SPACES THAT PERFORM THEMSELVES

By: Nicole L'Huillier
Bachelor of Architecture, Universidad de Chile, 2010

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning, in partial fulfillment
of the requirements for the degree of
MASTER OF SCIENCE IN MEDIA ARTS AND SCIENCES
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

August 11 2017 [September 2017]

spaces that perform themselves

spaces that perform themselves

Signature of Author: Signature redacted

Nicole L'Huillier, Program in Media Arts and Sciences
August 11 2017

Certified by: Signature redacted

Tod Machover, Muriel R Cooper Professor of Music and Media and Director of the Media Lab's Opera of the Future group

Accepted by:

Prof. Pattie Maes, Academic Head, Program in Media Arts and Sciences

SPACES THAT PERFORM THEMSELVES

Nicole L'Huillier

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning on August 11, 2017, in partial fulfillment of the requirements of the degree of Master of Science in Media Arts and Sciences at the Massachusetts Institute of Technology.

spaces that perform themselves

ABSTRACT | Building on the understanding of music and architecture as creators of spatial experience, this thesis presents a novel way of unfolding music's spatial qualities in the physical world. *Spaces That Perform Themselves* exposes an innovative response to the current relationship between sound and space: where we build static spaces to contain dynamic sounds. What if we change the static parameter of the spaces and start building dynamic spaces to contain dynamic sounds?

A multi-sensory kinetic architectural system is built in order to augment our sonic perception through a cross-modal spatial choreography that combines sound, movement, light, color, and vibration. By breaking down boundaries between music and architecture, possibilities of a new typology that morphs responsively with a musical piece can be explored. As a result, spatial and musical composition can exist as one synchronous entity.

This project seeks to contribute a novel perspective on leveraging technology, design, science, and art to provide a setting to enrich and augment the way we relate with the built environment. The objective is to enhance our perception and challenge models of thinking by presenting a post-humanistic phenomenological encounter of the world.

Thesis Supervisor:
Tod Machover, Muriel R. Cooper Professor of Music and Media and Director of the Media Lab's Opera of the Future group

SPACES THAT PERFORM THEMSELVES

By: Nicole L'Huillier
Bachelor of Architecture, Universidad de Chile, 2010

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning, in partial fulfillment
of the requirements for the degree of
MASTER OF SCIENCE IN MEDIA ARTS AND SCIENCES
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

August 11 2017

The following people served as readers for this thesis:

Signature redacted

Accepted by:

Dr. Joseph A. Paradiso, Thesis Reader, Alexander W. Dreyfoos Professor at MIT's Program in Media Arts and Sciences, Director of the MIT Media Lab's Responsive Environments Group

spaces that perform themselves
spaces that perform themselves

SPACES THAT PERFORM THEMSELVES

By: Nicole L'Huillier
Bachelor of Architecture, Universidad de Chile, 2010

Submitted to the Program in Media Arts and Sciences,
School of Architecture and Planning, in partial fulfillment
of the requirements for the degree of
MASTER OF SCIENCE IN MEDIA ARTS AND SCIENCES
at the
MASSACHUSSETTS INSTITUTE OF TECHNOLOGY

August 11 2017

The following people served as readers for this thesis:

spaces that perform themselves

spaces that perform themselves

Accepted by Signature redacted

Craig Dykers, Thesis Reader, Founding Partner at Snohetta, Architect, AIA, LEED AP, hon FRIBA, FRSA, RAAR

