

Full Length Article

Music for Life Sustenance: Does Music have a Role in Intensive Care Medicine?

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Abstract

The application of music as a therapeutic, strategized intervention in the intensive care environment is considered as critical consideration and evaluation of current research is explored. Through a comprehensive literature review, it is considered why music might prove suitable in ICU care, and how it can significantly affect cardiovascular, respiratory and metabolic parameters amongst other physiological and psychological aspects pertinent to recovery. Consideration of music application outside of the intensive care unit in affiliated areas is discussed as well as its use in targeted therapy application with specific patient groups. The importance of distinguishing between a live or recorded musical intervention and the music type itself is highlighted, particularly with respect to research where this has typically been poorly defined.

Keywords: *Music, Intensive Care, Vital Signs, Physiology, Pain, Cardiovascular, Respiratory, Sleep*

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Introduction

Music is a universal modality spanning not only across all known cultures, but historically through centuries, with instruments discovered as long as 35,000 years ago [1]. The intimate relationship that humanity and music seemingly share, has been postulated to contribute to psychological well-being [1], and has furthermore revealed evolutionary advantages [2], but what is perhaps the most intriguing and of recent attention, is the profound impact that music has contributed to body physiology alongside its resonance with the human psyche.

Musical “chills” for instance, is currently recognized to be the result of a dopamine release in the brain [3]. Pleasurable stimuli that provide such a release in this way may be considered as addictive or on the other hand, might be apt to confer to meet some sort of survival benefit. It is therefore interesting to consider that music is equally impacting on a physiological as well as an emotional level. With an increasing evidence base that music not may not only influence the brain in a similar way as a pharmacologic agent might, it is also notably significant that music affects the metabolic, cardiovascular and respiratory systems. In this way, it seems

reasonable that music and music therapy should hold a scientifically sound place in mechanisms involving conventional healing, particularly whereas a scientific basis is lacking, and thus merits academic attention.

Setting the Scene

Music therapy is a relative newcomer to healthcare; its début attributed to post-World War II (USA) where it was used as an intervention for trauma victims. From niche beginnings, this has led it toward becoming an internationally recognized medical treatment option for a number of conditions from Autism to Alzheimer’s [4]. Music is defined by the Oxford Dictionary (2010) as “vocal or instrumental sounds (or both) combined in such a way as to produce beauty of form, harmony, and expression of emotion” [5]. This phenomenon can be applied clinically according to the American Music Therapy Association “to accomplish individualized goals within a therapeutic relationship by a credentialed professional” to effectuate various nonmusical outcomes incorporating psychological, cognitive, social and physiological domains [6,7].

A recent critical review concerning noise in hospital intensive care environments found a poorly managed soundscape on the Intensive Care Unit (ICU) to be detrimental to patient health [8]. Despite being an everyday occurrence for some healthcare professionals, the ICU environment remains a strange, uncomfortable and hostile place for patients and relatives, who are often scared and confused. With most patients on mechanical ventilation, and of critical status, it is of paramount importance that any such variables conferring negative affects are well controlled.

The Environmental Protection Agency recommends maximum sound levels on an ICU must be between 40-45 decibels, decreasing to 35db at night [9], however the reality is

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that it ranges from 58-72 [6]. This merely provides another stimulus to raise stress hormones, which in turn impedes the immune system leading to reduced healing and immunity [6]. With patient's clinging to their last shred of vitality, a non-hostile and psychologically impacting complementary therapy it seems, is an ideal intervention; Queue the music.

Why does Music Lend itself to Manipulation of Human Physiology?

Schneck and Berger stipulated a number of attributes that both the human body and music possess; The body is a controlled system, run biorhythmically, and thus lends itself to a symbiosis with music. Only humans learn to play instruments, and moreover play them cooperatively in groups [10]. Indeed, Music itself is a human construct designed as a form of emotional expression. It therefore stands to reason that it should drive the very organism that created [4] it, and not surprisingly, this is supported by a developing evidence base demonstrating it's ability to entrain various physiological variables [11-13]. Breathing particularly, with an ability to succumb to voluntary control, can be easily metered by musical experience [11-13].

