Sensogenomics and the Biological Background Underlying Musical Stimuli

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The impact of musical stimulus in the human genome opens a new era of research. We hereby introduce and develop the term *Sensogenomics*, referring to the still unexplored field of research focused on the response of our genome to sensorial stimuli.

gene expression | sensogenomics | musical stimuli | next generation sequencing | parallel sequencing | transcriptomics | genomics

1. Background

The impact of music in human beings provokes inner feelings, triggers the reward system and, more than that, listening to music impacts our neurobiology. The existence of musical instruments >60,000 years ago (suggesting ancestral biological coevolution of music and humans) and the uniqueness of our human interest in music from the early days of life suggests the existence of a biological background (most likely connected with gene variation and gene expression) triggered by musical stimuli.

The evidence for music as a powerful stimulus for health can be found in early history from preliterate cultures, early civilizations (Mesopotamia, Egypt, Israel), Greek Antiquity, Middle Ages to Baroque.[1] Distant disciplines as philosophy, aesthetics or musicology have released arguments to reveal the power of music. For example, the Greek philosopher Aristides Quintilianus defended the power of music by establishing a system that links numbers and the cosmos[2]. And, the theories about Ethos in the Pythagorean and Platonic tradition represent the power that a sound can exert on the human being, attributing to specific musical instruments, rhythms and especially musical scales (modes) the power to modulate our mood and even our own moral. Throughout the Baroque period, the “Doctrine of affections” governed musical composition through the musical elements of intervals, key, and tempo because music is capable of arousing affections within the listener to produce an intended emotional response.

Nowadays, in the field of neurosciences, there is a growing interest in studying the impact of music in our brain, to explore the functioning of the brain itself, arguing that playing, listening to, and creating music involve practically every cognitive function[3]. This discipline has focused its advances in how music activates and interconnects brain areas, developing brain plasticity. Other studies have explored the influence of environmental-cultural and biological factors on musical perception, as well as the conditioning of musical training on the brain responses to music.

In addition, the field of psychophysiology has studied the biological role of music and its therapeutic role in diseases and disorders, such as autism spectrum disorder, Alzheimer, motor rehabilitation, Parkinson, or epilepsy. More generally, researchers have studied the impact of music related to neural bases of emotions, as a trigger of changes in heart rate, respiration, blood pressure, skin temperature and conductivity, muscle tension and biochemical responses, its impact in the reduction of stress, or in the immune system.

At the same time, advances in the field of health and in our understanding of the biological bases of the physical (phenotypic) human characteristics are progressing at an extraordinary rate. To a large extent, this is due to the enormous development that genomics (and the "-omic" sciences, in general) and molecular technologies are undergoing, as well as the important cost reduction that these techniques have experienced in the last few years. As such, progress has been made in understanding the genetic basis of a good number of common diseases (Parkinson's, Alzheimer's, schizophrenia, cancer, etc.) but also in our appreciation of the biological bases of human behavior or the ability of people to acquire knowledge. As a result of this research, a large number of genes, many involved in various neurobiological pathways, have been described.

Even so, genetics have contributed only very discretely to the understanding of the biological bases of music; the genetic architecture underlying music-related skills is largely unknown, remaining a field that is still in its infancy [4][5]. Only a few studies have been devoted to the analysis of gene expression regarding musical stimuli (transcriptomics) and other related areas (e.g. epigenomics). The arrival of new genotyping and sequencing genomic technologies provides us with great opportunities to further investigate this field.

In our recent contribution to *Genes* we introduce the term *Sensogenomics* to refer to a new era of research aimed at exploring the response of the genome to sensorial input. This concept is presented firstly in reference to music, as one such powerful stimulus.

2. Recent precedents: Music and gene expression

The study of the impact of music in gene expression remains an under-research area. Only a few studies have investigated the effect of music on the transcriptome. Kanduri et al. [6] explored the effects of music listening on the public transcriptome after a 20-min classical music concert of Mozart's Violin Concerto No. 3 in G major. The same experimental concert served to study the effects of music-listening on gene regulation by sequencing microRNAs of the audience [7]. In another similar experimental design aimed at studying the transcriptional response to musical performance, Kanduri et al. [8] analyzed the response of professional musicians after playing music. These authors investigated the transcriptional responses in peripheral blood samples after a 2-hour concert performance and after a 'music-free' control session. This group also analyzed the performance of professional musicians, with a special focus on how classical music affects their microRNA expression after two hours playing music[9] investigating a putative gene regulatory network representing the molecular mechanisms underlying music performance in professional musicians. The pioneering study by Bittman et al. [10] analyzed the expression of a few immune response-related genes using qRT-PCR, their results showed that recreational music-making has the ability to modulate human stress responses. Additionally, Qu et al.[11] carried out a gene expression analysis collecting peripheral blood samples before and after being exposed to a 60 min session of classical or relaxing jazz music; however, the main goal of this study was to analyze the results of a comprehensive yoga program, with music listening as a control activity.

All these findings are of interest to advance on the potential use of music as a therapy. Despite the limitations of these pioneering studies (in regard to statistical power and their ecological validity), the genetic response to musical stimuli appears to be a promising research field.

3. Near Future: Sensogenomics

With the arrival of parallel sequencing techniques and the relatively young '-omic' era, more effort should be devoted to the biogenetic study of the ways music can impact the expression of our genome, in a new discipline we propose to call sensogenomics. A retrospective look at the literature indicates that the new techniques have hardly been used in the study of musical skills; the advent of molecular genetics holds much promise for this relatively underexplored field. We contend that the empirical studies of gene expression, under well-controlled experimental conditions with statistical power, might help to understand the role of music in human biology and different pathological conditions.

> *It is necessary to understand why a madrigal by Gesualdo or a Bach Passion, a sitar melody from India or a song from Africa […] may be profoundly necessary for human survival, quite apart from any merit they may have as examples of creativity and technical progress*.
>
> John Blacking, ethnomusicologist (12)

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