

The Science of Sound and its Quantitative Applications

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Abstract Over 2500 years ago, Pythagoras laid down his "Harmony of Spheres" theory. This pervasively ambitious theory cites that all life on Earth is governed by the unique pitches of celestial bodies, beyond the range of the human ear. Simply stated, all the planets and stars in the Silar system move according to rigid mathematical equations, which in turn correspond to musical notes and produce a symphony. The Sun, Moon and planets all possess a unique frequency. The ratios of these frequencies correspond to musical intervals. These are further noticed in the placement of organs within the human body, shells, pinecones, even spiral galaxies. Hence, consonance and dissonance of music intervals manifest themselves in varying proportions through the intonations of the world around us. Music intervals demonstrate a stark similarity to the harmonic orbital resonance exhibited in planetary elements and can find multiple applications in the medical and astronomical field.

Keywords – Harmony, Orbital Resonance, Music Theory, Signal Processing.

I. INTRODUCTION

This article attempts to decipher the prevalence of mathematical 3 concepts in musical systems across varying cultures.

Johanned Kepler studied the presence of physical harmonies in planetary motion. He discovered that the maximum angular speed of any planet minus its minimum angular speed in its orbit provides an approximate harmonic proportion. For example, the maximum angular speed of the Earth with respect to the Sun varies by a semitone (with a ratio of 16:15), from an E to an F in Western Classical or Ga to Ma in Hindustani or Carnatic, between the aphelion and the perihelion. Venus only varies by an interval of 25:24; called a diesis in musical terms. Pythagoras, who is attributed with designing the twelve-tone temperament system of music, designated the distance between the Earth and the Moon as a whole tone, that between the Moon and Mercury as a semitone, and so on. The seven tones he discovered thus produced the so-called diapason, i.e. a universal harmony. The Pythagorean tuning system is built on the basis of the notes in a perfect fifth interval being in a ratio of 3:2; considered to be the most stable sounding interval in music.

By performing the logarithmic evaluation of this ratio, the harmonic progression can provide numeric details of this musical system.

In $3/2 = 1/1 + (1/(1+1/(1+3/2))) = 7/12; 7$ being the total number of notes in a scale and 12 being the total number of notes in an octave.

According to the Hindu mythology, the origin of life in the universe began with the sound 'Aum'. The sound Aum

consists of three letters, namely (A), (U), and (M) denoting Vishnu, Maheswara and Brahma respectively. If Aum in fact depicts traits of onomatopoeia, then its performance has the potential to stimulate a reaction within the nervous system. In a study performing time-frequency analysis on the speech signal of an individual chanting "OM", an enhanced steadiness was observed. [1]

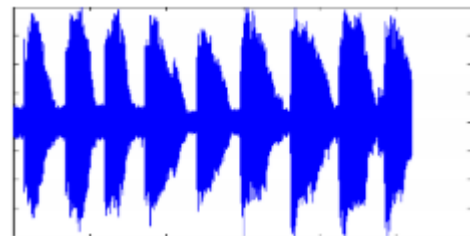


Fig.1. Initial chanting of "OM".

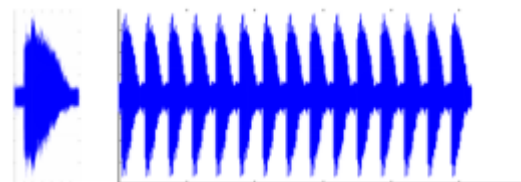


Fig.2. Chanting of "OM" after a few days.

The symbolic representations of certain sounds, however, can differ from one person to another. Like any tool, the consequences of each sound is dependent on the user operating them and the object of use; namely the condition of the mind and body. Silent repetition of mantras may also prove to have a resounding effect; when the frequency of any sound is high enough, it traverse an array of frequencies beyond the human range of hearing

and eventually achieves stillness, a state of settlement of soundwaves which is beyond sound itself. It has been demonstrated in a double-blind study that ultrasound probes applied to the skull can improve the subjective mood of a person. It has been evidenced that even imagining performing musical exercises rewires and strengthens nerve connections. Both of these studies speak to the capacity of mental recitation of mantra to activate and affect the physical nervous system. Moreover, group chanting or recitation of mantra can synchronize the brainwaves between the participants, achieving yet another level of collective effect, as has been shown between musicians, which can help to understand the functional basis for group chanting in many of the world's wisdom traditions.

As Johann Wolfgang von Goethe said and I quote: "Architecture is frozen music." There are multiple instances of the Sanskrit language being used to encrypt certain geometric patterns of nature, as well as sonic representations of the way nature works. Gathering data from supreme stillness or the absence of vibrations and subtle ultrasonic vibrations, these latent forms can cascade into being an audible sound, which then has the capacity to form or shape reality, as has been demonstrated by cymatics.

