Exploring the Morphological Aesthetics of Sound: Insights From Cymatics and Sandboxes

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Abstract
The Sandbox Game has been extensively explored in pediatrics and psychiatry, highlighting tactile and sensory engagement's mental and emotional benefits—mainly through interaction with sand. Such engagement fosters self-awareness, stress reduction, and overall emotional well-being while promoting a deeper connection to the present (Knudsen, 2023; Malonai, 2023). The multisensory stimulation provided by sand—combined with sound-based tools and visual interactions with geometric patterns—is a core element of mindfulness practices aimed at enhancing psychological health (Gibson, 1979; Joye & van den Berg, 2011). In the artistic research project "Cymatic Artifact" (2021-2023 UBB), we explored the transformative properties of sand and its resonance with other materials, investigating its potential to contribute to well-being through tactile engagement. We examined how natural elements—such as dunes, wind, and sound geometry via bamboo sections functioning as wind organs or sound gardens—can be integrated into therapeutic environments (Chladni, 1787; Castro & Pássaro, 2017). Our findings suggest that incorporating these elements can significantly enhance the design of therapeutic products and artistic installations. This research underscores the role of creative processes in harnessing sound energy to develop innovative design objects, such as ceramic spheres with textured surfaces inspired by cymatic patterns, thereby advancing both artistic and practical knowledge in design and well-being (Borgdorff, 2010; Blessing, Qureshi, & Gericke, 2013; Knudsen, 2023).

Keywords: Cymatics, Therapeutic Design, Multisensory Interaction, Sound-Driven Design, Material Exploration

Introduction

The interaction between sound and various states of matter reveals an intriguing morphological and aesthetic language that can be explored from multiple disciplines, including physics, psychology, and design. This exploration highlights how sound, typically perceived as an auditory experience, can simultaneously manifest visually in geometric patterns caused by vibration. These patterns, created in granular materials such as sand, serve as a visual representation of sound waves in motion. By examining these phenomena, one can uncover how sound waves, influenced by factors such as frequency and amplitude, translate into observable forms that provide insight into the complex relationship between sound and matter (Jenny, 1967; Frayling, 1993). In this context, sound does not merely interact with the environment but actively shapes it, producing an intricate choreography of geometric forms that speak to the underlying forces at play.

The phenomenon of standing waves consists of the interaction of sound waves, which are parameterized by variables such as amplitude, frequency, and wavelength. These waves interact with surfaces in specific ways, creating regions of constructive interference (nodes) and destructive interference (antinodes), which can be observed visually in granular materials such as sand. The ability to manipulate and observe these patterns provides a unique opportunity to study the behavior of sound in various materials. In liquid media, these waves produce transient patterns that dissipate once the sound ceases, but in semi-formed materials like sand or salt, the patterns persist, leaving behind a record of the sound's impact. This phenomenon reveals the self-organizing capacity of certain materials when exposed to specific types of energy, such as sound waves (Grillotti, 2019; Jenny, 1967). This ability to preserve geometric patterns offers a compelling insight into the intersection of physical forces, material behavior, and sensory perception.

In the realm of cymatics, the study of these geometric patterns goes beyond their aesthetic beauty. These patterns are not only visually captivating but also reveal deeper insights into the physical processes through which sound influences matter. The creation of these forms is not random; rather, it is the result of complex interactions between sound waves and the medium they traverse. This phenomenon has profound implications, not only for our understanding of acoustics and material science but also for its potential applications in human well-being (Knudsen, 2023; Delle Monache & Rocchesso, 2021; Ruz et al., 2010). Through the analysis of cymatic patterns, researchers have discovered correlations between these geometric forms and potential therapeutic benefits, suggesting that the careful manipulation of sound and its geometric representations can have a positive impact on emotional and cognitive health.

This article builds upon previous research conducted by the same authors, incorporating new insights and updates based on the ongoing exploration of design methodologies. The original publication laid the groundwork for understanding the significance of cymatics and sound-driven design, while this version expands upon that foundation by incorporating contemporary developments in design theory and material science. The translation of this research ensures that the core findings remain intact, while adapting the content to fit the specific context of the current study. This process highlights the continuity of the research while introducing innovative approaches that reflect the evolving nature of the field. The work is part of the proceedings from the Congreso Cultura Proyectual, held in Santiago, Chile, in October 2024, and serves as a continuation of the authors' investigation into the intersection of art, science, and design.

