The Effect of Geometric Sound on Physical Matter, Brain Waves and Well-Being

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ABSTRACT:

This study introduces Geometric Sound as a subfield of Spatial Sound by presenting auditory stimuli that are mathematically defined 3D geometric sound projections representing a geometric object. The study proposes a new and non-invasive method for the treatment of various illnesses of both physical and psychological characteristics, with emphasis on stress related conditions and neurological impairments. The effects of Geometric Sound projections on Faraday waves propagation, brain waves, physiological measurements and emotional well-being have been investigated. Identical sound frequencies projected in different geometric shapes were found to result in correlating Faraday waves patterns to the geometric sound projection. Geometric Sound was found to significantly affect brain waves topology, power amplitude and connectivity patterns compared to recorded baseline of participants where no sound was presented and standard stereo (control). Geometric Sound was found to improve sense of relaxation according to behavioral response and as measured by heart rate and blood pressure. Therefore, Geometric Sound may be used as a tool for treatment of various illnesses and disabilities such as depression, anxiety, stress related dysfunctionalities and neurotrauma impairments.

INTRODUCTION:

Geometric Sound (GS) incorporates mathematics and geometry to create an entrained feedback loop of natural systems using instruments and frequencies known from sound medicine to inflict a coherent balance on vital physiological systems. In order to base and verify this hypothesis on objective scientifically founded measures a line of preliminary exploratory experiments was conducted between the years 2017-2018, monitoring brain waves activity using electroencephalogram (EEG), heart rate (HR), blood pressure and behavioral response. A preliminary experiment in 2017 monitored 20 healthy young adults for their response to GS. Multiple physiological parameters such as EEG, heart rate, blood pressure and behavioral response were recorded. Results of the Autonomic Nervous System (ANS) were consistent with behavioral reports of enhanced relaxation and focus. In addition, interesting indications were shown to occur in the Alpha range. Following these results a second experiment was conducted in 2018 monitoring 30 young adults, utilizing an additional GS shape in order to verify the initial findings. The motivation for the second experiment was to verify the EEG results, study brain waves connectivity patterns as well as test additional GS shapes on a larger group. This experiment focused on behavioral

response and EEG recordings. In addition to the first study, EEG was further analyzed for topographical power amplitude changes in power and connectivity patterns. The study originated from an artistic-scientific project titled The Sound Is The Scenery (TSITS) which investigated the connection between sound, geometry and mathematics with healing and well-being by placing people inside geometric structures of spatial sound and light⁽¹⁾.

This study is interdisciplinary by nature and draws inspiration and information from various methodologies and fields. It is rooted in sound via sound medicine and advanced spatial sound technology, incorporates mathematics, mainly focusing on geometry, and is inherently related to biology and neuroscience. Following is a short background introduction to the different fields informing this study.

Spatial Sound and Advanced Sound Technology:

Spatial Sound is an emerging immersive technology enabling precise sound localization and movement notation that facilitates enhanced multi-directional sound experience and projection of audio holograms, providing a 360-degree field sonic experience. In the field of spatial sound 4DSOUND⁽²⁾ is a leading technology integrating hardware and software systems to provide fully omnidirectional sound environments which enable vivid sonic experience of sound, as well as advanced sound conception and computation. The effect of immersion provided by spatial sound systems exceeds the commonly known experience of listening, as it allows the entire body to be enclosed by directed sound vibrations. Notably, unlike the common perception of sound as a 2D waveform medium, it is in fact a spatial medium, spherical by shape and ever expanding⁽³⁾. Its spherical form contains a multiplicity of waves and their equivalent particle trajectories which generate toroidal energetic flow within each sonically-excited molecule. The holographic nature of sound became evident through experiments and measurements conducted with the Cymascope instrument⁽⁴⁾. The Cymascope instrument makes sound visible by transforming audio input periodicities to water wavelet periodicities, the latter known as Faraday Waves or cymatic phenomena.

Geometry and Mathematics as a Form of Natural Coherency with Fundamental Relation to Sound:

Geometric structures and numeric sequences appear in nature as functional energy distribution frameworks. Examples include Fibonacci sequence at the basis of nucleotide frequencies of appearance in human genome⁽⁵⁾, the geometric basis of atomic structure of chemical elements⁽⁶⁾, relation between prime numbers and atomic structure in crystal-like materials⁽⁷⁾, toroidal coupling of phonon, photon and electron information to mediate physical and emotional biological processes⁽⁸⁾ and crystallization processes⁽⁹⁾. Research suggests that water crystals tend to form in a hexagonal form when exposed to coherent stimuli as opposed to a chaotic structure when exposed to incoherent stimuli^(10,11). Mathematical sequences such as the Fibonacci sequence are widely present in growth algorithms in nature and harmonic ratios and are maintained in general natural phenomena⁽¹²⁾, for example various flora constants⁽¹³⁾, limbic and facial symmetries and constructions⁽¹⁴⁾. It is assumed by researchers that growth and alignment patterns in this sequence adheres strength and efficiency⁽¹³⁻¹⁵⁾. The “Golden Ratio”, or Phi, which is easily derived from Fibonacci numbers and Fibonacci like sequences is closely related to construction of geometry⁽¹⁶⁾ fractal geometry, coherent and cohesive energy distribution and symmetry, and was found to exist at the quantum level in magnetic resonance of atoms⁽¹⁷⁾. These mathematical constants allow similar geometric patterns to

repeat on all scales in nature, for example pentagonal and hexagonal structures ranging from DNA molecule binding^(18,19) to planetary trajectories⁽²⁰⁾.

Sound is inherently related to geometry and mathematics at the core of its existence with ordered symmetry of standing waves and their related mathematical ratios. Similar ratio patterns as those in the harmonic ratios of an octave have been found in various natural phenomena, such as the periodic table^(21,6), planetary relations⁽²²⁾, colors⁽²³⁾ and brain waves⁽²⁴⁾. An important example of how coherency is expressed in a geometric manner in nature is the propagation of sound waves, known as Chladni figures in its 2D expression⁽²⁵⁾, and Faraday Waves or Cymatics in its 3D expression⁽²⁶⁻²⁸⁾. Matter excited by sound frequencies can be visualized by vibrational patterns in the form of symmetrical geometries. The patterns are known to be determined primarily by frequency, amplitude and boundary condition of the observed medium⁽²⁹⁾. This phenomenon demonstrates the harmonic overlaying of sound frequencies and their relation to geometry and mathematics. A study by Reid et al. used cymatics to diagnose and differentiate cancer cells from healthy cells in brain tissue. The study effectively shows that healthy cells generate continuous symmetrical patterns while cancerous cells are prone to generate more chaotic patterns⁽³⁰⁾. In relation to self-biofeedback to support learning and self regulation processes it is interesting to note that sound researcher Hans Jenny was able to teach deaf children to better speak and improve their tonation and pronunciation by having them look at the cymatic patterns emerging from their own voice, hence seeing the dissonances in false pronunciation and the symmetry created by correct pronunciation⁽²⁶⁾.

