The Effect of Music on the Production of Neurotransmitters, Hormones, Cytokines, and Peptides: A Review

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Abstract
Research on the effects of music exposure on the release of biochemical messengers is an expanding field. The importance of understanding the influence of music on messenger production is a means of explaining behavioral reactions through physiological mechanisms. Signaling molecules that prove integral for important regulatory functions include neurotransmitters, hormones, cytokines, and peptides. Thus music elicits responses promoting positive emotions, alleviation of stress, and immune function. Study of the production of the messengers reveals the connection between the mind and the body. The purpose of the review is to provide a closer look into the effectual relationship between music and production of these messengers by providing literature and analysis.

Keywords
cytokines, hormones, music medicine, neurotransmitters, peptides

Music is widely regarded as a means of enjoyment and entertainment. However, music has also been used toward improving the well-being of patients. While the brain interprets music, successive biochemical reactions are induced within the body. Evidence indicates that music plays a role in activating pleasure-seeking areas of the brain that become stimulated by food, sex, and drugs.

Most research on the biological effects of music has revolved around studies involving brain mapping and physiological parameters such as heart rate and blood pressure, venturing to explain the cognitive processes behind music appreciation, stress relief, and manifestations of emotions. In all the reviewed studies, pathways for translation of music inception in the brain to changes in production of signaling molecules have been hypothesized to explain the mechanisms. Through production of messengers such as hormones, neurotransmitters, cytokines, and proteins, music elicits biological responses to stress, emotion, and immune function.

The messengers within the body range from simple to complex molecules that provide functions crucial to survival. Hormones certainly prove necessary for proper physiological growth and development. Neurotransmitters are messengers that regulate the activation or inhibition of neurons. Cytokines are imperative toward maintenance of immune function and growth. Proteins, such as antibodies, have many diverse roles ranging from cell composition to tissue integrity.

The cited literature state the case for music as a stimulator or inhibitor of messenger pathways in the body. To the author’s knowledge, no review or summary on the effect of music on production of all 4 aforementioned messengers has been attempted thus far. I will first incorporate important findings relating music to messenger production. I follow with a presentation of the remaining objectives to be accomplished in this field of research.

Music represents a noninvasive approach as opposed to treatments such as hormone or cytokine therapies and medications. Further research on the effects of music may reveal the precise functions of biochemical messengers. Today, an emphasis has been placed on pharmacological substances to serve as remedies for pain or hyperactivity when music provides the simplest solution as an easily accessible form without any known debilitating effects. For example, nicotine in cigarettes stimulates production of dopamine, a neurotransmitter involved in providing pleasure.

Music also has similar effects on the dopaminergic pathway. As a result, music may pose as an effective substitute for other supplements to help addicts quit smoking.

Music characterized by genres and musical elements evoke distinct patterns of messenger production. Music of Johann Strauss caused rises in atrial filling fraction and atrial natriuretic peptide and falls in cortisol and tissue-type plasminogen

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activator (t-PA). Prolactin, cortisol, noradrenaline, and t-PA concentrations decreased after listening to the music of H. W. Henze. Ravi Shankar’s music resulted in lowered concentrations of cortisol, noradrenaline, and t-PA. Listening to techno music was found to alter levels of β-endorphin, adrenocorticotropic hormone (ACTH), norepinephrine, growth hormone, prolactin, and cortisol in healthy people. Critically ill patients who listened to Mozart’s slow piano sonatas had increased growth hormone and decreased interleukin (IL) 6 levels. Appreciation of a mixed selection of rock music increased and intensity of music but decreased adrenaline. The effects of major and minor modes and intensity of music on cortisol production have also been studied.

Different methods of measuring the concentrations were implemented. Almost all the studies mentioned involve blood drawn from the participants and tested for cytokines, Igs, hormones, and neurotransmitters by immunosassays, such as radioimmunosassays and enzyme-linked immunosorbent assays (ELISA) to determine the concentrations. Dopamine levels were measured by observing fluorescence intensities with a brain-mapping analyzer. High-pressure liquid chromatography (HPLC) was used to measure norepinephrine and epinephrine.

In some studies, participants were administered music to assess the possible relationship of perception and levels of particular messengers. Platelet serotonin is lower in participants exposed to unpleasant music than those who listened to pleasant music. Cortisol, IL-1β, and IL-10 levels did not change in those listening to preferred music but changed in those exposed to relaxing music. Both morphine and IL-6 decreased in patients exposed to preferred music, leading to lower blood pressure.

