

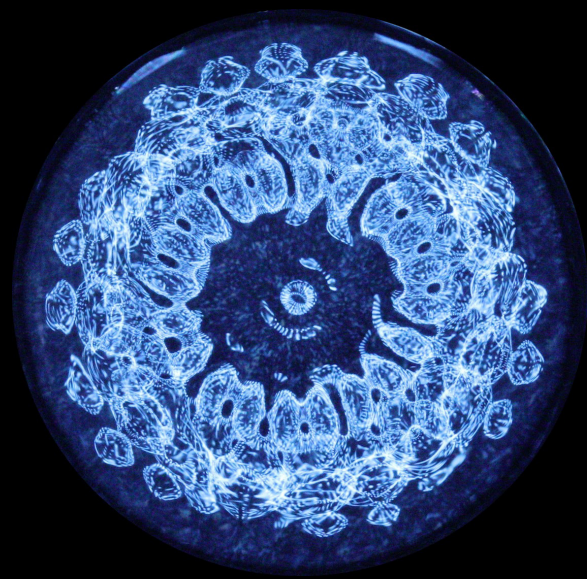


The Works  
harmonic coherence

# The Effects of Spatial Sound on Human Wellbeing



# Introduction

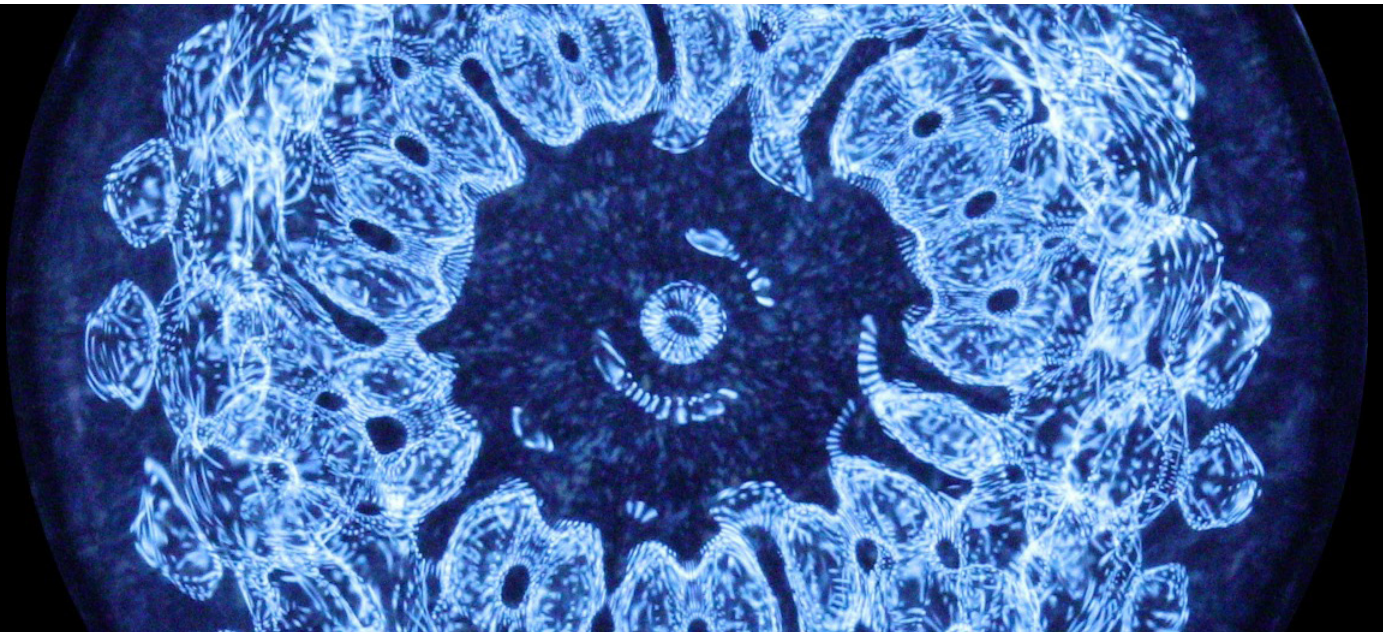


The Works Research Institute facilitates study into the emerging field of spatial sound. With our research, we aim to provide a new understanding of the principles of sound wave propagation and make benefit of its potential effects on human wellbeing.