These examples show a distinct correlation of geometric symmetry with coherency and effectively form the foundation of the present study in which a geometric feedback loop is employed to impose and to entrain natural systems into coherency.

Sound and Music as Medicinal Modalities:

Music was found to be beneficial to improve and enhance various healing processes⁽³¹⁾, relieve stress, depression and anxiety⁽³²⁻³⁴⁾, affect mood^(35,36), energy and physical state^(37,38), enhance longevity of blood cells⁽³⁹⁾ and ignite brain functioning supporting hearing mechanisms which could be described as enhanced structural and cellular reaction⁽⁴⁰⁾. Nowadays, the use of music therapy in hospitals and schools is increasingly growing across countries and cultures⁽⁴¹⁻⁴⁵⁾. As our society becomes more accustomed to the use of music as a healing modality, the use of sound in this context is relatively new to western societies. However, sound medicine, also known as sound therapy or sound healing, is an ancient practice used throughout history in different cultures around the world to relieve physical pain and emotional turmoil^(46,47). Sound medicine incorporates the use of sounds such as the human voice, nature sounds and various instruments including tuning forks, singing bowls, gongs and drums - all providing sound that is rich in frequencies and overtones. The natural mechanisms on which sound medicine relies upon are entrainment and resonance coherence of frequencies and rhythms. Notably, sound is rhythmic by definition as each frequency is derived from its vibrational oscillation. Music and sound medicine modalities ignite physiological and psychological responses. Examples include beneficial hormone secretion⁽⁴⁸⁾, synchronization of brain waves to beats and binaural beats⁽⁴⁹⁻⁵¹⁾, improvement in symptoms of neurotrauma brain impairment⁽⁵²⁻⁵⁵⁾ and induction of stress and pain relief mechanisms^(37,56).

Though often assumed that sound is perceived only by our ears, its fundamental vibratory essence is perceived by our skin, bones, internal organs and cells⁽⁵⁷⁾. It is this vibratory essence that makes sound and music therapies useful practices to affect and support people dealing with various psychological and physiological conditions. Furthermore, natural living systems emit sound as part of their functional mechanism as well as depend on sound for a healthy systemic maintenance. Commonly known examples include the sound of our breath, heart and nervous system. Additional examples show that cocooned butterflies produce sound as part of their mechanical oscillation metamorphosis⁽⁵⁸⁾, plants are affected by sound as they grow^(59,60), sound of a healthy coral system supports rehabilitation processes of dead corals⁽⁶¹⁾, cells were reported to emit audible sound and react with high pitched sound when agitated by toxic substances⁽⁶²⁾. These examples demonstrate the core theme leading sound medicine of sequenced entrainment and revival of physiologic mechanical processes. Notably, while the use of such practices to affect health could be disregarded as alternative medicine there is solid scientific evidence confirming natural enhancements are as beneficial, and sometimes more beneficial than synthesized medication⁽⁶³⁻⁶⁶⁾.

While growing in scope, there's only very little scientific research on the physiological effects of sound medicine. In addition, most studies that explored the effects of sound medicine focused on behavioral evidence. For example, Goldsby, et al.⁽⁶⁷⁾ reported the effects of sound meditation on mood, anxiety, pain and spiritual well-being. Following sound meditation participants reported significantly less tension, anger, fatigue, and depressed mood, while feeling of spiritual well-being significantly increased. Another research by Cooper et al.⁽⁶⁸⁾ explored the effect of sound meditation and shows statistically significant effects of physical relaxation, imagery, ineffability, positive mood, insightfulness, disembodiment and unity across both live and recorded sessions. Fewer studies have addressed the physiological basis of sound medicine; a study by Ito et al.⁽⁶⁹⁾ examined the effect of high-resolution audio music box with positive hypersonic effects on brain waves, as recorded using EEG. Results indicate that high-resolution audio music box sound has the effect of increasing vigilance and relaxation of the brain. In addition there is accumulating evidence of the physiological effects of relaxation therapy practices other than sound medicine, including mindfulness⁽⁷⁰⁾, meditation⁽⁷¹⁾ and music therapy⁽⁷²⁾, as recorded by EEG⁽⁷³⁻⁷⁵⁾ Functional Magnetic Imaging (fMRI)⁽⁷⁶⁻⁷⁹⁾ and Heart Rate Variability (HRV)^(80,81).

While the use of technology in mindfulness and meditation practices is growing in scope, sound medicine is commonly conducted in private or group sessions and the use of technology, including advanced sound technology, is rarely considered. This study proposes a method using high-end spatial sound technology in combination with sound medicine practices in order to induce positive physical and emotional effects.

Medical and Neurologic Background on Related Implications of the Suggested Method:

Modern science acknowledges the negative effect of stress on well-being. Stress and anxiety have been found to increase vulnerability to disease, including autoimmune disease and inflammatory processes⁽⁸²⁻⁸⁸⁵⁾, acute pain⁽⁸⁶⁻⁸⁸⁾, various skin conditions⁽⁸⁹⁾, reproductive system failure⁽⁹⁰⁻⁹²⁾, cardiovascular disease^(93,94), respiratory system failure⁽⁹⁵⁻⁹⁷⁾, dysfunction in muscular dystrophy^(98,99), bone depletion⁽¹⁰⁰⁾, immune system deficiency⁽¹⁰¹⁾, eruption of psychological conditions^(85,102,103), premature and enhanced aging symptoms⁽¹⁰⁴⁻¹⁰⁶⁾.

Further, when modeling neurotrauma, whether caused by Acquired Brain Injury (ABI) or Traumatic Brain

Injury (TBI), it is common to see structural impairments in brain regions. These structural impairments could indicate increased uncontrolled blood flow or mechanical hit, or decrease in blood flow depriving oxygen from the affected area eventually causing damage to neural tissue. Some non-invasive approaches have been in use - for example, conditions of neurotrauma were shown to improve functionality following neurofeedback processes and practice, where patients learned to regulate and control brain activity to the point that the physicality of their brain modeling had changed in conjunction with improved capabilities⁽¹⁰⁷⁾. Post neurofeedback modeling scans support behavioral and functional results and neurofeedback is increasingly used and accepted as liable treatment to various conditions including more mundane ones such as ADHD⁽⁶⁶⁾. These results imply brain plasticity holds an important role in neurotrauma recovery processes and could benefit restitution of neurotrauma destructive influences⁽⁵³⁻⁵⁵⁾. However, types of neurofeedback and music interventions can not be applied with people in comatose or vegetative conditions and people suffering from a very short patience and focus span.