The human system functions through feedback mechanisms and regulation of homeostatic operating 'set-points'. These can be modulated via external stimuli and through sensory integration occurring in the brain [4]. Though research has addressed music as one of these external stimuli, there remains a number of pitfalls in existing literature. The selection of musical stimuli is not standardised, and often referred to heterogenously despite a wide range of genres. There is often no non-musical control group leading some to hypothesis that human presence alone may be a confounding variable, and musical choice, whether by researcher or participant is rarely specified [14]. Importantly, the interventional type, whether passive listening or active therapeutics is often considered synonymously [14], despite evidence that human musical intervention bears the ability to adapt pitch, tone, tempo and tonality, thus entraining and manipulating physiological variables whilst addressing numerous other therapeutic patient needs [15].

How is Music Processed by the Brain?

It appears reasonable to start by considering the basic mechanisms of how we perceive and process these aforementioned 'vocal or instrumental sounds.' Sound waves enter the external auditory canal triggering a vibration of the eardrum or 'tympanic membrane', which is then transmitted via three tiny bones called 'ossicles', through the oval window into the fluid filled cochlea. Hair cells located on the basilar membrane of the cochlea convert these vibrations to an electrical potential so that it may be conducted by the auditory nerve. A swift passage through the nervous system, first the cochlear nuclei, upper motor neurons and thalamus take the

impulse to the primary auditory cortex of the temporal lobe [16].

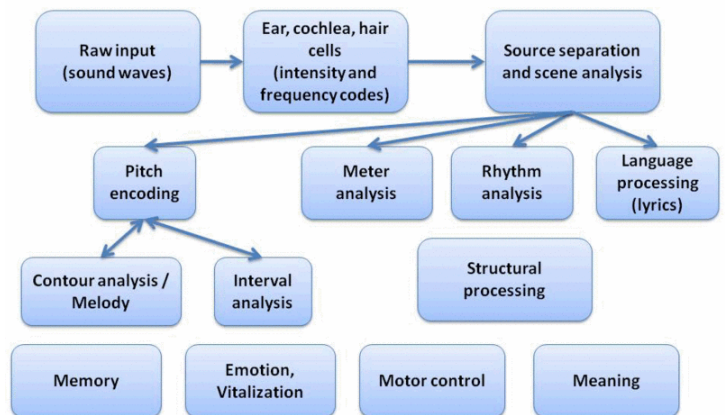


Figure 1: A modular framework to describe music perception in the human brain (CC 2008 Felipe Gerhard)

Pitch, contour or melodic shape, syntax and meter are some of the aspects to be analyzed [17]. Pitch is determined by its frequency and where specifically, it stimulates the basilar membrane along its length [16]. Since nerve fibres of the vestibulocochlear nerve cross over in the Medulla, information gleaned from both ears is processed on each side of the brain. Hyde and colleagues found, however, that the right secondary auditory cortex takes part in more fine pitch processing than the left. Furthermore, rhythm is processed in the left frontal and parietal cortex and right cerebellum predominantly [17]. The right auditory cortex also predominates in establishing tonality [18]. It must be remembered that music remains a multisensory experience, and hearing is only one of the sensory modalities in play. This bares particular importance when considering an integrated therapeutic approach with live music.

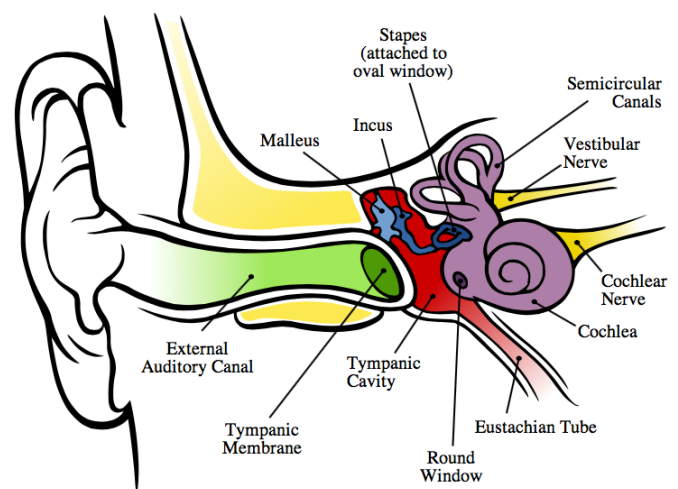


Figure 2: Anatomy of the Human Ear (CC 2009 Chittka L, Brockmann A)

The Targeted Impact of Music on Various Human Processes

As a safe, intervention, that may reduce the need for medications with high side-effect profiles, there is research supporting the impact of music on a diverse series of human biological events. These will be considered here categorically. All hold clear importance in an ICU setting as they impart a direct impact on patient prognosis.