Throughout the history of human evolution, the auditory faculty has evolved to process a set of unchanging characteristics in nature, which possess the ability to make up the core syntax of auditory perception. These are the bite-sized pieces of sound information that the brain has evolved to process and of which to make sense. Through our sense of hearing the brain detects certain forms in space, not unlike the phenomenon of echolocation in bats, which is carried out by recognizing the sounds of interactions among solid-object physical events. Certain forms of speech, and even music as an organized narrative of sounds, makes use of our brain's evolved capacity to perceive natural sounds.

Some ancient languages other than Sanskrit have also honed layered systems of onomatopoeia, such as the Tibetans, prototypical Egyptians and the ancient Hebrews. By using complex mathematical formulae to visualise different soundscapes from circles to polyhedrons, these cultures have formulated sounds with frequencies that can evoke movements of stimulated energy. This evocation is both qualitative and subjective. It is also linked with interoception (inner body sensations) and possesses an emotional sense of self, both predominantly represented in the right hemisphere of the brain. On the other hand, the narrative strand of sounds in which we give them meaning is done predominantly through the left hemisphere. What is deeply fascinating about these chants is that from a purely scientific standpoint, the sounds themselves, before they are assigned any meaning, have been found to resonate in different parts of the body and

mind, creating a synthesis of certain interactions or events. Much like the emotive quality of immersing oneself in music, frequencies can be employed to evoke movement of physical and emotional energy through stimulation of the nervous system, from which emerges meaning and narrative.

Below are a few applications of harnessing the data obtained from studying tonal systems in the domain of harmonic resonance:

1. Trappist-1 System

The planetary system commonly known as Trappist-1 was observed by Spitzer for a period of 500 almost-unbroken hours in 2016 [3]. During that period, seven planets—astronomically named b, c, d, e, f, g, h—as they orbited a distant star were observed. From Spitzer's perspective, the planets could be detected as they transited across the front of the star, periodically blocking a tiny bit of the star's light. Tim Pile from the California Institute of Technology composed the music based on the timing of these transits. Each of the seven planet transits was accompanied by a music note of the same name. A "b" note was played when planet b transited, a "c" note for planet c, all the way up to g. Since there is no "h" note in music, an "a" was played for planet h, which only transited a single time during Spitzer's observations.

What resulted was a one-minute tune that was surprisingly melodic. After adding some simple background instruments and a drum track, the final composition sounds as if the TRAPPIST-1 system was born to create music.

This is not the first time someone has produced music from astronomical data. The existence of orbital resonances in the solar system has been known for a long time.

2. Automated Sound Check System based on Harmonic Orbital Resonance

In a real-time sound check system, feedback is obtained on account of a zero frequency gain being created in a loop in the frequency domain. By detecting the frequency of the zero gain feedback loops and feeding the corresponding third and fifth harmonic resonant frequencies to the PA system, the feedback can be detected and terminated with higher efficiency. After obtaining a uniformly sampled data, the velocity of each sound wave can be observed.

3. Brain Tumour Detection using Chromatic Frequency Patterns

Certain neural activity centers in the brain can be stimulated by improvisational music patterns often seen in jazz music. As studied in a functional MRI scan, the brain can register these frequencies even in an unconscious state and respond accordingly. These changes in prefrontal activity during improvisation were accompanied by widespread activation of neocortical sensorimotor areas (that mediate the organization and

execution of musical performance) as well as deactivation of limbic structures (that regulate motivation and emotional tone). This distributed neural pattern may provide a cognitive context that enables the emergence of spontaneous creative activity.

What I understand of what happens in our ears, is that sound forms vibration patterns on the membrane inside our cochleae. Since music isn't a pure tone, it produces interference patterns on the membrane.

If these frequencies in the music are very close to each other or fall within a narrow bandwidth, they form patterns that are perceived as dissonant. If the component frequencies are in some regular ratio or "harmonics" then their corresponding interference is perceived as consonant.

Now how our brains have grown to associate these emotions with these sounds, is a matter of evolution and adaptation.

Regarding ultrasound diagnosis of tumour presence, music lies in the audible range so it can't be directly used for that modality of diagnosis.

Usually for detection, high intensity sound that's out of the auditory range is used.

IV. CONCLUSION

The MIT researcher, Josh McDermott worked with 64 Tsimané villagers, asking them to rate the synthetic tones and recorded notes, all played through headphones. When he did the same for US citizens, they preferred evenly spaced chords over dissonant ones. Sounds appealing to them might be quite different and if music were to be written for them that would perhaps require formulations of scales or chords that are dissonant. However it is too soon to arrive at that conclusion. Them calling out higher note for what it is. Is not that big of a surprise as much as their liking for the dissonant notes. They have relative pitch which means their understanding of semitone intervals are the same as ours. But if they had more than 12 notes in their octave like we do, not only would the ratios of their octaves be different but they may also possess a deeper soundscape.

They were right from a pitch-position perspective. But that presents a paradox in the frequency domain. Treat the musical scale as a set of frequencies. These frequencies each have a set of harmonics that are integral ratios of the frequency itself. However in practice, not all these harmonics are integral ratios of the frequencies.