SPACES THAT PERFORM THEMSELVES

Nicole L'Huillier

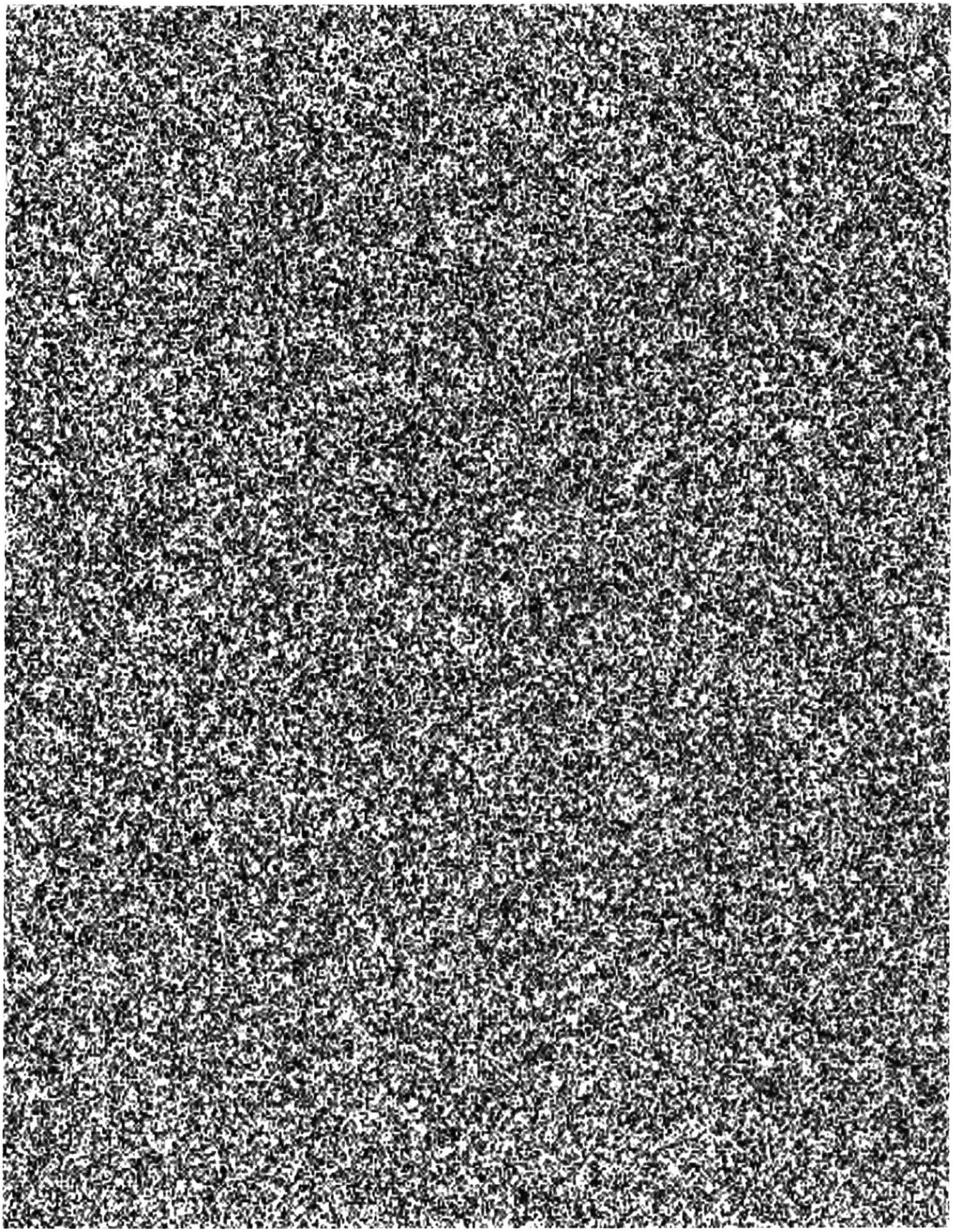
spaces that perform themselves

ACKNOWLEDGEMENTS |All the ideas, passion, inspiration and fun come from the people around me. I am fortunate to be part of this universe with all of you. Especially Juan Necochea, who not only helps me to build a life every day, but also helped me to build this thesis project from the very beginning to its end. I also want to thank Tod Machover for his constant support and guidance, which made this process an extremely fun and exciting learning and growing experience. I want to thank my readers Craig Dykers and Joe Paradiso for their time and valuable feedback, these have been essential to develop richer ideas. Thanks to all the dear friends that not only worked with me, but also gave me endless support and inspiration to achieve this dream: Tal Achituv, Thomas Sanchez Lengeling, Alexandra Rieger, Penny Webb, Miguel Perez, Miriam Simun, Xin Liu, Jan Casimir, Phil Tinn, Kevin Shum, Gabriel Li, Victoria Ouyang, Chantine Akiyama, Sarah Hua, and all the Opera of the Future group.

This research was supported by the Opera of the Future group at the MIT Media Lab, as part of the Program in Media Arts and Sciences. Partially funded by the Council for the Arts at MIT, thank you so much for that!

spaces that perform themselves

contents



SPACES THAT PERFORM THEMSELVES
INTRODUCTION

CONTEXT | This thesis presents an exploration of how motion and time give and guide the many layers of meaning that compose our spatial experience. It will explore how the distinct character of a space emerges from the interaction between itself and one or more individuals. It will also address how this interaction can transform multiple physical surfaces into a narrative that people can engage with. This thesis will propose a parallel between spatial composition and music composition. To describe music, we use architectural and spatial vocabulary; because music unfolds over time, it is frequently equated with architecture. Music indeed has kinetic and gestural spatial qualities that are performed in time and are embodied by a listener. Furthermore, music's relationship with one or more individuals is what gives meaning and sense to its innate form and sonic structure; it builds an enveloping experience in time, making music a simultaneous space creator.

The study of the relationship between sound and space, or music and architecture has been fundamental to the opening of new explorations towards the expansion and merger of both fields. In the second half of the 20th century, many creators explored this in experimental ways. Contributions such as Stockhausen's sound spatialization[1], La Monte Young and Marian Zazeela's Dream House[2], and Bernhard Leitner's sound architectures[3], to name a few, revealed expressiveness and malleable capacities of spatial sonic experience, as well as opening an extensive discourse around musical spaces and plastic architectures. Many of these creations –for example Le Corbusier's Philips Pavilion[4] or Xenakis' Polytopes[5] – were supported by moving image projections and/or sound reactive light installations. Despite these additions, the buildings containing the experiences remained static: heavy concrete structures unchanged by sound and unable to move or morph. Today we have the technological means to push

this further.

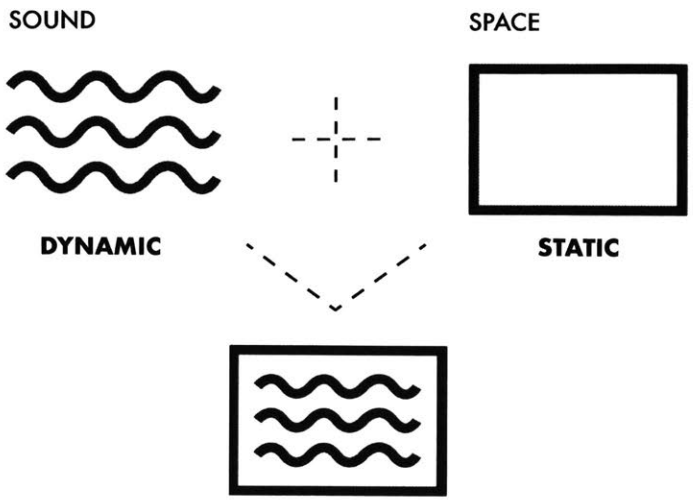
Cedric Price's Fun Palace[6] proposed a cybernetic architectural system that could adapt depending on the varying necessities of individuals and its context. Today this vision is no longer considered to be a utopia, as shown in the work of researchers like Behnaz Farahi[7], Ruairi Glynn[8], Skylar Tibbits[9] and Michael Fox[10], which have opened engaging possibilities to augment the interaction between humans and dynamic forms of the built environment.

Spaces That Perform Themselves continues and extends the discussion from a sonic-spatial perspective; it poses the question: how does a kinetic architectural system change the way we think about and perceive sound? This project's objective is to create a new relationship between sound and space: currently, we generally build *static*[11] spaces to contain *dynamic* sounds, but what if we start building *dynamic* spaces to contain *dynamic* sounds? By integrating kinetic behavior as part of the performance of a space, one is able to give life to a container that morphs along with a musical piece: bringing to life an emerging aesthetic form of expression, augmenting the field of exploration that combines architecture, music, science and technology.

OBJECTIVES | This thesis seeks to present an architectural typology that re-configures itself and presents a multi-sensory scenario to perceive sound. *Spaces That Perform Themselves* is a project that will allow music to give shape to a dynamic room that is both alive and in constant flux: it moves, changes its geometry and size, breathes, feels and responds. This room will take the shape of a cube that can host one individual at a time, presenting an intimate and personal experience.