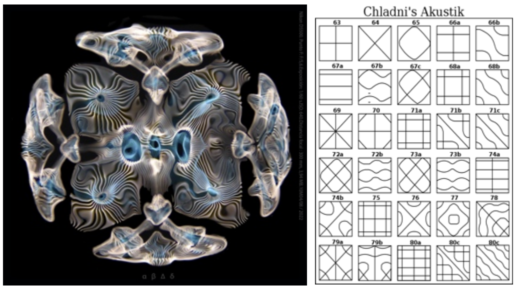

Figure 1: (Left to Right) Cymatic Sand Record, Liquid Cymatics
(Source: Author), Chladni Figures (1852)

Materials and Methods

The methodology of this research is grounded in procedural design, integrating insights from multiple fields of knowledge, including acoustics, material science, and user-centered design. Sound-driven design (SDD) has emerged as a novel practice within design, focusing on the multisensory aspects of sound interactions and their potential impact on human well-being (Delle Monache & Rocchesso, 2021). By incorporating sound into the design process, this approach seeks to enhance the sensory experience of users, fostering a deeper connection with the environment and promoting emotional and cognitive well-being. Our approach builds on proven procedural design strategies, drawing from previous experiences in sound design and therapeutic practices, while proposing a more specialized integration of sound and material interaction in the design of cymatic artifacts.

To achieve the goals of this project, we adopt the Research through Design (RtD) methodology (Blessing et al., 2013; Frayling, 1993). RtD is characterized by its dual focus on both theoretical foundations and practical applications, providing a hybrid approach that incorporates both qualitative and quantitative research methods. The process of designing prototypes and models plays a central role in RtD, allowing for iterative testing and refinement of design concepts. Prototypes act as crucial verification tools, facilitating the exploration of various media, processes, and materials, and enabling designers to test their hypotheses in real-world settings. Through this iterative process, the research itself becomes a dynamic system of feedback and refinement, enhancing the understanding of how design can influence sensory experiences and their associated outcomes.

The research is organized into three primary stages: (a) Artistic Installation; (b) Reproduction, Digitization, and Cymatic Materialization; and (c) Design Project Process. Each stage builds upon the previous one, integrating artistic and scientific principles to explore the relationship between sound, materials, and human well-being.

Artistic Installation

The design of this cymatic artifact is inspired by the geometric patterns created when sound interacts with granular materials such as sand. These patterns serve as a visual representation of the sound waves at play, providing valuable insights into the relationship between sound and form. To capture these patterns, sound recordings were made in the AOIR laboratory, as well as during an artistic installation conducted in 2023 in the Yani dunes (Quidico / 37°23'16"S 73°36'44"W). The installation utilized the resonance capabilities of sand, wind, and bamboo sections, which acted as a natural wind organ. These elements were carefully chosen for their ability to amplify sound and create a dynamic interaction with the surrounding environment, producing a rich array of sound patterns. The recordings were captured using specialized instruments, including geophones for low-frequency vibrations and condenser microphones for higher frequencies, allowing for a detailed exploration of the sonic phenomena involved.

Figure 2: (Left to Right) Yani Dunes, Sound Installation AOIR Laboratory, Teja Verde Website

Reproduction, Digitization, and Cymatic Materialization

The recordings obtained from the artistic installation were processed using advanced audio editing software, which allowed us to isolate and manipulate specific sound frequencies to stimulate granulometric patterns. These patterns were then reproduced using Chladni plates, which provided a physical medium for observing the interaction of sound with granular materials. The frequencies used in this process included those known to have potential health benefits, such as alpha (8-13 Hz), beta (14-29 Hz), and gamma (30-100 Hz) waves, as well as Extremely Low Frequencies (ELF) that are inaudible to the human ear but are present in the Earth's electromagnetic spectrum (Ruz et al., 2010; Macleod & Holdridge, 2006). By studying these frequencies and their effects on materials, we hope to uncover new insights into the therapeutic potential of sound-driven design.

Parametric Design Technology and Digital Processes in Translating Cymatic Geometric Patterns

The role of digital technologies in materializing complex forms has become increasingly important in creative design processes. Computational tools, particularly those used in parametric design and algorithmic programming, enable designers to generate highly precise forms that mimic natural phenomena such as cymatic patterns. These digital tools offer several advantages, including greater accuracy, reduced energy consumption, and a lower environmental impact compared to traditional methods (Berridge & Robinson, 2003). Additive manufacturing techniques, such as 3D printing, have proven to be particularly effective in capturing intricate geometric patterns, allowing for the rapid prototyping and testing of cymatic designs (Grillotti, 2019). These technologies enable us to explore new ways of materializing sound and geometric patterns, offering a bridge between artistic expression and scientific inquiry.

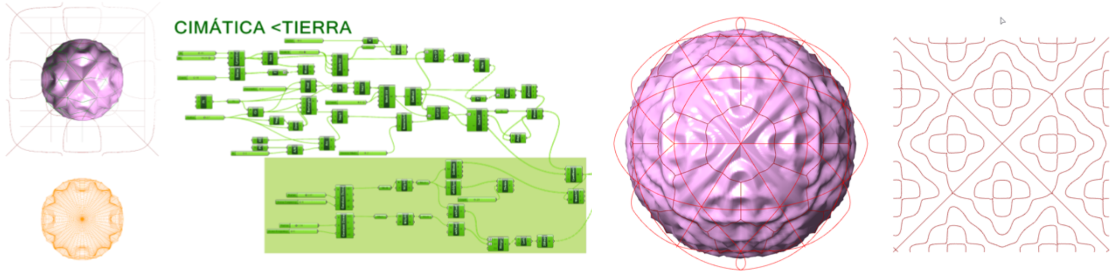

Figure 3: (Left to Right) Parametric Programming, Rhinoceros & Grasshopper. Parakeet Plugin. Cymatic Frequency on Copper Sheet. Sphere With Texture, According to Cymatic Geometric Patterns