This study suggests a non-invasive treatment for various stress related and brain impairment conditions using sound and mathematical bio-feedback processes as a medicinal practice. The method at hand uses high-end spatial sound technology and could support healing processes as it was found to effectively reduce stress and advance relaxation among participants in a short time. Another application of this study provides a non-invasive method to treat conditions of neurotrauma.

METHODS:

We investigated the effects of GS on physiological parameters as recorded by EEG and measures of the ANS monitoring blood pressure and HR in conjunction with behavioral measurements as analyzed from standard and custom questionnaires. Experiments were conducted within group comparison and all participants were exposed to all sound stimuli. Two separate experiments were conducted monitoring an overall of 50 participants. First experiment in 2017 (E1) monitored 20 participants listening to Sphere GS shape and 10 participants also listening to Pyramid GS shape. The second experiment in 2018 (E2) monitored 30 participants listening to Pyramid, Cube and Sphere GS shapes. Across both experiments all participants were monitored for base and Stereo (control) conditions. All sound stimuli were monitored for an epoch of 5 minutes each. All measurements were taken while participants were comfortably seated with eyes closed. Participants were enclosed in the GS shapes projections, sitting in the center of the shapes at their base vertical level. Order of sound stimuli randomly alternated between participants and was recorded on a double blind paradigm. The study was approved by the ethics committee of the Medical Faculty of Tübingen University. Both E1 and E2 were conducted on 4DSOUND at MONOM Center for Spatial Sound, Berlin.

Subjects:

A total of 50 participants were monitored in E1 and E2, of which 22 female and 28 male, mean age 26.

In E1 20 participants were monitored, of which 8 Female and 12 male, mean age 26.

In E2 30 participants were monitored, of which 14 female and 16 male, mean age 26.

All participants were young adults (20-40) and signed an informed consent and waiver form prior to enrolling in the study. Subjects declared not to suffer from any mental or health issues to their awareness and were not taking any medication regularly. Subjects were instructed to sit with eyes closed for the

entire experimental paradigm.

Sound Stimuli:

The study focused on one interval of an octave between two frequencies - 272.2Hz and 544.4Hz played simultaneously. The frequencies were produced by unweighted tuning forks manufactured by Acutonics⁽¹⁰⁸⁾. The sound sample used for the sound stimuli was recorded and then looped and projected in mathematically defined structures of GS and stereo positioning (control). The exact same sound sample was used in all GS and control. Each sound stimulus was played for an epoch of 5 minutes. All samples were played on 4DSOUND using a spatial configuration of 48 omnidirectional loudspeakers placed above, below and around the subjects. All sound stimuli were played on the same output volume of -16DB. Acoustic output level was adjusted to project the same sound pressure level (SPL), loudness and volume ensuring none of the GS shapes or control was perceived louder to the listening subjects. Control sound stimulus was played in the same configuration as all GS shapes and according to the same sound projection characteristics. Presentation and order of sound stimuli randomly alternated between participants. The sound stimuli monitored were:

0. Five minutes No Sound (Base condition)
1. Five minutes Stereo sound (Control)
2. Five minutes Pyramid GS
3. Five minutes Cube GS
4. Five minutes Sphere GS

Geometric Sound Shapes:

All GS and stereo positioning were constructed in the same ratio with the same diameter and played on the same speaker configuration space. All shapes were constructed in relation to each other, for instance the length of the square L in Cube GS is identical to the length of the Pyramid base, all shapes are constructed with the same diameter.

The calculations for the shapes are as follows:

Pyramid:

The Pyramid is based on the (inverse) Golden Ratio (ratio = $1/0.618=1.618$), which dictates its ratio, and hence steepness.

Pyramid Base Length: $L=8m$. Height Pyramid: $H= ratio * L = 4,944m$.

The Pyramid was decomposed into three (square) horizontal slices, from its base to its top (point) via an intermediary level, with the following coordinates:

1. Base: $L1 = 8m$ center is situated at $(0,0,0)$
2. Intermediary: $L2 = 4,944m$ center is situated at $(0,0, 1.889m)$
3. Top: $L3 = 0m$, $y3 = 4,944m$ center is situated at $(0,0,4.944m)$

Cube:

The Cube is a Cube of side $LCube = 8m$ centered in space.

Sphere:

The Sphere is computed according to the ratio earth-moon, under the following representation: Earth is symbolized in a square, inscribed in a circle, and Moon is represented by the space between the square and the circle.

Its diameter is: $D = (1 + \text{moon/earth}) * L = 10.184\text{m}$

4DSOUND:

Experiments were conducted on 4DSOUND system at MONOM Centre for Spatial Sound Berlin. The 57 channels 4DSOUND setup in MONOM studio consists of 48 omnidirectional satellite Bloomline Acoustics OmniDrive Pro Mark II speakers in a 4 x 3 x 4 equally spaced grid, combined with 9 Bloomline Acoustics 4D OmniSub (Custom) subwoofers. The available spatialisation surface dimensions are 12m x 12m, and 4m in height. In combination with the proprietary 4DSOUND software algorithms, this three-dimensional speaker configuration produces high definition sound spatialisation. The frequency range is 20Hz to 20kHz, and acoustic dynamics up to 116dB. The sound output of each loudspeaker was determined by computer-generated rated sound field consisting of virtual point-specific audio components and a panning algorithm using the 4DSOUND v1.3 software.

Cymascope:

A stereo recording from the center of the GS shapes, where participants were placed, was recorded using Zoom H4n Pro with an angle of 120 degrees under the same sound projection conditions. All recordings were conducted at the same location under the same conditions as E1 and E2. The recordings were then sent to Cymascope laboratory in a stereo 24Bit, 48,000HR Wave format for cymascopic analysis. Within the Cymascope instrument, the fused-quartz water-filled cuvette is direct-coupled to a Voice Coil Motor (VCM) with vertically driven piston. Electronic filtering is applied in the signal path to ensure that resonances, inherent in the VCM-cuvette assembly, are negated, resulting in a flat response characteristic curve. All samples were observed via direct ocular viewing, then photographed using a Canon EOS 5D Mark camera and analyzed under the same conditions. The sound stimuli samples as recorded and analyzed by the Cymascope instrument, are available via the following link [Appendix 1](#).

EEG:**Data recording:**

In E1 data was collected and analyzed by neuroscientists from the BioKeshev Institute (IL) (Figure 1).

In E2 data was collected by neuroscientists from the Institut für EEG-Neurofeedback and the Peak Brain Institute (DE). In E2, spectral and functional connectivity analysis as well as the statistical analysis of EEG results was conducted at the MEG-Center, University of Tübingen (DE).