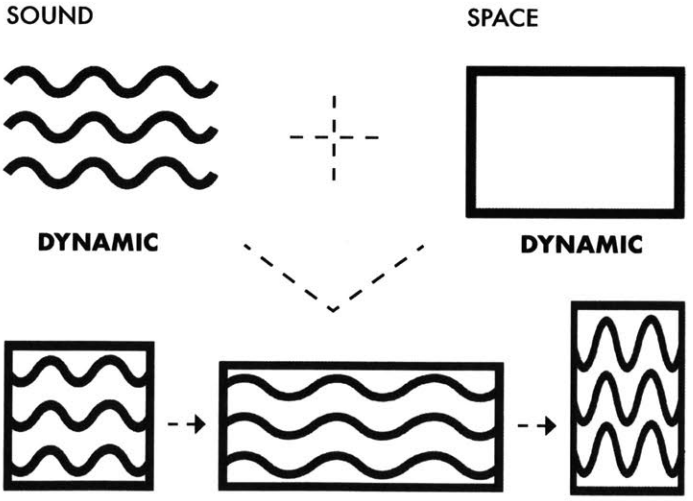
Through digital mapping, musical input will power the re-

1. Dynamic sounds contained by a static space diagram
2. Dynamic sounds contained by a dynamic space diagram



1

introduction



2

configuration and spatial organization of this cube. By creating the perception of a single space that morphs along a progression of sonic situations, this room will have the ability to become "many rooms" within the same structure. A synchronous choreography of sound, motion, vibration, light, and color will shape this perceptual experience, confounding the senses and giving the possibility of inducing different mental states.

The body of the room is in the form of a 6'x 6' cube. This is a cube without a bottom that is suspended over the floor. The opening beneath the cube allows a person to enter it. To access the cube, the individual will need to bend down and then emerge into the cube's interior. This action resets our normal sense of presence by forcing an unusual bodily action, and by doing this, it reinforces the idea of stepping outside of the world we know in order to encounter a completely distinct environment. The five inner faces of the cube feature a mechanical system of rack and pinion, which engages acrylic rods to actuate flexible fabric walls. These walls will adopt different shapes and positions, creating a malleable room. By embedding sensors in the environment, the room can react; it becomes responsive and interactive.

Every experience is the result of a cumulative phenomenological encounter with the world, in which perception plays a key role. Through perception, human beings are able to understand and represent our environment. In other words, our bodies mediate the experience of being in the world. This characteristic of perception allows us to simultaneously interact with objects in space and individuals within them. This is supported by Merleau-Ponty's[12] and Bergson's[13] theories of how the world makes sense through experience and our embodied existence in time. In other words, how all of our knowledge comes to us through sense data.

introduction

In the exploration of spatial experience and its relationship to the phenomenon of sound, it is imperative to understand how sound and space are linked: as we generally experience on earth, there is no space without sound and sound carries the essence of the space it is embodied in. To be able to explore this further, it is necessary to have in mind notions of acoustics and acoustemology[14]. These fields of study are essential for an optimal achievement of a sonic-spatial composition, because both reflect the constitutional relationship between sound, space, and experience. They define how the characteristics of a space will affect the way we perceive sound, derive meaning therefrom, and in turn, how the characteristics of sound will affect the perception of a space and its experience.

By encountering a dynamic room that morphs and reacts to dynamic sounds, it is possible to reconstruct the way we think about space and its relationship to sound. This encounter allows us to compose a mind-expanding and field-augmenting choreography of music and architecture. As a result, unusual possibilities are triggered challenging systems of thinking, making us aware of our bodies in an emotional relationship with space, sound and time. To support this idea, Juhani Pallasmaa[15] suggests the concept of *Architecture of the Senses* and writes about the importance of cross-modal experience exploration in order to engage novel sensory and emotional possibilities of human-spatial perception, communication, and interaction. This idea promotes the creation of further unusual, unconventional and awe-inspiring environments with the capacity of bringing to life a space with which we can establish a dialectic relationship.

In compiling the selective phenomenological terminology to understand the multi-sensory ways that we perceive

introduction

sound, we have revised the importance of both a) the person's perception and b) its relationship between sound and space. Additionally, it is important to add c) the relationship between bodies and space. In order to do so, we must clarify that the notion of space that this thesis will address is the uniform boundless medium where things are organized in three dimensions, thus enabling encounters between animated and unanimated bodies.

In order to understand the mediation that connects space to bodies, we must explore the body-and-space relationship. A scenario that represents a regular body-and-space relationship can be typified by imagining an individual inside an architectural body, for example, a person sitting inside a container composed of static walls. Due to the simplicity and familiarity of static architectural bodies, an individual in this specific situation can easily understand and predict his or her interaction with this scenario. In other words, it is not a challenging situation for him or her to experience due to our accustomed experience of encountering rooms with fixed structures.