When the supposed "God" particle passed through the Higgs's field, its speed reduced. Everyone is familiar with the equation $E=mc^2$. Which is why the mass of this particle increased, and that created Hydrogen.

Two hydrogen particles combined to give Helium. That's how everything came about. Now we don't know much about the Higgs Field. But it has been mathematically proven that sound waves have mass. The only thing we know that converts energy to mass is Higgs Field.

Which means there must be some very interesting ways that sound waves are interacting with the Higgs Field.

In the beginning there was just energy. Photons were the only particles that could pass through the Higgs Field undetected. We know so far that sound waves don't react with gravitational, magnetic or electric fields. What if there really was a fundamental frequency which was being split into multiple frequencies by the Higgs Field?

So did city-dwellers from La Paz and residents of a rural Bolivia town, albeit to a weaker extent. But the Tsimané didn't care. A few years later, McDermott's team repeated the study with a different group of 50 villagers, this time playing them pitch-shifted recordings of their singing peers. Again: no preference. This goes to show that the twelve-tone temperament scale may not be the optimal mode of tuning. The circle of fifths has been developed on a limited set of frequencies following which several microtonal systems such as the 313 tonal system and the 42-tone Arabic system have resulted in vastly different soundscapes. Taking 8/7, the ratio of the seventh frequency interval as the basis of a tonal system, we can apply Pythagoras' logarithmic evaluation as follows:

$\ln 8/7 = 1/(1+1/8/7)$ which settles the ratio at 7/22, an approximate inversion of the number pi. The circle of sevenths is a harmonic reflection of the more widely attested circle of fifths, with the orbital extremes matching and the diagonals staying immutable.

A 22 tone scale would form a perfect circle, because there are anyway seven notes in a scale. With 22 semitones, you'll actually get a 22/7 ratio for each adjacent pitch. The perfect fifth, 3:2 ratio fits this model.

To try out the infrasonic harmonies, one must add the harmonics of the natural frequencies of each planet.

If we add up the harmonics in some subset of the current equal temperament scale, we can obtain the fundamental frequency of the universe. And if you add all the individual frequency signals of the Solar System and filter the harmonics, you get the frequency of the universe at 432Hz.

The frequencies of the other planets are below 20 Hz, so they won't be audible. However, we know that these notes will repeat themselves at double the original frequency, so we can figure out their pitch by theoretically extending the keyboard.

One way of proceeding is to construct a transformation mapping between different tuning systems and then look at its properties. Earth, maybe. It is because of the vacuum for the other planets.

Pythagorean tuning defines the optimum ratios and intervals, but the fundamental frequency can be anything, which is why you have multiple tuning systems. [4] The Schumann frequency solidifies how the earth and out body is tuned to 7.83 Hz. But because of external

harmonics from Wifi, telecom etc these frequency signals are distorted and that's one of the reasons why city folk are way more stressed out than people closer to nature. There is a lot of interesting math being done by our ear as well. But the boundary condition is our hearing range, 20 Hz to 20kHz. So we can't hear the frequencies of any of the planets. We know the octave ratios and define their specific pitches, so we can say the frequency of earth is Csharp. But it will be something else in a different tuning system. The standardization is not universal.

You know when the equal temperament system first came about, it focused more on lower basser notes because we had instruments like the organ. Then around the seventeenth century, more emphasis was given to instrumental work like woodwinds and operas. So instrument manufacturers would compete by a process called pitch inflation. This got so extreme that singers started complaining of throat burns and violin players snapped their strings. Around the same time, the international board of standardization hosted a conference where it was settled that the current equal temperament system would be maintained. But there is nothing to prove it is the optimum system. It is just the most widely used system.

No single note in the musical scale sounds harmonious with all other scales. There will always be at least one dissonant sounding pair of notes, usually in the ratio 8:9 or 2:3. Adjacent notes basically.

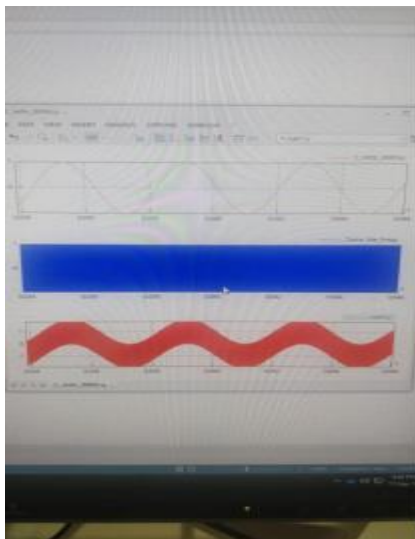


Fig .3. Mapping of soundwaves.

The notes are numbered from 1-8. But there has to be a frequency that resonates with all the twelve other notes. We can find this using the Chi square algorithm or probability density function. The one that sounds harmonious with all possible pairs of notes in our twelve pitch scale. If we can find this frequency, noise all over the world is eliminated.

You can see only amplitude increases frequency remains the same:

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