## CONTENTS

HYPOTHESIS	3
RESEARCH OBJECTIVES	3
METHODS AND INSTRUMENTS	4
TIMELINE	4
TEAM	5
COMPANY DETAILS	5
APPENDIX 1	
Acoustic Effector Stimulation	6
APPENDIX 2	
Sound Shape Holography	7
APPENDIX 3	
Spatial Wave Transform	8

# The Effects of Spatial Sound on Human Wellbeing



## HYPOTHESIS

Based on prior studies conducted during 2018-2020, we have observed that the spatial coherence of sound waves may have a distinct effect on the harnessing of energy in natural systems, such as improved homeostasis of the human body (Method and System for Improving a Physiological Condition of a Subject, Oomen & Geffen, 2020).

This notion informs and gives rise to the hypothesis that coherent spatial projection of sound could be used for Acoustic Effector Stimulation (AES, Appendix 1) to restore, maintain and optimize balance in cell organisms, implying beneficial effects for treatment and prevention of pathological conditions associated with disease and trauma.

The spatial coherence of sound is observed in the alignment of sound waves in specific symmetrical patterns and the amplification of specific harmonic spectra as a result, which coincides with observed improved physiological state of subjects. We consider these aspects are intertwined as part of a unified non-discrete system, meaning the connectome of various natural systems to each other and bound by the fundamental principle of syntropy (negentropy).

## RESEARCH OBJECTIVES

Our study focuses on the following main themes:

- The effects of spatial sound on physical and emotional wellbeing and its potential as a non-invasive clinical methodology.
- Observable wave patterns and harmonic spectra resulting from spatial sound.
- Governing rules of sound wave propagation and its effects on natural systems.

The study targets the outlined topics in a line of experiments monitoring physiological somatic response and behavioral effect of subjects exposed to AES, as well as documenting the underlying acoustic and physical phenomena.

We assume that the harmonic spectra resulting from spatially coherent sound projections could be inverted and enhanced by technology to bring upon balance, i.e. homeostasis of natural systems, including physical and emotional wellbeing in humans. We aim to progress the clinical methods using spatial sound for the benefit of people dealing with a wide range of physiological and psychological diseases - therewith extending upon existing

practices of vibrational medicine, including sound and music therapy.

The target ambition of our research for the long term (beyond 2022) is to establish a non-invasive, self-regulating method using sound to effectively treat people suffering from Traumatic Brain Injury (TBI), chronic diseases such as Alzheimer and Parkinson, and mental and consciousness disorders.

Preliminary experimental results indicate the method at hand could support a novel clinical practice which benefits both physiological and psychological response in a very short time. To further probe and establish the potential of the method, a bottom-up paradigm of research experiments is to be concluded over the coming two years to cover different aspects of the clinical and acoustical effects of spatial sound.

The research and experiments are conducted in collaboration with physicians, neuro-scientists, mathematicians, physicists, acousticians and audio engineers.