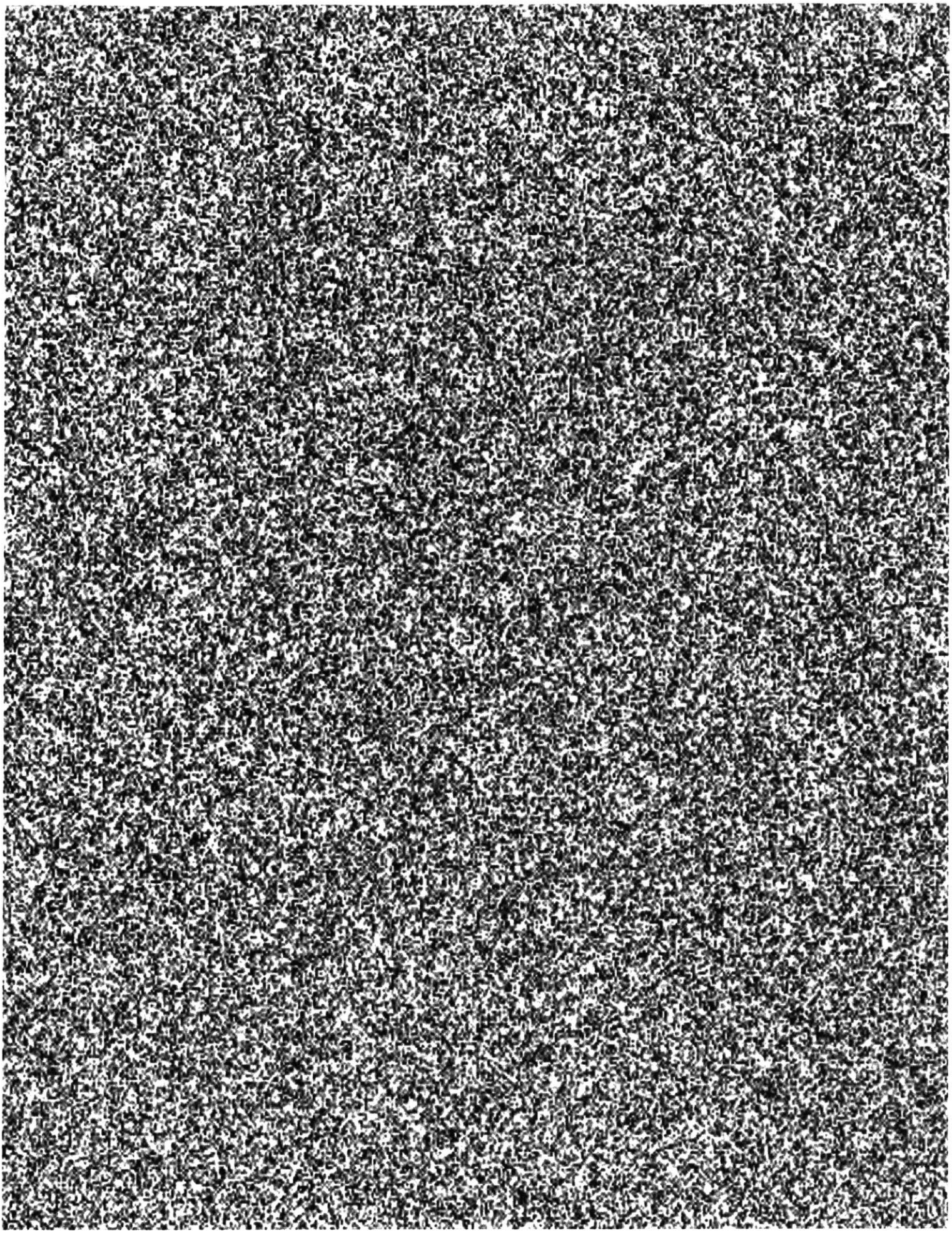
However, the individual's ability to understand and predict the body-and-space relationship becomes increasingly more complex if, in the previously mentioned scenario, the architectural body is replaced by a natural body. A natural body is an organic container that is dynamic in its essence and presents an unpredictable and ever-morphing constitution. When an individual is placed inside a natural body, he or she is challenged to maintain continuous cognitive connections to the ever morphing space relationships inside the kinetic container. As it is in the case of when a room is constantly changing or evolving, it demands more of our attention to be able to understand our relationship to it. To exemplify the complexity of this situation, we can compare it to when we meet a person with whom we have to collaborate for

the first time. In order to achieve our objective, we must be cognitively attentive to a great deal of information to determine the best way to interact with them in order to reach our goal.

To re-create a natural body interaction, this thesis will be accompanied by the construction of a cube that will interact with individuals to create a platform for embodied cognition. The cube will mimic closely the characteristics of a natural body. The cube will require the individual to establish a dialogue with it, thus creating a multi-sensory conversation of stimuli within the cube. The cube's natural body features include dynamic motion, sound, light, color and vibration. It will be able to combine these features to perform a dynamic composition, transforming it into what Bruno Latour would call an *Actant*[16], or enhanced body of "Vibrant Matter", referencing Jane Bennett's[17] vital materialistic theories. The cube becomes a sentient agent that aims to construct a relationship with other individuals.

OUTLINE | This thesis is organized as follows. Chapter II presents the conception and design of the cube's body, analyzing its shell, its guts, and its brain: its architectural, electronic and computational structure. Chapter III explores the cube's expression: the embodiment of movement and choreographic capacities. Finally, Chapter IV presents the construction of a relationship: between the cube and an individual. This way, this thesis unfolds the foundations of a novel musico-spatial aesthetic expression, where the piece is an experience of sound that is choreographed by a dynamic space and embodied in an individual's relationship to it.

noitcubortni



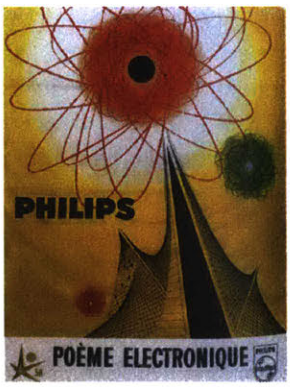
I.I TOWARDS A SONIC SPATIAL COMPOSITION | The manifestation of music as an experiential fact is an act of experience that comes from interaction. It must be understood not as an object that the listener observes from a distance, but as an enveloping phenomenological encounter. The musical experience is given by the contact of a musical object and a human subject. This encounter is physical and the sound acts as the container of the experience, becoming a space.

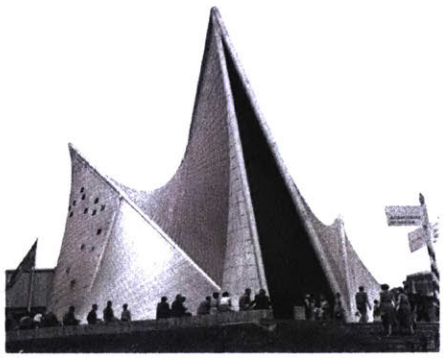
When music is heard, it is being embodied by the listener. It is in this experience that music is given the possibility of making itself meaningful by creating strong affective associations to its listener's memories.

The spatiality of sound and music rest on its material characteristics. These are granted by the person's embodiment and not by the music or sound's objectual initial form. It is not about the object that you can surround, it is about the material that contains you.

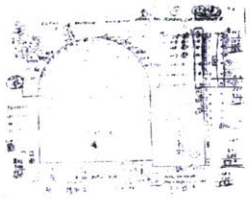
Many musicians, architects, artists, and experimental researchers seek ways to link sound and space. The necessity of doing this comes from the urge of connecting the material dimension of buildings and the immaterial dimension of the sonic container. The understanding of this could help model how the psyche expands towards new perceptual models of relating with the world.