Both in E1 and E2 participants' EEG was recorded in the standard 10/20 system. EEG was recorded continuously with a sampling rate of 256 Hz and an antialiasing lowpass filter set to 64 Hz. Each sound stimuli was monitored for 5 minutes. In E1 the last minute of each epoch was analyzed and participants with noisy artifacts were removed from the analysis paradigm. In E2 subjects with noisy artifacts were removed from the analysis paradigm of brain waves power amplitude. For the connectivity analysis segmented data were visually inspected and epoques contaminated by artifacts were discarded. Using this procedure all subjects could be considered for the brain connectivity analysis. Analysis methods varied

according to the protocol of the team analyzing them.

Spectral Power and Connectivity analysis

Investigating the functional connectivity of brain activity by means of coherency, EEG data were analyzed using MATLAB (MathWorks Inc., Natick, Massachusetts USA), NBS Connectome⁽¹⁰⁶⁾, and FieldTrip, an open-source MATLAB toolbox specifically developed for the analysis of electrophysiological data⁽¹¹⁰⁾.

After offset removal and high-pass filtering of the EEG data at 1 Hz data were segmented in junks of 500 ms. In a subsequent step eye and heart artifacts were removed using an Independent Component Analysis (ICA). In the subsequent frequency analysis a multitaper approach, with Discrete Prolate Spheroidal Sequences (DPSS) as tapers with a smoothing window of ± 4 Hz was used. The Fourier spectrum of the signal was determined, selecting for frequencies ranging from 2 to 64 Hz, in steps of 2 Hz. Connectivity analysis was performed on n trials at the sensor level, using the absolute part of imaginary coherency as measure of functional connectivity.

$$c = \left| \text{Imag} \left(\frac{\sum_n F_{ik}(f) F_{jk}^*(f)}{\sqrt{\sum_n F_{ik}(f) F_{ik}^*(f) \sum_n F_{jk}(f) F_{jk}^*(f)}} \right) \right|$$

With $\sum_n F_{ik}(f) F_{jk}^*(f)$ and $\sum_n F_{ik}(f) F_{ik}^*(f)$ being the cross and the auto spectra, respectively, of the EEG activity $F_{ik}(f)$ recorded in trial k at channel i and j . The absolute part of the imaginary part of coherency ($I(\cdot)$) was chosen in order to avoid spurious connectivities due to the spreading of the signal to neighboring electrodes⁽¹¹¹⁾. Given the electrodes, the output of the connectivity analysis was a $n \times n$ connectivity matrix (19 x 19), quantifying the level of interaction between all pairs of EEG sensors.

Network statistical analysis

NBS connectome⁽¹⁰⁹⁾ has been used to perform network statistical analyses, applying the cluster-based nonparametric method implemented in the Network Based Statistic (NBS) software. A Non-parametric way of testing was chosen due to the non-normally distributed values of coherency. The cluster-based approach was chosen to avoid exhaustive multiple testing. Connectivity matrices were used as input for the analysis. For the statistical analyses in NBS, design matrices and contrast vectors were defined in terms of a General Linear Model (GLM).

The Network-Based Statistic method involved four different steps. First, it runs a massive univariate test to define a test statistic value for each connection. Second, it compares the t-statistic of each connection, with the previously defined threshold set to $t > 3.1$ in order to identify all supra-threshold connections. Then the presence of any topological clusters among the sets of supra-threshold connections are selected. To this end significant connections that shared common nodes were summarized in individual clusters. Finally, to run a second level statistical testing comparing the differences of connectivity patterns across

conditions, connectivity data of individual subjects were randomly assigned to the conditions to be compared. A total of 5000 permutations was performed in each permutation t. The size of the largest cluster, expressed in a one-sided FWER-corrected p-value⁽¹¹²⁾, is recorded. Permutations provide an empirical null distribution for the size of the largest cluster. For the statistical analysis pairwise comparisons between conditions were carried out.

Behavioral Response and Questionnaires:

In E1 all participants were required to answer BECK Depression Inventory (BDI) before enrolling in the experiment. Participants also answered a custom questionnaire composed by the researcher, to monitor their well-being and emotional response before and immediately after enrolling in the experiment (To view the full custom questionnaire please see [Appendix 2](#)). In E2 participants were required to answer the Multidimensional Mood Questionnaire (MDMQ) and the same custom questionnaire as in E1 before and immediately after enrolling in the experiment. BECK and the MDMQ are verified questionnaires and the custom questionnaire provided additional indication on the effect of the stimuli on participants without impinging the procedure. All questionnaires were administered in the same order both before and after the experiment.

Both in E1 and E2 participants were given the option to provide additional written and video recorded testimonials of their experience. Statistical analysis of results of all questionnaires both in E1 and E2 was conducted on SPSS 25.0 using paired t test. Statistics were conducted for each experiment separately and the average response to both experiments was also computed. Not all items were filled in by all participants thus some were disqualified from being considered for the statistical analysis of results.

Blood Pressure and Heart Rate:

20 participants in E1 were monitored by a trained nurse for their Blood Pressure and HR immediately after each epoch of sound stimulus. Blood Pressure and HR were also monitored for base condition.

Figure 1: E1 EEG measurements by Dr. Anat Barnea from the BioKeshev Institute (IL) at MONOM Center for Spatial Sound Berlin.

RESULTS:

Faraday Waves Cymatic Emergence:

Cymascopic analysis of the wave files show a distinct correlation between the projected GS shape and its Faraday wave pattern. Importantly, all sound stimuli play the exact same sound sample - same frequency combination (272.2Hz & 544.4Hz) in the same loop, duration, and SPL and measured under identical

conditions. Evidently, Pyramid GS creates a triangular pattern, Cube GS creates a square pattern and Sphere GS creates a circular pattern. Hence, identical sound samples result in different Faraday wave patterns as a result of the sound spatial propagation (Figure 2A-C). This result is novel in the field of sound induced Faraday waves, showing patterns are affected by the spatiality of sound. Furthermore, the images strongly indicate the sound is indeed projected in the said geometric shapes and stand as a testimonial for the holographic nature of sound (Figure 2A-C).

Figure 2A: Faraday waves excited by Pyramid GS projection

Figure 2B: Faraday waves excited by Cube GS projection

Figure 2C: Faraday waves excited by Sphere GS projection

Physiological Response - Brain Waves (E1, E2):

Both in E1 and E2 a significant decrease in Alpha activity is observed between base condition and Stereo, further decrease is observed between Stereo and all GS shapes projections (Figure 3A, 3B). In both experiments Pyramid is showing the lowest Alpha activity. In E2 most significant results of Alpha decrease are obtained between base, Pyramid and Cube conditions (Table 1).

In E2 which measured more GS shapes, brain waves power amplitude at different frequency bands show varying activity patterns between the sound stimuli. Beta2 is significantly affected by all GS and not control (stereo). Gamma is significantly affected only while exposed to Pyramid GS (Table 2).