# The Effects of Spatial Sound on Human Wellbeing



## METHODS AND INSTRUMENTS

The Works Research Institute has a state-of-the-art research facility at the Tungram factory premises in Budapest, Hungary, incorporating means for spatial sound reproduction, recording and analysis, and physiological measurements:

- Sphere: sound-proofed fully spherical loudspeaker construct for a single person to sit within, offering a high-precision instrument for spatial sound projection and recording.
- 4DSOUND 2.0: spatial audio framework providing an advanced scripting environment for modelling sound shapes, transformations and configurations.
- Sigview Pro: software for audio analysis and spectrography.
- Cymascope Pro MF+: device for imaging audio input signals as Faraday Waves by acoustic excitation of a water-filled fused-quartz cuvette of various dimensional shape and size.
- Faraday Cage and Sonic Incubator to monitor the effect of sound on in-vitro blood cells.
- Physiological Measurements: 32-channel gNAUTILUS to measure Electro-encephalography (EEG), Blood Oxygenation level with functional Near Infra-Red Spectroscopy (fNIRS), Heart

Rate Variability (HRV), Galvanic Skin Response (ECG), Respiration, Blood Pressure (BP), Electrocardiogram (ECG) and hormonal responses of subjects.

- Behavioural Questionnaires: monitoring experience of wellbeing, a.o. psychological and emotional responses of participants.

## TIMELINE

The potential effects of AES on emotional, behavioural and physiological parameters will be further investigated in a line of experiments.

The first year of the research (2021) will focus on the documentation of acoustic phenomena underlying AES and the effect on healthy humans and extending hypothesis on its relation to harnessing energy in natural systems. The research will apply in specific the Geometric Sound (GS) component of AES, meaning perfect geometrical projections of spatial sound realised under laboratory conditions and documenting the resulting sound wave patterns and harmonic spectra associated with the projection.

The second year of the research (2022) will focus on further specified application of prior observed phenomena, continuing documentation of the effect on healthy humans and start targeting

specific research groups dealing with semi-acute conditions such as ADHD, PTSD and Depression in collaboration with medical experts. The research will focus on working with derived harmonic spectra and mathematical constants of inverted GS patterns, to observe if the derivative parameters of spatial coherence may result in the identical enhanced states.

The Works Research Institute aims for broad collaboration with other research institutes, universities and hospitals in the execution of studies, the development of methodologies and verification of obtained experimental data.

The research will be conducted in full responsibility to the wellbeing of the participating subjects. The bottom-up paradigm ensures a stepwise process of gaining valuable traction and ensuring the study is aligned to the highest standards of ethical conduct.

# The Works Research Institute



## TEAM

The Works Research Institute collaborates with an interdisciplinary team of researchers and scientists in the field of Neuro-Science, Psycho and Physio-Acoustics, Physics, Mathematics, Electro-Acoustics and Audio Signal Processing.

- **Paul Oomen**  
Head of Research and Development
- **Rona Geffen**  
Lead Medical and Sound Research
- **Dr. Amira Val Baker**  
Lead Physics & Mathematics
- **Prof. Dr. Christopher**  
Braun Clinical Neuro-Biology,  
Data Analysis, MEG-Center,  
University of Tübingen
- **Ia Mgvdliashvili**  
Software Prototyping
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# Appendix 1

## Acoustic Effector Stimulation - SOUND ENHANCING HOMEOSTASIS

### WHAT IS ACOUSTIC EFFECTOR STIMULATION?

Acoustic Effector Stimulation (AES) is a method of projecting symmetrically aligned sound wave patterns on the human body. AES, in combination with carefully chosen frequency and sound stimuli as audio input, may provide a means for physiological triggers that effectively guide the human body into enhanced homeostasis, as confirmed by data obtained from research.

### HOW DOES ACOUSTIC EFFECTOR STIMULATION WORK?

AES uses new methods in sound holography, such as Sound Shape Holography (SSH, Appendix 2) and Spatial Wave Transform (SWT, Appendix 3), to enable the projection of sound sources with a dimensional shape, size and density using omnidirectional loudspeakers and vibro-transducers.

The improved homeostasis of the body in response to the exposure of AES is indicated by measured significant decrease in Alpha-wave mean power and Alpha:Beta-wave power ratio of the brain activity (EEG), and measured significant decrease in the LF:HF power ratio of the heart rate variability (HRV) in subjects - as well as reported effects by subjects of reduced anxiety and stress, and increased deep relaxation, improved emotional balance and enhanced state of mental clarity.