The clinical area has displayed promising effects of music in battling specific conditions. Music decreases plasma concentrations of cortisol, epinephrine, and t-PA in patients exposed to regional anesthesia. Music also is known to aid in fighting cerebrovascular disease by activation of parasympathetic nervous system, lowering concentrations of IL-6, tumor necrosis factor (TNF), adrenaline, and noradrenaline. Adrenocorticotropic hormone, cortisol, adrenaline, and noradrenaline also have been measured before and after gastroscopy. Biochemical messenger production has been found influential in providing a calming effect in elderly patients with Alzheimer dementia.

Music has proven effective in improving the immune function. Decreased corticosteroid production correlates with the effect of music on immunity. Rises in concentrations of salivary IgA and IL-1β are associated with falls in salivary and plasma cortisol levels, respectively. In regard to countering the harmful effects of stress on immunity, music has even proven to be as helpful as pharmacological treatments, such as benzodiazepines and 5 hydroxytryptamine (HT) agonists. There is also evidence that music may lead to production of hormones and neurotransmitters that participate in T cell proliferation and antitumor signaling.

Explanations for certain phenomena, such as learning, have become possible with knowledge of the effect of music on the production of messengers. For example, music influences production of steroids including cortisol, testosterone, and estrogen as well as their receptor proteins, leading to neurogenesis and improvements in learning in the brain. Music may regulate the production of neurotrophins in the hypothalamus, causing reduction in stress and improved learning as well.

Not all studies concerned have produced results indicating correlations between psychological and physiological outcomes. Although patients felt less anxious after listening to music, they revealed no differences in concentrations of norepinephrine, epinephrine, cortisol, or ACTH. Some results have been found to conflict with each other. Music therapy increased adrenaline in one study but decreased adrenaline in another, a result of the fact that music therapy protocols vary from one administrator to another.

Further research is needed to explain with more specificity the relationship between the psychological and physiological manifestations of music. It has long been considered that physiology affects psychology in a unidirectional manner. However, some evidence indicates otherwise as oxytocin production is increased by listening to music. Thus, psychological mechanisms influence physiological processes. More studies are needed to clarify such cause and effect relationships.

Most studies simply observed the direct involvement of music on messenger production by allowing participants to listen to music before measuring changes in concentrations. However, some studies combined both music and treatment with a substance in order to examine the effect of the substance which was either accentuated or reversed by music or vice versa. For example, thrills in listeners are intensified by the opiate receptor antagonist, naloxone hydrochloride. The thrills of music could thus be linked to endogenous opioids. However, other studies state that music decreases stress-induced hormones, such as β-endorphin and ACTH. It is important to note the areas sampled for the messengers. Goldstein measured central opioid activity as opposed to Halpaap et al who measured peripheral concentrations of β-endorphin.

While the studies exhibit promise toward the effects of music on messenger production for developing improved medical care, certain issues remain for further consideration. Most experiments have focused attention on particular types of music and have included neither large sample sizes nor wide ranges of musical diversity as variables. Thus far, studies have selected musical pieces for participants based on certain musical elements such as rhythm, tempo, and tonality but must not ignore basic qualifications such as instrumental versus vocal melodies and ethnic diversities.

Few studies were found to have compared profiles of messenger production of musically educated and untrained participants. Active participation in producing music increased natural killer (NK) cell activity and changed gene expressions for interferon-γ and IL-10. However, the participants were merely motivated by a trained mentor to play percussion instruments rather than to perform independently with musical knowledge. Musical ability has been found to influence the production of hormones.
listening to music have been compared with respect to production of IgA and cortisol.\textsuperscript{45}

Exploring the exact functions of cytokines, neurotransmitters, hormones, peptides, and other messengers requires further research. While exposure to music may reveal such functions through trends in messenger production, they are not by any means causative. Complexity is apparent when discussing the aggregative effects of the messengers. A trend in the production of a particular messenger may be offset or amplified by the potency of another messenger. Thus, pathways of messenger production prove crucial to understanding the connections between the mind and the body. One study has shown that music may balance messenger levels by increasing and decreasing steroids in those with low and high hormone levels, respectively.\textsuperscript{46} Further research on the link between messenger outputs and physiological homeostasis remains to be determined.\textsuperscript{47}

Learning about specific messenger changes as a result of listening to and processing music proves promising toward elucidating therapeutic benefits. This article seeks to place emphasis on a field believed to have real biological implications that may become even more relevant in the clinical realm in the future. Neurotransmitters, hormones, cytokines, and peptides provide a more quantitative means of comparison for music studies. They represent the direct link between music interpretation and physiological reactions. Further research may encourage development of better pharmacological drugs to combat problems with lesser side effects or to pave the way for newer treatments. All the literature reviewed for the effects of music on biochemical messenger responses do not contain recordings or any other type of specific musical content. The titles and composers of the music were provided in the articles as they can be readily accessed through the Internet. Thus, the relationships between the specific types of music and their effects on the levels of biochemical messengers serve as a foundation for further understanding the role of music in physiological mechanisms.

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