Sand, Ceramics, and Biophilia

Biophilia, the human tendency to connect with nature and other living organisms, plays a key role in the design of objects that promote well-being (Kellert & Calabrese, 2015). In the context of our research, biophilia informs the design of cymatic ceramic pieces, which are intended to foster a deeper connection with the natural environment. By incorporating natural materials and organic forms into the design of these artifacts, we aim to enhance emotional and psychological well-being. The interaction between users and these objects encourages a sense of connection to nature, which can lead to improved cognitive and emotional flexibility (Joye & van den Berg, 2011; Malonai, 2023).

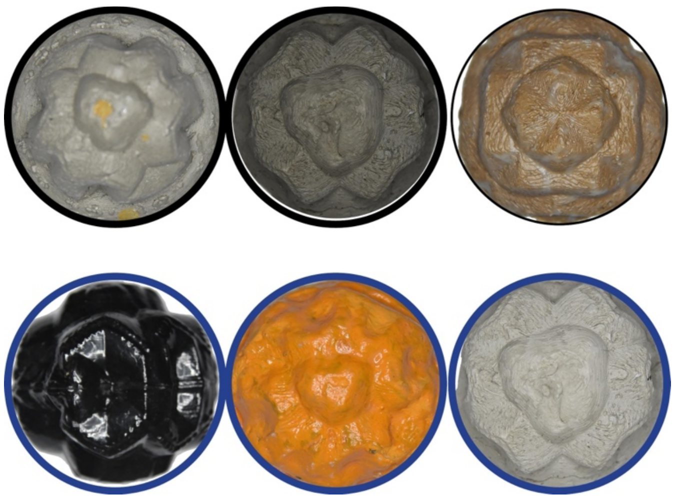

Figure 4: First Prototypes in 3D Printing at Low Resolution and 1 mm Extrusion. Studies of Proportion and Hapticity

For this project, we collaborated with Teja Verde Ecodiseño (Chile Diseño, n.d.), a ceramic design studio, to create high-quality ceramic pieces that combine artistic and therapeutic elements. The ceramics were first modeled using PLA 3D printing before silicone rubber molds were created to capture the intricate geometric details. These molds were filled with high-definition clay pastes, resulting in finely crafted cymatic ceramic pieces that serve as both aesthetic objects and therapeutic tools.

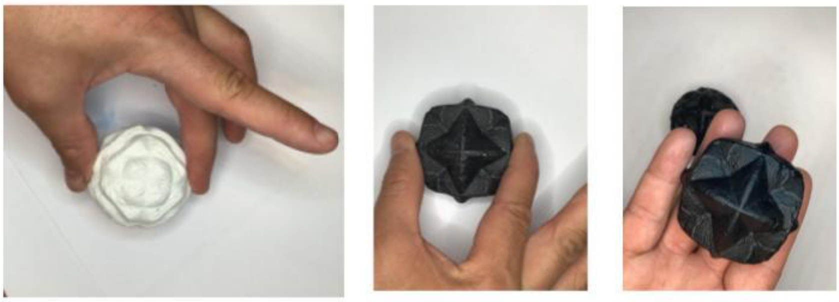

Figure 5: Study of Hapticity, Types of Clay, and Finishing Alternatives (Source: Author)

Results

Cymatic Artifact Exhibition:

- Museum of Natural History, Concepción. December 2023
- Cymatic Artifact Exhibition: College of Architects of Concepción. January15th to 23rd, 2024

Object syntax of the exhibition consists of three essential components:

a. Set of cymatic spheres based on sound recordings (3)
b. Backlit LED sand table (1)
c. Reproducible sound source via QR code (3)

Figure 6: Prototypes Set Outcome Display. Exhibition at the Museum of Natural History, Concepción (Source: Author)

Conclusion

The research conducted over the past two years has opened new avenues for understanding the relationship between sound, design, and human well-being. Our findings suggest that the design process can have a significant impact on the sensory experiences of users, potentially offering therapeutic benefits. At this stage, we consider the results as preliminary but promising, as they provide a foundation for future exploration. The next steps will focus on testing and optimizing the components, pieces, and processes to refine the design methodology and validate the theories presented in this work. Through continued research and development, we hope to contribute to the growing field of sound-driven design and its potential applications in improving human health and well-being (Blessing et al., 2013; Frayling, 1993).

Figure 7: Infographic Poster of Cymatic Artifact Exhibition at the Museum of Natural History, Concepción (Source: Author)

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