A study, conducted according to the Helsinki Ethics Declaration, was executed throughout 2018-2020 involving 50 participating subjects. They answered MDQM Questionnaires pre and post-exposure to PSS and were monitored on Brain Activity (EEG) and Heart-Rate Variability (HRV). The data obtained shows the effects of the method compared to the base-state of the subjects and compared to other sound reproducing methods, such as stereo sound.

### WHAT CAN ACOUSTIC EFFECTOR STIMULATION BE USED FOR?

AES could yield future applications for stress-relief with potentially beneficial implications for a variety of areas in Healthcare, such as Integrated Treatment of Diseases, in particular PTSD, Epilepsy, Postpartum Depression, ADHD, Major Depressive Disorder (MDD), Patient Stimulation in Comatose and Vegetative State, Conditions relating Balance Disorders such as Ménière and Vertigo, Patients with Psychological and Psychiatric Conditions, Posture and Hearing Problems, Stress Related Autoimmune Diseases and General Illness, Heart Problems, Hearing Disorders, High Blood Pressure, High Blood Sugar, High Cholesterol, Chronic Headaches and Stomachaches, Fertility Problems, Erectile Disfunctions, Low Sex Drive, Irregular Menstration, PMS symptoms, Elevated or Decreased Secretion of Hormones Production, Tense Muscles and Ligaments, Insomnia, Heartburns, Mind Fog, Irritability, Increased Inflammation, Diarrhea, Ulcer, Stomach Cramps, Reflux, Nausea, Weight Fluctuations, Constipation, Indigestion and Nutrient Absorption and Palliative and restorative care.

Furthermore, AES could yield potential applications for general Stress-relief for patients, Stress-relief at workplaces, Stress-relief for students, Sound and Music therapy, Spa and Wellness Centers, Meditation Aids, Rehabilitation Centres, Psychiatric Centers and Hospitals.

### WHAT ARE THE BENEFITS OF ACOUSTIC EFFECTOR STIMULATION?

Based on the data obtained from research, AES could reduce stress faster than other methods, within less than 5 minutes. As such, the method may be specifically suitable for people with a short patience span such as people suffering from ADHD or cognitive conditions - or for bringing the body to a more optimal state shortly before operation or an MRI scan.

The method would require no prior instructions, training practice or specific skills, would not require constant practice and would be immediately effective. It would be physically non-invasive as no intake of substance by the subject would be required and no measured negating side-effects are present.

The method would be socially non-invasive as it can be done in private, it would not require physical contact with a specialist, removal of clothing, placement of apparatus on the body or any other actions by subjects that may be considered compromising.

### PUBLICATIONS

Method and System for Improving a Physiological Condition of a Subject (Oomen & Geffen, 2020, patent application N2026299, publication pending)



## Appendix 2

### Sound Shape Holography - PHYSICAL MODELLING OF SOUND REVERBERATION

#### WHAT IS SOUND SHAPE HOLOGRAPHY?

SSH is a new method for generating reverberation audio signals. SSH allows to effectively reproduce a reverberating space of a dimensional shape, size and density in dependence of the presence of sound sources and the observer in the virtual space. Similar to visual holography, SSH enables a listener to experience spatial depth and dimensionality of the sound from all directions and from any chosen perspective within space.

#### HOW DOES SOUND SHAPE HOLOGRAPHY WORK?

SSH obtains shape data by generating a resolution of particles defined on a shape and executes command-flow processes to calculate and filter out the essential data required for efficient, real-time acoustical modelling of a virtual space with a shape. The command flow process drives an audio signal process that encodes the spatial data into the audio waveform using a conversion of spatial dimensions to time, a Spatial Wave Transform (SWT).

#### WHAT CAN SOUND SHAPE HOLOGRAPHY BE USED FOR?

SSH consists of a dedicated audio signal process and command flow process, that can be used in stand-alone audio software or integrated as a module into digital audio plug-ins or audio processing systems.