These results indicate significantly different activity patterns in the power amplitude of Alpha, Beta2 and Gamma brain waves. This indication is identified between base and all sound stimuli, between control (stereo) and all GS shapes, and between the different GS shapes (Table 1,2). The results are further demonstrated in connectivity patterns.

E2 EEG recordings were further analyzed for connectivity patterns and topology. The results emphasize the trend observed in brain wave power amplitude patterns between GS and control. Since connectivity was shown to increase and power amplitude to decrease these measurements are regarded as independent. The analysis shows identical sound samples result in different connectivity patterns following each GS shape. Results are inline with Faraday waves cymatic analysis observations and indicate that each GS

shape creates specific connectivity patterns between brain regions. Concentrating on statistically significant connectivity clusters only, different connectivity patterns are observed between base condition (no sound) and all GS shapes, between control (stereo) and all GS shapes and in comparison between some of the GS shapes. The frequency interval that was measured showed significant activity in connectivity patterns in the Alpha range mostly at 12Hz (Figure 5A). As values of power amplitude decrease in the Alpha range in all projections, (statistically significantly in Pyramid and Cube GS, and close to significantly in Sphere and control) it can be concluded that connectivity patterns are of high significance. At 12Hz different connectivity patterns were observed in all sound stimuli and were more present in the left hemisphere, especially in the frontal left lobe (Figure 5A). Significantly different connectivity patterns are observed in Pyramid GS compared to base condition in the frequency range between 10Hz and 16Hz. Each band shows different connectivity patterns between different GS projections. Different patterns were also observed in Cube GS at 16 Hz (Figure 5A). Furthermore, significant differences are found between the sound stimuli - between Sphere and Pyramid GS at 8Hz and between Cube GS and Stereo at 12Hz (Figure 5B). Other significant connectivity patterns were observed at more sephoradic frequencies in the Beta and Gamma bands, for more information on the different frequencies and connectivity patterns please see [Appendix 3](#).

Notably, results on all activity measures - topologic power amplitude and connectivity patterns are consistent with respect to larger effect of GS compared to control (stereo) and predominantly in the Alpha band.

Figure 3A, 3B: 3A: E1 EEG power amplitude values (N=16), 3B: E2 EEG power amplitude values (N=28)

Effect	F	df	p
Baseline – Stereo (control)	3.814	1,27	0.061
Baseline – Pyramid	13.052	1,27	0.001
Baseline – Cube	5.856	1,27	0.023
Baseline – Sphere	3.876	1,27	0.059

Table 1: E2 Decrease in Alpha activity compared to base condition (N=28).

Alpha decreases in all sound stimuli compared to base condition. Pyramid condition shows the most significant results of Alpha decrease. Both Pyramid and Cube present a significant Alpha activity decrease. Baseline-Stereo $p \leq 0.061$; Baseline-Pyramid $p \leq 0.001$; Baseline-Cube $p \leq 0.023$; Baseline-Sphere $p \leq 0.059$.

Effect	F	df	p
BETA 2			
Baseline – Pyramid	7.858	1,27	0.009
Baseline – Cube	5.855	1,27	0.023
Baseline – Sphere	4.764	1,27	0.038
GAMMA			
Baseline – Pyramid	8.113	1,27	0.008

Table 2: E2 Significant activity patterns between all tasks in Beta2 and Gamma bands (N=28).

Beta 2: Baseline-Pyramid $p \leq 0.009$; Baseline-Cube $p \leq 0.023$; Baseline-Sphere $p \leq 0.038$

Gamma: Baseline-Pyramid $p \leq 0.008$

Figure 4: Significant results are displayed of topological analysis. Red spots are showing areas of significant change in activity in the Alpha, Beta and Gamma bands during exposure to different stimuli compared to baseline (N=30)

Behavioral Response:

In E1 and E2 effects of exposure to the sound stimuli were monitored by a combination of questionnaires. The results from all questionnaires show a clear tendency towards improved sense of well-being, enhanced positive feelings and decreased negative feelings. Quantitative results are presented in the figure legend of respective graphs.

Behavioral Response - Custom Questionnaire (E1, E2):

Significant results in E1 were obtained in enhanced sense of relaxation and physical sense and reduced sense of fear and frustration (Figure 6A).

Significant results in E2 were obtained in enhanced sense of relaxation, happiness and confidence and reduced sense of fear and frustration (Figure 6B).

An average of results from both experiments was also computed and shows significant results in enhanced sense of relaxation, happiness and confidence and reduced sense of fear, depression and frustration (Figure 6C).

Notably, the positive trend towards improved general well-being is maintained in items that did not generate significant statistical results.

Behavioral Response - MDMQ (E2):

MDMQ results show ~~similar patterns to the custom questionnaire with~~ significant improvement in items: Rested, Relaxed, Deeply Relaxed, Restless, Bad, Worn Out, Uneasy, Unhappy, Nervous. Most significant results were achieved for Deeply Relaxed, bad and Nervous items (Figure 7).

Behavioral Response - BECK Depression Inventory (E1):

In E1 participants were asked to answer the BECK Depression Inventory (BDI) before enrolling in the experiment. The average score of all participants was 7.45 points which is considered normal. Four participants scored 11-25 points which is within the range of conditions considered between mild mood disturbance to moderate clinical depression. Replies to the custom questionnaire among these participants show improvement in the mentioned above items (Figure 8).

Behavioral Response - Experiential Testimonials of Participants (E1, E2):

Participants were given the option to elaborate on all items in the custom questionnaire and provide free testimonials on their experience. The testimonials are inline with quantitative replies collected over the MDMQ and custom questionnaires. 95.8% of participants, an absolute majority, reported the overall experience was positive, uplifting and beneficial. Participants pointed out a combination of positive sensations such as a sense of deep relaxation, enhanced sense of focus, improved sense of self esteem, confidence, calmness, hopefulness, and vitality, improved sense of physical feeling, enhanced imagery including elaborated images, colors and memories. Participants also largely refer to a feeling or sensation similar to meditation. Some examples of quotes from participants include: *"I feel happy and relaxed, much calmer after than before"*, *"Noticeable less agitated by everything"*, *"I feel more relieved, also physically and possibly more elastic"*, *"Sounds helped me calm and see the good rather than the bad"*.

A few participants reported being diagnosed with ADHD, their elaborated replies following exposure to the sound stimuli are positive and fall inline with the general trend of enhanced focus and relaxation: *"(I feel) more aware of what I'm feeling/thinking. Feeling a little calmer after the session"* , *"Slightly less*

fear, Slightly less frustrated... I feel more aware of my hands and (deep relaxation on hands, strangely) and my head” , “I am more relaxed and at ease than before” (For a full list of replies please see [Appendix 4](#).