Music and Vital Signs

Vital signs are the most fundamental of variables that could be measured in critical care patients. These include pulse, blood pressure, temperature, and heart rate. They are recorded observations that predict a patient's stability, and should be conducted on a regular basis. Adequate documentation of these parameters has been shown to improve all-cause mortality [19]. A Cochrane review of eight major studies has shown a significant impact of music in improving heart and respiratory rate in mechanically ventilated patients although no significant difference to blood pressure was noted and oxygen saturation did not appear to be affected at all [20].

In all cases but one, this did not require the use of a certified music therapist. Whether employing one along with the ability to situationally regulate tone, key, tempo and other musical parameters, might further increase these outcomes is yet to be established. It is perhaps telling of the nature of these studies that participants totaled only 213 in all eight combined, stressing the need for further research, with larger scale randomized control trials (RCT). This also limits the conclusions that can be drawn from the study particularly when considering blood pressure and oxygenation parameters, which could in fact prove dependent on music should a larger sample size be employed.

Maleki and colleagues found a significant difference between patients exposed to music with traumatic brain injury and those with no exposure. Beneficial effects on the physiological parameters were noted in the musical group leading to reduced blood pressure, pulse, respiratory rate and temperature with an increase in arterial oxygen concentration. This study recommends that hospitals put in place the means to play light music to patients [21]. It could be further extrapolated by increasing the sample size, which was small at 35 patients. The notion of musical preference would also have to be accounted for, as undesirable music may adversely affect patient recovery. Important further considerations currently not made, include patient satisfaction or indeed medical outcomes. There is also no reference to cost-effectiveness in any case [20].

Music and Metabolism

Metabolism, stemming from the Greek 'Metabole' meaning 'change' is a word for the many chemical processes occurring in the body [22]. Yamasaki summarized current research on

the impact of music on metabolism, learning that music can have positive effects on metabolic recovery from stress, but also gut and intestinal motility [23]. The latter bares great importance following gastrointestinal surgery, since complications such as obstruction leading to further surgery may ensue in the unlucky patient, and must be avoided in patients of critical status.

With regards to the stress response, mixed results are found regarding music's impact on hormonal metabolism. Trappe showed less of an elevation in cortisol when music is played, a hormone that rises in situations of physical or psychological stress [24], and a study of 40 patients under regional anaesthesia for spinal surgery also found significantly reduced cortisol when music was played [25]. Though released for immediate beneficial properties following a dramatic physiological incident, the negative flip-coin is that cortisol actually reduces immune defenses by prohibiting the production of interleukins and thus the proliferation of T cells. It also reduces the inflammatory response, and increases the catabolism of fat and protein. All these processes are detrimental to the recovering patient [16], thus any positive benefit conferred, particularly by a non-invasive, non-expensive and enjoyable intervention such as music, deserves further interest.

Nevertheless, a lack of consensus is illustrated in results of a RCT over 12 ICU's in the USA, which found no significant difference in cortisol with music exposure [26]. Two further studies considering how prior music listening could ameliorate physiological response to a stressor, also showed no reduction in cortisol, despite other physiological improvements [27,28]. In all cases however, live music was not employed, and although there was an element of patient choice from a preferred collection in the former RCT, the latter two studies used one researcher-selected piece (Miserere, Allegri, & Pachelbel's Cannon in D major) with little selection logic revealed. They were also limited by specific populations (women only in one, and undergraduate students in the other) and results may have differed had cortisol been measured during music exposure not proceeding it.

No studies as yet demonstrate the mechanism by which music might reduce cortisol, however Koelsch and his team did postulate three means:

1. Up regulation of the dopamine system in the brain, with corresponding changes to the way we perceive stress and pain.
2. Down regulation of the central nucleus of the amygdala, affecting our level of fear and worry, but also nuclei involved in generating the hypothalamus-pituitary-adrenal (HPA) or stress hormone axis.
3. Finally, the use of cognitive resources including attention, leading to a distraction process [25].

An additional attestation to music's metabolic impact is the reductive effects it has on lipids and lactic acid levels both

during and following exercise. A recent study has shown that listening to motivational music following exercise in 20 young men lead to increased voluntary activity in participants, and a statistically significant decrease in blood lactate levels [29]. This has been considered from a sporting perspective, however just as lactate levels rise in physical stress, so they rise in physiological stress inhibiting effective metabolic processes, and therefore it can be assumed that music will aid these parameters in acute medicine also.