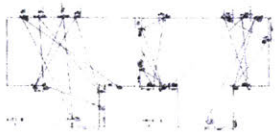
background





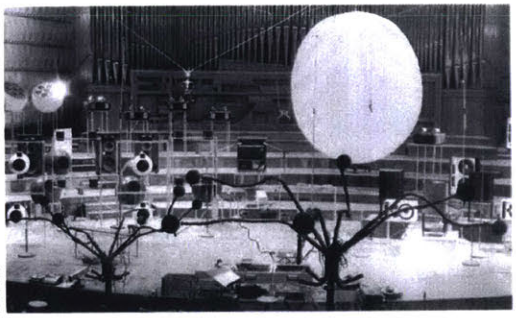
The Philips Pavilion, 1958 by Le Corbusier and Iannis Xenakis. It was made to host the performance of "Le Poème Electronique" composed by Edgar Varèse, and the projection of a composition of selected videos and moving images by Le Corbusier. The experience lasted 8 minutes and was a completely new thing at the time. People were genuinely impressed by the projections and sounds. Many didn't liked it and the pavilion was very criticized. People even got scared and overwhelmed during the performance. It really left a mark on those who experienced it.





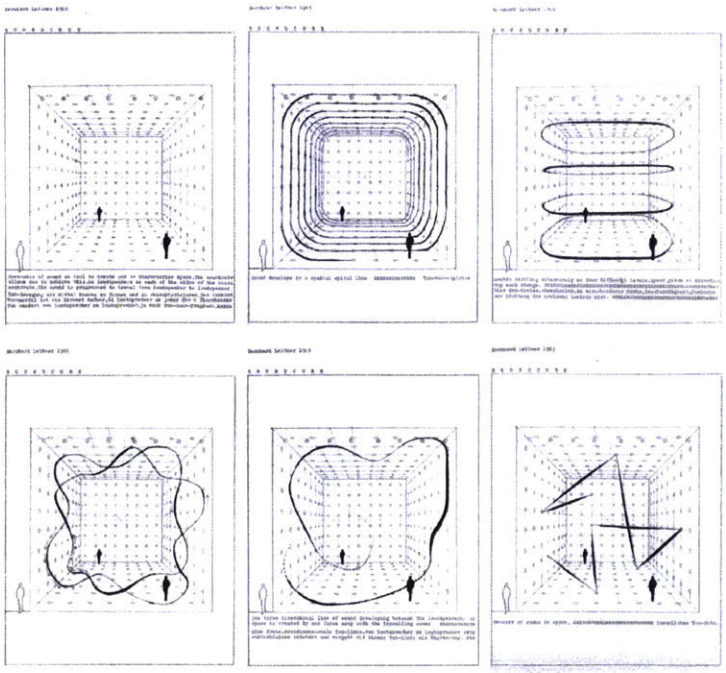
"The Polytope" was a multi-sensory typology created by Iannis Xenakis. It overlaps light, color, sound, and architecture to construct an immersive experience. The space was completely dark and was filled with extremely loud multi-channel audio, and bright light from laser beams. These elements created a very experimental space that delivered an impressive experience. After the 20-minute performance, people came out of this changed. This is a great example of how to compose for the senses. Though it was known to be a not very pleasant experience, as it was very aggressive and crude.

For the 1970 World Expo in Osaka, Germany built the world's first spherical concert hall. Karlheinz Stockhausen was leading the project along with a team of architects and audio technicians. Fifty groups of loudspeakers were arranged all around its structure. This way, the audience that was placed at its center could enjoy the complete spatialization of sound in three-dimensions. During 180 days, there were daily performances of Stockhausen compositions, other electro-acoustic commissioned work, as well as adapted pieces for this environment. Unfortunately, after the Expo, it was destroyed.

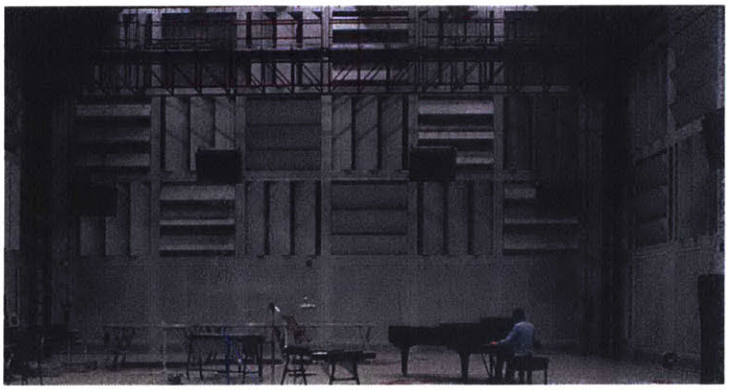


Disposition de l'acousmonium pour la création de l'œuvre « Erosphère » de François Bayle au grand auditorium de la Maison de Radio-France en 1980 (Ruszka).

The "Acousmonium" was conceived and created by François Bayle in 1974. Its primary objective was to host the performance or diffusion of acousmatic composition, though it was also used for other electro-acoustic pieces. This environment was specially designed for listening. It was composed by an orchestra of speakers placed in front, around, and among the audience. This multi-channel set up provides all the flexibility for unique configurations and movements of sound around the hall.



Soundcube, 1969-1970, Bernhard Leitner
"Movement of sound as tool to create and to characterize space. The soundcube allows one to achieve this. 64 loudspeakers on each of the sides of the xxxxx soundcube. The sound is programmed to travel from loudspeaker to loudspeaker. Sound spaces are in substance spaces of time. Their form is composed of sequences of part-spaces in time. Space is created, evolves, only to end again." Text credit: Bernhard Leitner.



The IRCAM Performance Hall is a concert hall that can be "tunned" to specific music keys or resonances by rotating 171 motorized panels. These panels have 3 parts and they are meant to change the acoustics of the room by affecting reflection, diffusion, and absorption. These acoustic properties can be changed independently or create three mixed properties: reflection-diffusion, reflection-absorption, diffusion-absorption). This hall is a model for later morphing sonic environments and kinetic acoustic panels. In spite of being very innovative, the system presents a lot of noise and is not as flexible as desired.

The "Dream House" is a Sound and Light Environment that is part of an Extended Exhibition at MELA Foundation, NYC, since Fall 1993. On this immersive installation, Young and Zazeela created an environment that changes upon the movement of the body. The space evolves and moves around the listeners. Loudspeakers constantly play extended durations of frequencies in the room, the body's movement between one source and the others will create changing sounds using the position of the body as the kinetic tool of this spatial composition.