Possible areas of application include Acoustical Modelling, Acoustical Correction Systems, Acoustical Enhancing Systems, Music Instrument design, Audio Production and Editing Software, Audio Plug-ins, Sound System Design, Streaming Services, Audio Plug-Ins, Audio-Visual Rendering Engines, Sound Distribution Systems, (Audio-Visual Media), Sound & Music Production, Real-time Game and VR Sound, Live Sound, Theatre Sound, Cinema Sound, Home Cinema and Home Sound Systems, Headphones with built-in DSP, Real-life Immersive Experiences (Entertainment), Sound Ambiance (Interior Design), Healthcare, Hearing-Aids (Sound-As-Medicine), Palliative and Preventive Care, Applications for Meditation-Aid, Mindfulness (Wellness), Digital Signal Processing, Acoustical Design and Engineering and Modelling of Data Sets (Scientific Methods).

#### WHAT ARE THE BENEFITS OF SOUND SHAPE HOLOGRAPHY?

SSH is a new technique that allows high-precision real-time modelling of virtual spaces with a distinct shape, size and materiality.

The technique can be applied for processing sound reverberation of virtually unlimited resolution, scalable from small to very large CPU requirements.

The technique allows quality output independent of the amount of loudspeakers used, ranging from application for mono and stereo sound up to very large scale multi-channel sound systems.

#### PUBLICATIONS

Method for Generating a Reverberation Audio Signal (Oomen, 2020, patent application N2026361, publication pending)

## Appendix 3

### Spatial Wave Transform - ENHANCING SPATIAL COHERENCE OF SOUND WAVES

#### WHAT IS SPATIAL WAVE TRANSFORM?

Spatial Wave Transform (SWT) is a technology applied for sound holography, where an audio signal is transformed into a 3-dimensional sound image. Using the principle of wave interference, complex data with regards to a sound source shape, size, distance, depth and height can be encoded in the audio waveform.

As a result, the projected sound image increases in spatial coherence and becomes more stable. The presence of the loudspeakers reproducing the sound is masked and instead one experiences the projected sound source to be physically present in the room.

#### HOW DOES SPATIAL WAVE TRANSFORM WORK?

SWT is an algorithm that defines time as a function of spatial dimensions. The time intervals of the wave interference produce interlocking at given frequency ratios and this encodes the spatial information in the waveform as complex resonance quanta.

#### WHAT CAN SPATIAL WAVE TRANSFORM BE USED FOR?

SWT is a building block for integration in digital and analogue audio processing systems.

Possible areas of application include Music Instrument design, Audio Production and Editing Software, Sound System Design, Streaming Services, Audio Plug-Ins, Audio-Visual Rendering Engine, Sound Distribution Systems (Audio-Visual Media), Sound & Music Production, Real-time Game and VR Sound, Live Sound, Theatre Sound, Cinema Sound, Home Cinema and Home Sound Systems, Headphones with built-in DSP, Real-life Immersive Experiences (Entertainment), Sound Ambiance (Interior Design), Healthcare, Hearing-Aids (Sound-As-Medicine), Palliative and Preventive Care, Applications for Meditation-Aid, Mindfulness (Wellness), Acoustical Modelling, Architecture (Auralisation), Digital Signal Processing, Acoustical Design and Engineering, Data Sonification, Modelling of Data Sets and Spectral analysis (Scientific Methods).

#### WHAT ARE THE BENEFITS OF SPATIAL WAVE TRANSFORM?

SWT provides great benefits over simulation-based audio processing, as the encoding is based on wave interference instead of finite data sets. This yields more depth and higher precision of sound holography while requiring significantly less processing power.

The method enables the design of new audio technologies while also being fully backwards compatible with existing audio reproduction formats.

#### PUBLICATIONS

Generating an Audio Signal Associated with a Virtual Sound Source (Oomen, 2020, patent application N2025950, publication pending)





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