Figure 6A: E1 statistically significant results to custom questionnaire, N=20. Relaxation $p \leq 0.001$, Physical $p \leq 0.025$, Fear $p \leq 0.008$, Frustration $p \leq 0.014$. (significance level $.01 < p < .05$; **: $0.001 < p \leq 0.01$; *: $p < 0.001$)

Figure 6C: E1 and E2 statistically significant results to the custom questionnaire, N=48. Happiness $p \leq 0.004$, Confidence $p \leq 0.002$, Depression $p \leq 0.002$, Fear $p \leq 0.001$, Relaxation $p \leq 0.001$, Frustration $p \leq 0.001$. (significance level $.01 < p < .05$; **: $0.001 < p \leq 0.01$; *: $p < 0.001$)

Figure 6B: E2 Statistically significant results to custom questionnaire, N=28. Happiness $p \leq 0.011$, Confidence $p \leq 0.015$, Relaxation $p \leq 0.001$, Depression $p \leq 0.007$, Fear $p \leq 0.001$, Frustration $p \leq 0.001$. (significance level $.01 < p < .05$; **: $0.001 < p \leq 0.01$; *: $p < 0.001$)

Figure 7: E2 Statistically significant results to MDMQ questionnaire, N=26. Rested $p \leq 0.002$, Relaxed $p \leq 0.001$, Deeply Relaxed $p \leq 0.001$, Restless $p \leq 0.045$, Bad $p \leq 0.001$, Worn Out $p \leq 0.030$, Uneasy $p \leq 0.025$, Unhappy $p \leq 0.048$, Nervous $p \leq 0.001$. (significance level $.01 < p < .05$; **: $0.001 < p \leq 0.01$; *: $p < 0.001$)

Figure 8: E1 Results of custom questionnaires in people suffering from depression according to BDI

Physiological Response - Heart Rate and Blood Pressure (E1):

HR and blood pressure of all 20 participants in E1 was monitored before and after exposure to Sphere GS and Stereo (control). For technical reasons only 10 participants were monitored before and after exposure to Pyramid GS.

Heart Rate:

General HR between all participants decreased during the experiment from an average of 73 at base condition to average 69 after both stereo and Sphere GS, and average 67 after Pyramid GS. A closer look and computation of average results for male and female participants shows a distinct pattern of relaxation after immersion in GS (Table 3). Results show a tendency towards relaxation as well as suggest different physical reactions to GS in comparison to control. Results of male participants in particular show enhanced reaction to GS compared to control. Average HR among male participants was 72.7 in base condition and 70.1 after exposure to Stereo (control). Both are considered within the range of average HR for males in this age group in resting condition. HR decreased to 69.4 after exposure to Sphere GS and further decreased to 66 after exposure to Pyramid GS. Both considered Good HR conditions for males in this age group in resting condition. Average HR among female participants was 74 in base condition which is considered average HR for females in this age group in resting condition. HR decreased to 67 after exposure to Stereo and to 68 after exposure to Sphere and Pyramid GS. All considered within the range of Great condition for females in this age group in resting condition.

Blood Pressure:

Average Blood Pressure of participants decreased from 120/80 in base condition, which is considered Elevated Blood Pressure according to the American Heart Association, to 113/78 following Stereo, 112/76 following Sphere GS and 111/77 following Pyramid GS, all considered normal. Male participants show a decrease in both systolic and diastolic blood pressure following exposure to Sphere and Pyramid GS. Female participants show a decrease in both systolic and diastolic blood pressure following exposure to all sound stimuli with GS Sphere having the most significant results (Table 4).

	Base Condition	Sphere GS	Pyramid GS	Stereo (Control)
General	73	69	67	69
Male	72.7 (average)	69.4 (Good)	66 (Good)	70.1 (average)
Female	74 (average)	68 (Great)	68 (Great)	67 (Great)

Table 3: E1 Average heart rate among participants (N=19)

	Base	Sphere GS	Pyramid GS	Stereo (Control)
General	120/80	112/76	111/77	113/78
Male	116/81	116/77	111/74	118/89
Female	113/78	105/74	108/80	106/75

Table 4: E1 Average Blood Pressure among participants (N=19)

DISCUSSION:

This study investigated the effect of GS on brain wave activity and general well-being. In order to demonstrate the spatial differences of the different sound projections we further studied Faraday waves cymatic propagation. Results show encouraging implications of GS projections on Faraday wave patterns, brain wave topologic power amplitude and connectivity patterns across three analysis paradigms. Results indicate GS is prone to induce relaxation, improve sense of well-being and stress related coping mechanisms according to behavioral and ANS measurements.

Faraday wave cymatic analysis shows each GS shape creates a mirroring pattern. This result is novel in the field of sound induced Faraday waves, showing patterns are affected by the spatiality of sound. Furthermore, the images strongly indicate the sound is indeed projected in the said geometric shapes and stand as a testimonial for the holographic nature of sound (Figure 2A-C). The holographic principle of sound hypothesis suggests that each sound “particle” holds spatial information of the sound it is part of. Thus, even a mono or stereo recording of a 3D GS shape projection includes characteristics of its spatial propagation in space. This is demonstrated in Faraday Waves patterns affected by GS spatial information, hence sound creates interference patterns which can be visualized by Faraday Waves. These patterns are correlating to the geometric projections. This may imply a process of geometric synchronization which could possibly take place in other geometric substances such as molecules. Thus suggesting broken molecules could self rearrange and rebuild into their original geometric structure following exposure to GS, possibly using super high ultrasound rather than audible sound. Another possible application of this finding could suggest that polluted water with broken crystal structure could be cleaned and restored to its coherent hexagonal structure following excitation by GS. These are just a few possible applications of the possibilities emerging from this finding.

Both in E1 and E2 EEG results indicate a significant decrease in Alpha activity between base condition (no sound) and all sound stimuli, with enhanced effect in all GS projections compared to control (stereo). Most significant results of Alpha decrease are obtained during exposure to Pyramid GS. Studies suggest that high resolution sound stimuli were found to enhance relaxation compared to low resolution sound stimuli while showing decrease in Alpha activity⁽⁶⁹⁾. Decrease in Alpha activity was also observed while monitoring relaxation effects of listening to monochord compared to progressive muscle relaxation tapes of the same length and sonic characteristics during chemotherapy treatments on cancer patients^(56,113). Lower levels of Alpha activity in the left front central region, as we found in the topological analysis, were significantly associated with higher levels of self acceptance, environmental mastery, personal growth and total psychological well-being⁽¹¹⁴⁾, also suggesting a positive effect on cardiovascular and respiratory systems in accordance to mood induction⁽¹¹⁵⁾. Decrease in Alpha is reported to relate to higher levels of blood oxygenation⁽¹¹⁶⁾. This notion is inline with observation on the effect of music compared to a silent environment on blood cells longevity indicating music and sound positively affect increased oxygenation of red blood cells compared to silence⁽³⁹⁾. Interestingly, both experiments tested a state of immersion in sound.