Music and Pain Management

Pain has been reported as moderate to severe in the majority of patients on ICU [30,31]. Moreover, when inadequately managed it predisposes to many complications [30]. It is believed that because the experience of pain is partially subjective, by altering pain perception, one can alter the physical experience of pain. Music acts to achieve this by altering neurochemical processes in the brain, but also down-regulating the HPA axis leading to reduced production of stress hormones. Both these processes help to disrupt the feedback loop where pain causes stress, and stress in turn increases pain perception [32].

Often in intensive care, pain is managed by pharmacological means alone. Yet music could form part of a multi-modal pain management plan, and although it has little impact on acute pain stimuli, anxiolytic effects have been confirmed prior to, during and following surgery [33], as well as during invasive procedures and the domain of terminal care [34]. Trappe while discovering music's aforementioned ability to lower cortisol, also recorded a significantly greater relaxing effect preoperatively than midazolam [24] suggesting that music intervention may play an important role in decreasing medication use. A recent RCT containing 200 patients further supports its use in palliative medicine, showing a significant decrease in numeric pain rating scales [34].

Bernatsky and team found that music selected by the patient had more beneficial effects than music selected by others [32]. In an intensive care environment, ascertaining patient preference may not be possible, therefore it would seem of great importance to involve friends and relatives to determine a patient's musical inclination. Although both individual differences and degree of pain stimulus will rationally impact its effectiveness, Matsota et al conclude that music is still an inexpensive and readily available option for pain relief, free of adverse effects [33]. The conclusion that it can serve as a form of complementary pain management therefore seems important to recognize.

Music, Anxiety and Sleep Quality

Anxiety, alongside psychological upset including delirium, confusion, nightmares and hallucinations, contributes to a harrowing ICU experience [35]. Psychological well-being is further impacted by the poor quantity and quality of sleep evidenced in critical patients [36]. Despite this, few studies

focus on the patient experience on ICU [35]. A recent multicenter RCT employing patient-directed music tailored by a music therapist across 12 ICU's in the USA, found significantly reduced daily anxiety measures using a visual analogue scale, as compared to controls [37]. When considering that increased sedation has been shown to lengthen the mechanical ventilation period and hospital stay, whilst increasing the risk of renal failure, these findings merit further academic attention, and may provide an effective safe intervention that can be integrated into standard care.

Promising impact on sleep quality has also been attributed to music therapy. The association of music and sleep in the form of lullabies bears an established evidence base in the neonatal intensive care domain [38], however promising results are also seen in a 2012 RCT which reported improved nocturnal sleep, self-reported sleep quality, and reduced heart rate in ICU patients exposed to music [39]. Furthermore, a recent meta-analysis of 10 randomised trials with a total of 557 participants, found significant improvement in sleep quality in patients with acute and chronic sleep disorders [40]. This meta-analysis again only considers passive or pre-recorded music, thus highlighting an unmet need for a live musical therapeutic focus.

Music and Cardiovascular Health

When St Joseph's hospital in New York installed 'muzak' in their ICU, heart attacks were reduced, and the mortality rate fell to 8-12 percent below the national average [6]. A study at the Maryland University Medical Center measured blood vessel diameter in subjects under four parameters namely; Listening to recorded music that brought them joy, a further genre that made them anxious, a funny videotape and a relaxation recording. After due consideration, a number of further variables were controlled including avoidance of emotional desensitization by disallowing the group to listen to the piece for at least two weeks beforehand, and random allocation to the order in which each subject was exposed. Results showed a 26% increase in blood vessel diameter after listening to the joyful music, and a 6% average decrease after listening to the anxiety-inducing music. Like so many of its kind this study was limited in that it only utilized 10 participants, however the large statistical differences are never the less encouraging [41].

When considering the impact of recorded music on cardiovascular variables, Bernardi et al found reductions in blood pressure with increased skin vasodilation when listening to a uniform passage of music from a Bach Cantata. Conversely, progressive crescendos in Beethoven's 9th Symphony Adagio caused vasoconstriction and increasing blood pressure in direct correlation to musical phraseology. Phrases of two Verdi Arias also demonstrated entrainment of cardiovascular autonomic variables at around 10 seconds for participants [42]. These phenomena highlight the importance of music choice (incorporating phrasing, tempo and instrumentation) and adaptability to patient physiological

status when using music in a therapeutic sense. This adds weight to the use of live musical intervention which affords both individual and situational adaptability, and may further amplify these results.