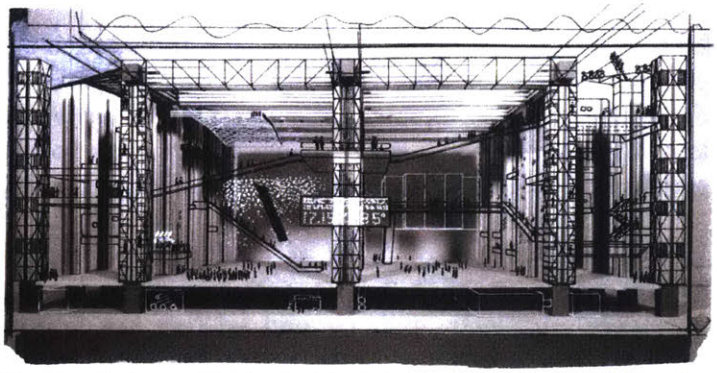
I am sitting in a room (for voice on tape) by Alvin Lucier, 1969. For this performance, Lucier read a text into a microphone and recorded while speaking. The text is a descriptive note about the actions he is doing and what will happen to the sound. Once the text ends, the recording is played back into the room and recorded again. This action was repeated in a loop. With each interaction, the recording started to change with the acoustic characteristics of the room. By the end, the voice is completely lost and mixed into the sonic landscape of frequencies of that particular architectural space. Lucier reveals a presence of sound that we are not used to appreciate at a first glimpse.

I.II KINETIC ARCHITECTURES | Envisioning mega structures as puppets that can be controlled and directed was immense during the postwar utopian movements. Today's motivation towards kinetic design is more about ceding the control and creating a symbiotic relationship with the built environment.

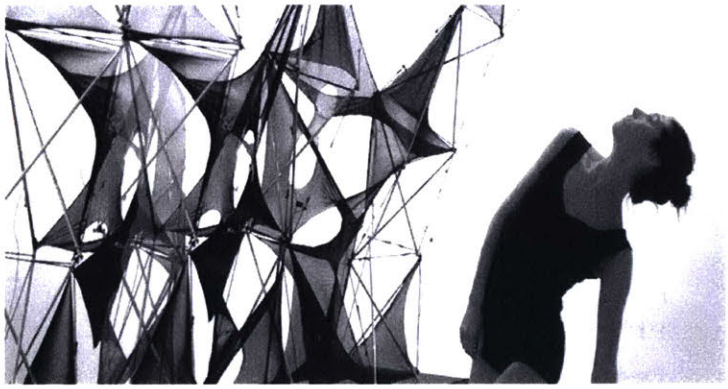
Among the pioneers of the cybernetic architecture, it is fundamental to mention the research and work done by engineers, architects, authors, and futurists like Gordon Pask, William Zuk, Roger Clark, Cedric Price and Nicolas Negroponte.

Kinetic architecture relates to the idea of giving life and agency to structures. When spaces move, they not only transform what we understand as a building, but they also change our presence in it. Their movement makes us aware of our body's relation to change and time. Interactive or kinetic architectures have the power to mutate our physical and psychological milieu. The plasticity of a building is not only related to its capacity to move, change and evolve, but it also has to do with conquering and developing our own plasticity and evolution as humans.

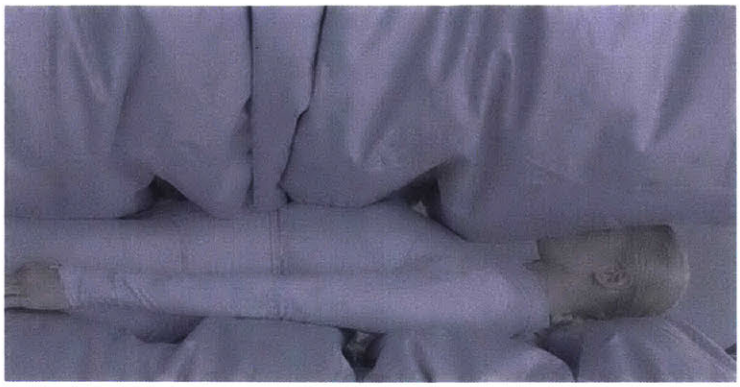
background



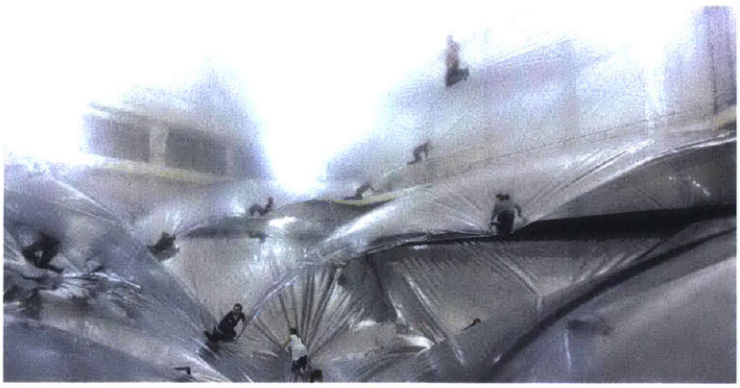
The Fun Palace, 1964, Cedric Price and Joan Littlewood. The Fun Palace is a very big referent of cybernetic architecture from the post-war utopias. This architectural system was designed to fulfill its users needs, and change or evolve to be able to do this. The building was constructed with a scaffolding system, so it was thought as a modular structure that could adapt and move. Spaces were designed to mutate and be compartmented according to the needs: they could be bigger or smaller. Creating subdivisions to host smaller groups or openings of space for larger activities This was meant to be a free place for experimentation, performance, and art. A place were everything was possible and architecture is there to help humans to achieve happiness. This utopia was about giving humans the scenario to be creative without any limits.



Alloplastic Architecture, by Behnaz Farahi, 2013. "Alloplastic'"is a term used in psychoanalysis that refers to an individual inlfuencing the environment. *Alloplastic Architecture* proposes a kinetic system that will move and "dance" with an individual, reacting to proximity and bodily gestures. By doing this, this project looks to engage with the psycological benefits of an responsive environment; an environment that can adpat and evolve with its users.



JB1.0 Jamming Bodies Laboratory, Lucy McRae, Skylar Tibbits and MIT's Self Assembly Lab. This project was commissioned by Storefront for Art and Architecture. It consisted on transforming the gallery into an inflatable structure that evolved and interacted with a human body. This was a scenario to evaluate the implications that self-reconfiguring and morphable materials can have on the body's psychology, behavior, and health.