Observation of EEG results in conjunction with participants' testimonials imply participants were in a state of enhanced concentration, i.e. immersion⁽¹¹⁷⁾. Furthermore, Magosso et al. reported that while being immersed in a Virtual Reality (VR) experience, Alpha is shown to decrease during arithmetic tasks compared to purely mental tasks, suggesting by the authors that attention is being imposed inwards⁽¹¹⁸⁾. The observed effect of GS may indicate that the brain derives spatial information of the geometric shapes and mathematical attributes of sound through hearing. Another non-traditional interpretation of these results could suggest the mathematical component of GS supports analytical and logical thinking, usually attributed to left hemisphere processing, while the sonic and melodic component of GS supports holistic and creative thinking, usually attributed to right hemisphere processing. Thus GS could improve deep cohesion and communication of left and right hemispheres while strengthening a healthy sense of self awareness and mind-body connection. This indication is demonstrated by topological analysis showing symmetrical patterns in both hemispheres in all GS projections compared to control in the Alpha band (Figure 4). Analysis of EEG results in conjunction with participants' testimonials and behavioral effects suggests participants were in a state of relaxed alertness, also known as orchestrated immersion. It could be assumed that exposure to GS inflicts orchestrated immersion on people, in which they inhibit focused attention, which is considered the optimal condition for learning^(119,120).

The implications of these results are wide. For example, studies show that people with ADHD exhibit increased brain activity in frontal and temporal regions, mostly in the left hemisphere, in situations involving intellectual stress⁽¹²²⁾. Major Depressive Disorder (MDD) was related to a decrease of Alpha symmetry^(123,124). It could be postulated that GS effect on Alpha symmetry could support MDD rehabilitation and that specific GS projections could be used to relieve challenges and balance left and right regions activity. Furthermore, this overall body of results suggests an in hand non-invasive brain rehabilitation practice that could possibly support recovery of neurotrauma.

Harnessing brain plasticity is a largely growing practice to support rehabilitation of neurotrauma⁽⁵⁴⁻⁵⁵⁾, also used with Computer Brain Interface (BCI) and neurofeedback processes to model and ignite

non-functional areas, which requires active participation⁽¹²⁷⁾. As GS affects the entire brain it could support both Contralateral and Ipsilateral recovery paradigms. Moreover, considering Hebbian Learning (“Neurons that fire together, Wire together”)⁽¹²⁸⁾, it could be assumed that long term exposure to GS could possibly support cognitive recovery processes from neurotrauma while supporting rehabilitation of related mood disorders. The method at hand incorporates brain rehabilitation processes while being emotionally and physically beneficial as it uses the benefits of sound and music therapies. GS proposes a method that does not require an active participation and could be highly beneficial for people with unconscious conditions or low attention span. These indications should be further investigated in future research.

Brain waves are known to entrain to a sound frequency, or combination of frequencies (interval) they are exposed to⁽⁴⁹⁻⁵¹⁾. This study shows brain waves are affected differently not only by tonality but also by the spatial properties of sound propagation. This indication is inline with Faraday Waves patterns observed following excitation by GS. Results show different brain waves activity, connectivity and topological patterns during exposure to the different sound stimuli Pyramid, Cube, Sphere GS and control (Stereo) - all playing the same sound sample. The sound sample tested, an interval of an octave between 272.2Hz and 544.4Hz, showed significant changes in brain connectivity patterns mainly in the Alpha band. As power amplitude value is shown to decrease in the Alpha band during exposure to all sound stimuli including control but mostly in all GS projections, it can be concluded that connectivity patterns are of high significance. Furthermore, Topological analysis shows significant changes in the Alpha band during exposure to all sound stimuli, and in the Beta and Gamma bands only during exposure to GS. These results are inline with power amplitude analysis. Changes occur mostly in all GS shapes compared to control and mainly in Pyramid and Cube GS projections. Though results above 64Hz were considered as noise and removed from this analysis, possible effect in the higher frequency ranges is plausible and would be further investigated in future analysis using different filters. Notably, at this point we can not conclude whether the effects in EEG are specific for spatiality of the sound projections or due to resulting spectral filtering.

It should be emphasized that these are the results following exposure to one interval of an octave between two distinct frequencies. It is plausible that different intervals, frequencies and frequency ranges will produce alternate patterns around varied brain wave bands. Further, while this research tested only 3 GS shapes (Pyramid, Cube, Sphere), further research will explore and document the connectivity patterns of more GS shapes and other mathematical sound attributes. Once all GS shapes connectivity patterns are documented and analyzed, and in relation to various frequencies and intervals, they could be used to rehabilitate brain function in a non-invasive manner. This indication will be further investigated in future research and experiments.

Although GS could be compared to meditation, as indeed suggested by participants' testimonials, brain activity patterns are quite different. For example, meditation and mindfulness are commonly related to enhanced activity in the Alpha and Theta bands^(123,124) which was not observed with exposure to GS. Alpha band was shown to decrease while no significant change was monitored in the Theta band. However, it has been found that different types of meditation as well as different types of neurofeedback result in a variance of brain activity patterns^(125,126). This could suggest GS is a form of new meditative

practice. Another possible explanation is that GS, being tightly connected with immersion and exposure to sound, activates and affects the brain differently than methods related to silence, while achieving similar results related to enhanced relaxation, sense of focus, self awareness, positive emotional and physical function. The overall feedback generated by the majority of testimonials and behavioral responses of participants suggest GS has a similar effect as obtained through exercise of mindfulness and meditation in a shorter time and without practice. The positive effect of relaxation following regular meditation and mindfulness practice, also resulting in improved immune function⁽⁷¹⁾, is postulated to remain and grow with continued exposure to GS and will be further investigated in future research.

The emotional benefits of the method came forth in participants' testimonials and behavioral effects. Notably, both the MDMQ and custom questionnaires show similar patterns and a significant enhancement in reported sense of happiness, relaxed, deeply relaxed and confidence along with a significant decrease in reported sense of depression, fear, restlessness, nervousness, frustration, bad, worn out and uneasy feelings. Most significant items results are reported in enhanced sense of relaxation and decreased sense of nervousness and bad feelings. General testimonials from participants indicate improved sense of well-being including enhanced sense of focus, enhanced imagery including elaborated images, colors and memories, reports of a meditative feeling and improved self esteem. These results indicate sound medicine in general and GS in particular are a promising method to relieve stress after a short exposure in a non-invasive way. Furthermore, in E1 four participants scored 11-25 points in the BDI which is within the range mild mood disturbance to moderate clinical depression. Replies to the custom questionnaire among these participants show improvement in the mentioned above items (Figure 8). Although further data should be gathered as the number of participants dealing with depression is insufficient to conclude a statistically valid observation, a trend towards well-being in participants dealing with depression can be indicated.