Contrary to reason, but encouraging from a clinical perspective, no differences were found between the 12 musical and 12 non-musical participants studied. This study is not only limited once more by its sample size, but the limited use of 'choristers' as musical participants, whom may have a greater exposure and appreciation of classical music than other types of musicians, thus limiting generalisability.

Which Music Works Best and Who are we Targeting?

Florence Nightingale noted most particularly that voice and soft strings were beneficial to patient health⁶. A 2012 review found that classical and vocal music are the most likely to have beneficial cardiovascular and respiratory effects on the body, and thus have a practical application in intensive care medicine.¹⁶ Interestingly, Bach, Mozart and a number of Italian composers have the most reported strongly positive effects, and heavy metal was found to have an opposing effect, even proving harmful in some instances [24].

It is, however, important to account for individual differences, and also acknowledge varying approach needs to different target populations. The effects of music in geriatric patients in intensive care is quite profound. Music from youth leads to motivation, increased mood and vitality and is consequently important for patients with depressive symptoms [24]. A study considering elderly patients undergoing hip and knee surgery found reduced levels of confusion and pain, as well as improved ambulation in those that listened to music [43].

Music in neonatal ICU has long provided a focus for the application of live music therapy. A meta-analysis of nine randomized trials concludes there is a significant clinical benefit of music therapy in these patients, however it was noted that music was often combined with other interventions such as skin-to skin contact [44] perhaps complicating the isolation of cause and effect. Improved physiological variables are seen across the board. For example Chou et al found raised oxygen saturations in neonates receiving music therapy with endotracheal suctioning [45]. Caine noted positive impact on long-term variables including length of hospital stay, weight gain and stress behaviors [46].

Music's impact is not best restricted solely to patients. Perez-Cruz investigated relatives and healthcare workers' (HCW) preference at having background music in patient areas. A study was conducted using 99 patients, 101 relatives and 65 HCW's. On average 71% of all three groups had a preference for background music, with black ethnicity predicting a lower preference [47]. This shows that whilst music in public areas is a desirable notion, it is still limited to a small degree, by public preference for different music styles, which will vary between age, ethnicity and religious choice. Nevertheless, it has a promising application in aiding relatives

through the strange and difficult time of having a loved one on ICU.

Related Applications: Preceding and Following the Ward Experience.

The stress and anxiety reductive effects of music have also been considered beyond the acute ICU setting. A small 2009 study based on 23 patients exposed to recorded music during critical ambulance transit found opinions that music improved comfort and relaxation, but offered only a minimal reduction in anxiety. No statistically significant change in vital signs was documented, however conclusions cannot be drawn from a study with such a small sample size, and patient opinion alone detects this as an area of further consideration and research [48].

There is evidence that the patient ICU experience can be complicated by post traumatic stress, anxiety and depressive symptoms.⁴⁹ This highlights the importance of a supportive network around the discharged patient, where musical therapeutics may prove a promising intervention. Holm et al (2012) considered the use of music in occasions of less favorable outcome, ascertaining positive feedback from nursing staff regarding the use of ambient music in after death care on ICU. They postulate that music played during the preparation of the body promoted peace, respect and dignity, and that music played during the viewing might aid the grieving process for relatives. They did however find that the use of music was situational. For example it was sometimes inappropriate after a frantic resuscitation attempt, and the importance of choice for both family and healthcare staff was noted [50].

Conclusion

Research evidence considering the impact of music on health and body physiology is promising. Though many original studies have sample sizes, there is statistical evidence that music, particularly live music, impacts the body's metabolism, cardiovascular, respiratory and gastrointestinal health amongst other processes. It seems sensible to introduce such an intervention into a healthcare setting, especially when such a diverse range of positive effects can be seen with little in the way of side effects. Currently most music under consideration is prerecorded [12], and stronger results might be obtained by employing the use of certified music therapists in the ICU, where musical interaction can be tailored to both the patient and sensitive surroundings. Current knowledge needs to be confirmed with larger scale RCTs, but should consider also the practicalities of implementing musical therapeutics in hospitals. Investigation of the scientific processes instigating these observed physiological changes could then be considered, as well as the global impact on patient outcomes both short and long-term.

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