On Space Time Foam, by Tomás Saraceno, 2013. This installation plays with the notion of body, matter and contextual liaison. This installation is not a robotic architecture system, but it is kinetic and symbiotic. The bodies on this suspended air space are moving and affecting the others; they are all sharing a skin, so every single bodily action will have a physical reaction on somebody else's space.

background

background

I.III SENSORY CHOREOGRAPHIES | Cross-modal perception opens up the possibility of creating new perceptual associations. Through this, it is possible to augment human cognition via aesthetic and scientific multi-sensory experimentation. Early explorations of this phenomenon led to an increased interdisciplinary quest of connecting and crossing art, sciences, technology, and psychology, to name a few. These investigations resulted in the invention of new mediums. For example, the experimentation with moving image and the emergence of immersion resulted in cinema. Once the quest of connecting and crossing art became mainstream, additions like sound and color were part of a sustainable industry. One of the first explorations towards immersion was Edison's "Kinetoscopes", a boxed individual cinematic experience. Other less sustainable art forms benefited from this boom and expanded into more experimental practices. An example of the degree of experimentation is the 1962 "Sensorama" or the "The cinema of the Future" by Morton Heilig, one of the fathers of VR. Even if the "Sensorama" wasn't profitable at the time, it was the foundation for a technology (VR) that has largely affected and changed our world today.

Cross-modal perception opened up the notion of synesthesia. Synesthesia is a perceptual phenomenon that affects and augments the semiotics of psychophysiological experience. It happens when one sense connects with another sense or part of the body and stimulates a linked reaction. Many times it is also associated to and triggered by psycho- affective memories. The idea of synesthesia or intersensory modalities has led to a vast production of work and research around it.

background

The Dreamachine (or Dream Machine) was created in 1960 by artist Bryon Gysin, with William S. Borroughs' and Ian Sommerville's help. It is a rotating cylinder with perforations that create a flickering light at a particular frequency. The objective is to stimulate the brain with alpha brainwaves to achieve a state of relaxing contemplation. The machine is meant to trigger lucid dreams or lucid hallucinations. Many times, the kinetic light stimuli were accompanied by sound at the same frequencies to induce the desired mental state.

CYSP 1. (cybernetics and spatiodynamic) is the first "spatio-dynamic sculpture." It was created by Nicolas Schöffer in 1956. It had total autonomy of movement in 2 speeds, as well as axial and eccentric rotation. This kinetic sculpture presents a spatial composition in steel that moves and deploys different choreographies of light, sound, and movement. This sculpture combined mobility and animation to deliver a dynamic performance.

The "Disembodied Performance" system was created by Tod Machover, Peter Torpey and Elena Jessop from the Opera of the Future Group at MIT Media Lab for Tod Machover's Opera "Death And The Powers". It is an interface created to expand and enhance expression once the main character "leaves" the stage. This system allows the Simon Powers (main character) to continue acting in spite of not being present on stage in his human form. The character uploads himself to a computational system, so the Disembodied Performance allows him to continue having presence on stage through mapping his backstage acting to on-stage lights and robotic movements. This system maps emotional and physiological cues gathered from sensors to deliver and affect robotic walls with light and motion. This way, the human emotional data are transfered to an expressive robotic system. Following the tradition of the "Hyperinstruments" developed in our research group, this expands the emotional communication and enhances bodily gestures with sound, light and color. This system explores cross-modal perception and digital mapping of human emotions to deliver a spatial output on stage. This is a spatial sensory choreography that set an important framework for my project.

background

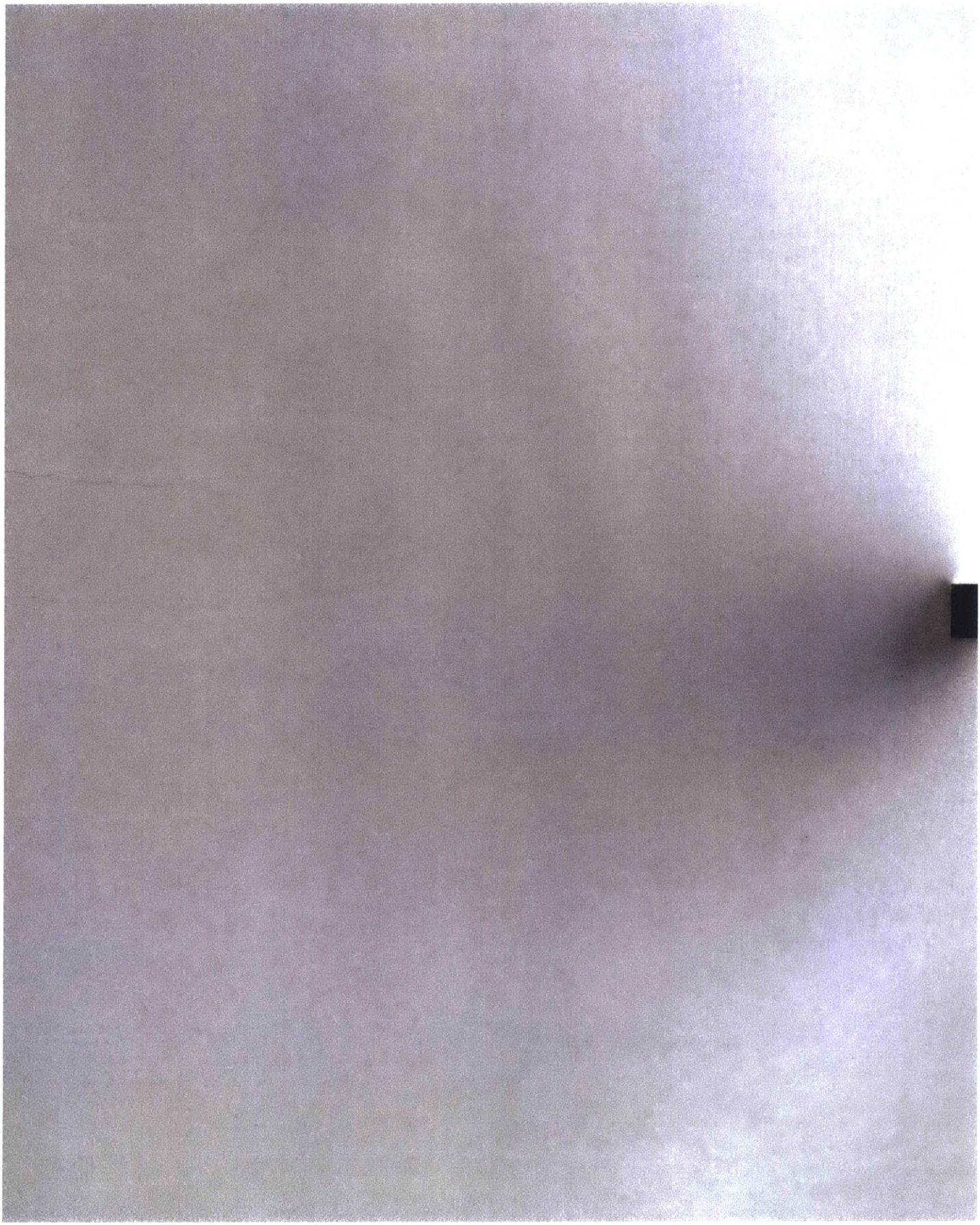
Hakanaï, Claire B. & Adrien M., 2013
Performance for a dancer inside a moving images cube. This choreography draws upon the evanescence of dreams and the impermanence of things. The images are animated live, reacting to models of physical movements following the rhythm of a live performed sonic creation.