While it is difficult to differentiate the effect of GS from control by behavioral response, further information on the enhanced effect of GS compared to control can be gathered from ANS results. Physiological measurements show significant improvement in participants' HR and Blood Pressure especially following exposure to GS compared to control. Among all participants Pyramid GS showed the highest effect and lowest rates of HR, while Blood Pressure reduced the most at Sphere GS. Compared to base condition male participants show a decrease in both systolic and diastolic blood pressure only following exposure to GS. Exposure to control (Stereo) showed an increase in both systolic and diastolic blood pressure among male participants. Female participants show a decrease in both systolic and diastolic blood pressure following exposure to all sound stimuli with Sphere GS having the most significant results. Male participants also presented improved HR only following exposure to GS and not control. Results are inline with research showing reduced HR, reduced systolic and diastolic blood pressure along with improved pain endurance following exposure to music therapy⁽¹²⁹⁾ and may indicate GS could also be used to improve pain endurance. This notion will be investigated in future research.

The difference in results between GS and control, as well as between the different GS shapes was maintained in brain wave topology power amplitude, connectivity patterns, HR and blood pressure. Thus further suggesting the body can perceive the difference between the geometries and their spatial

characteristics through sound. It is possible that pure mathematical and biologic constants are related to this observation. For example, most significant results on the majority of physiological measurements were obtained while participants were immersed in Pyramid GS, which was constructed according to the Phi Ratio. Nature is greatly constructed by Fibonacci numbers and its derived Phi Ratio. Experiments have shown that exposure to natural stimuli, whether visual or audial, is prone to induce relaxation and a positive physiological change⁽¹³⁰⁾. The connection of Fibonacci numbers to Phi, Pi and their implicated geometries generate their echoing relation to coherent energetic and fractalic systemic reproduction. It is plausible that a natural system will self entrain to a mathematical pattern of coherency which could be represented in a geometric shape. This process is likely to take place in an enhanced manner when presented to a self related mathematical system, such as Fibonacci numbers and Phi. Considering the human body, from blood cells⁽¹³¹⁾ to limbic formation⁽¹⁴⁾, is constructed according to Phi ratio, it is highly probable that our physiological system recognizes this pattern, and self adjusts itself to it.

Another possible demonstration of this notion comes forth by the enhanced effect shown in decreased Alpha activity on Pyramid and Cube GS, both strongly related to the platonic solids. The platonic solids define the atomic structure of all elements on the periodic table. Cube being one of the five platonic solids and Pyramid being half of an Octahedron, another polygon of the platonic solids. We can assume that the other four platonic solids (Tetrahedron, Octahedron, Icosahedron and Dodecahedron) will all generate significant results and effects. It can be assumed that their related and “mother” shape - the Cuboctahedron, will also generate significant results. This notion will be further investigated in future research.

In biology, neuroscience and behavioral design it has been shown that structure and function are intimately related - shape informs function and function determines form⁽¹³⁰⁻¹³²⁾. It is probable that form represents function and could possibly affect it. In a fractal syntropic system such as nature, including human physiology and psychology, shape's function informs and inevitably constantly imposes its characteristics on its surroundings. It is a feedback loop between developmental stages governed and tightly related to mathematics and fundamental geometry. Evidently, this phenomena is demonstrated in the Faraday Wave patterns observed during exposure to GS.

The advanced sound technology used to induce GS and immerse people within mathematical and geometric attributes of sound is essential. While some of GS characteristics are preserved in a recording due to sound holography and as demonstrated by Faraday Wave analysis, immersion within GS greatly relies upon the use of a sound system that can enclose people within the projected GS shapes. Health benefits of sound vary between listening to it and being immersed in it. Immersion creates an effect influential on the entire cavity, whether human or any other natural system. The advanced sound technology, both software and hardware, and high resolution sound projection it guarantees are responsible for the accuracy of the geometric and mathematical components of sound projection as well as on sound's dynamics. High resolution sound stimuli was found to enhance relaxation compared to low resolution sound stimuli⁽⁶⁹⁾, probably in relation to overtones within the sound which high resolution sound allows compared to compressed sound which is poor in dynamics. Harmonious and rich in overtones sound was found to affect cells as a valuable nutrient at the G0 stage (Quiescence)⁽¹³³⁾.

The sound used in this study was produced by tuning forks calibrated to 136.1Hz. These tuning forks are used in sound medicine practices to induce a sense of grounding, relaxation and improved sense of well-being.

The theme and concept leading this research was to combine spatial sound technology, geometry, mathematics and sound medicine to entrain natural systems into coherency. The overall body of results of this study indicate this relation is valid. The notion that the nature of reality, governing both mind and matter is mathematics, is becoming increasingly accepted, suggesting there is a fractal and symmetric pattern that possibly supports growth and efficiency of natural systems. Exposure to geometry and mathematical ordering by a medium that is of a fundamental vibratory essence, such as sound, allows for self entrainment of natural systems, including human biology.

CONCLUSION:

GS was shown to affect Faraday Waves patterns indicating sound's spatial properties affects its wave propagation. This observation suggests manipulation of matter through spatial properties of sound by means of geometric and mathematical entrainment. In conjunction with this finding, GS effect on brain waves connectivity patterns indicates each geometric projection, hence mathematical information, is generating a unique pattern. GS had a distinct effect on brain wave topology, power amplitude and connectivity patterns compared to control. Effect is mainly observed in the Alpha range, some effects are observed in the Beta and Gamma ranges. It is unclear if this effect is demonstrated in relation to the tonality of the tested sound stimuli or whether all sound stimuli will result in similar patterns across the same bands. GS was shown to have an enhanced positive effect on blood pressure and HR compared to control. The effect was more present among male participants compared to female participants who showed improved measurements following exposure to all sound stimuli. These results are inline with reports of improved sense of relaxation, happiness, confidence, restlessness, fear, nervousness, uneasiness, worn out, depression and bad feelings following exposure to all sound stimuli. Accordingly, the absolute majority of participants reported the overall experience was positive, uplifting and beneficial. Participants pointed out a combination of positive sensations such as a sense of deep relaxation, enhanced sense of focus, improved sense of self esteem, confidence, calmness, hopefulness, and vitality, improved sense of physical feeling, enhanced imagery including elaborated images, colors and memories. Results indicate GS may be used to treat people suffering from a line of stress related conditions as well as neurological impairment conditions. Results were replicated on both experiments taking place in 2017 and 2018. We believe GS offers a new methodology for a non-invasive medicinal practice as well as a new understanding of how mathematical sound applications could be used to generate coherency in various natural systems. Further study of GS should shed more light on the effect of different geometric and mathematical sound projections.

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