence of the usefulness of music therapy in alleviating grief and in combating bouts of depression. Music no doubt plays a pivotal role in the lives of human beings. Incorporating music therapy into regular therapy programs for psychiatric disorders can help speed recovery and also help make therapy a more positive experience. Music therapy is a valuable but relatively unexplored asset in the field of psychiatry and psychotherapy. However, the patient may or may not like the music chosen by the therapist and thus is given a choice to include music or not. Careful selection of music that incorporates patient's own preferences may yield positive results, whereas contrary effects may result from use of the wrong type of music. Selection of "wrong" music can intensify depressive syndromes, aggressiveness and anxiety. In addition, feelings toward music may change during different phases of life and may lead to different effects.

Conclusions

Music is used more and more as a therapeutic tool, because all subjects, whether musically trained or not, respond in a similar manner. Music is a combination of frequency, beat, density, tone, rhythm, repetition, loudness, and lyrics. Different basic personalities tend to be attracted to certain styles of music. Energy block patterns can intensify, reduce, or change the natural inclinations of a person's identity. Music influences our emotions because it takes the place of and extends our languages. Research conducted over the past 10 years has demonstrated that

persistent negative emotional experiences or an obsession and preoccupation with negative emotional states can increase one's likelihood of acquiring the common cold, other viral infections, yeast infestations, hypersensitivities, heart attacks, high blood pressure, and other diseases. For better personal health, we can then choose „healthful" music and learn to let ourselves benefit from it. The most benefit from music on health is seen in classical and in meditation music, whereas heavy metal or techno are ineffective or even dangerous. There are many composers that effectively improve quality of life and health, particularly Bach, Mozart or Italian composers. Various studies suggested that this music not only makes one happy, but has significant effects on the cardiovascular system and influences significantly heart rate, heart rate variability and blood pressure as well. Music is effective under different conditions and can be utilized as an effective intervention in patients with cardiovascular disturbances, pain, depressive syndromes, psychiatric diseases, and in intensive care medicine. A distracting effect of music can prolong exercise by increasing the threshold for pain or dyspnea. An externally driven autonomic modulation could be of practical use to induce body sensation, increase in heart rate or skin vasoconstriction, which might finally reach the level of consciousness or at least create a continuous stimulus to the upper brain centers. This might explain the efficacy of music in pathological conditions such as stroke, and it opens new areas for music therapy in rehabilitative medicine. Nevertheless, the possible therapeutic value of Bach's or Mozart's music on cardiovascular parameters and health should be a point of immediate interest. The hypothesis that Bach's or Mozart's music is helpful on health has to be proven by prospective, randomized animal and human being studies.

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