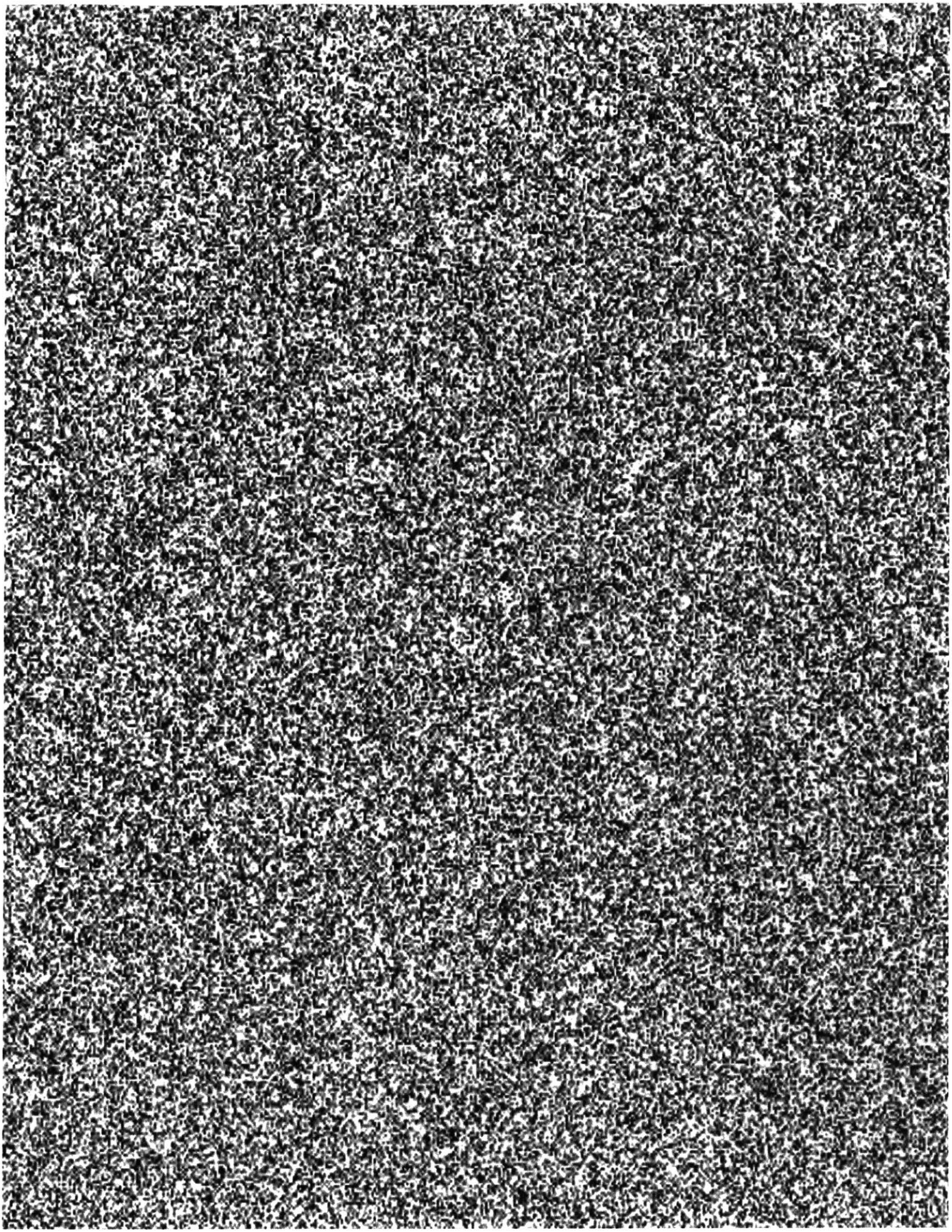
Unicolor, by Carsten Nicolai, 2014. Unicolor examines the psychology of color perception. Fundamental starting points for the work are the chromatics by Johann W. Von Goethe, as well as studies, texts and theories by scientists like Hermann Von Helmholtz, Werner Heisenberg, Wilhelm Ostwald and the visual artist and associate professor for chromatics Eckhard Bendin. Artistic influences of works by Josef Albers and Johannes Itten are further essential to mention.
Unicolor operates with a number of 24 modules that examine a special color perception. One module, for example, is the perception of RGB color filters that move in a high velocity sequence and visualize the process from slow to fast, thus evoking an optical effect of a grey surface in the visitor's perception. (text by: Carsten Nicolai)

"Test Pattern", Ryoji Ikeda, 2008-2016. Intense flickering of blak and white is projected onto several surfaces. The most engaging ones are the big scale projections that actually transform the landscape where people are moving. These flickering projections are the translation of diverse data (text, sounds, photos and movies), that is transformed into barcodes and binary patterns of 0s and 1s. This creates an immersive perceptual installation of sound and light.

ISAM is an immersive audio visual show designed and implemented for Amon Tobin's 2011 World Tour. This 3D animation and projection mapping made a big imprint on the world of electronic music and visual arts. What was most compelling was its scale and constant apparent reconstruction of the space; always keeping the artist at the center. The groundbreaking visuals were perfectly synchronized with music, creating the illusion of music as the construction material for the diverse projected worlds. It was directed Vello Virkhaus and the team of V Squared Labs in collaboration with Amon Tobin, Leviathan and set designer Vita Motus.

background





Inhabiting a diversified body of sound

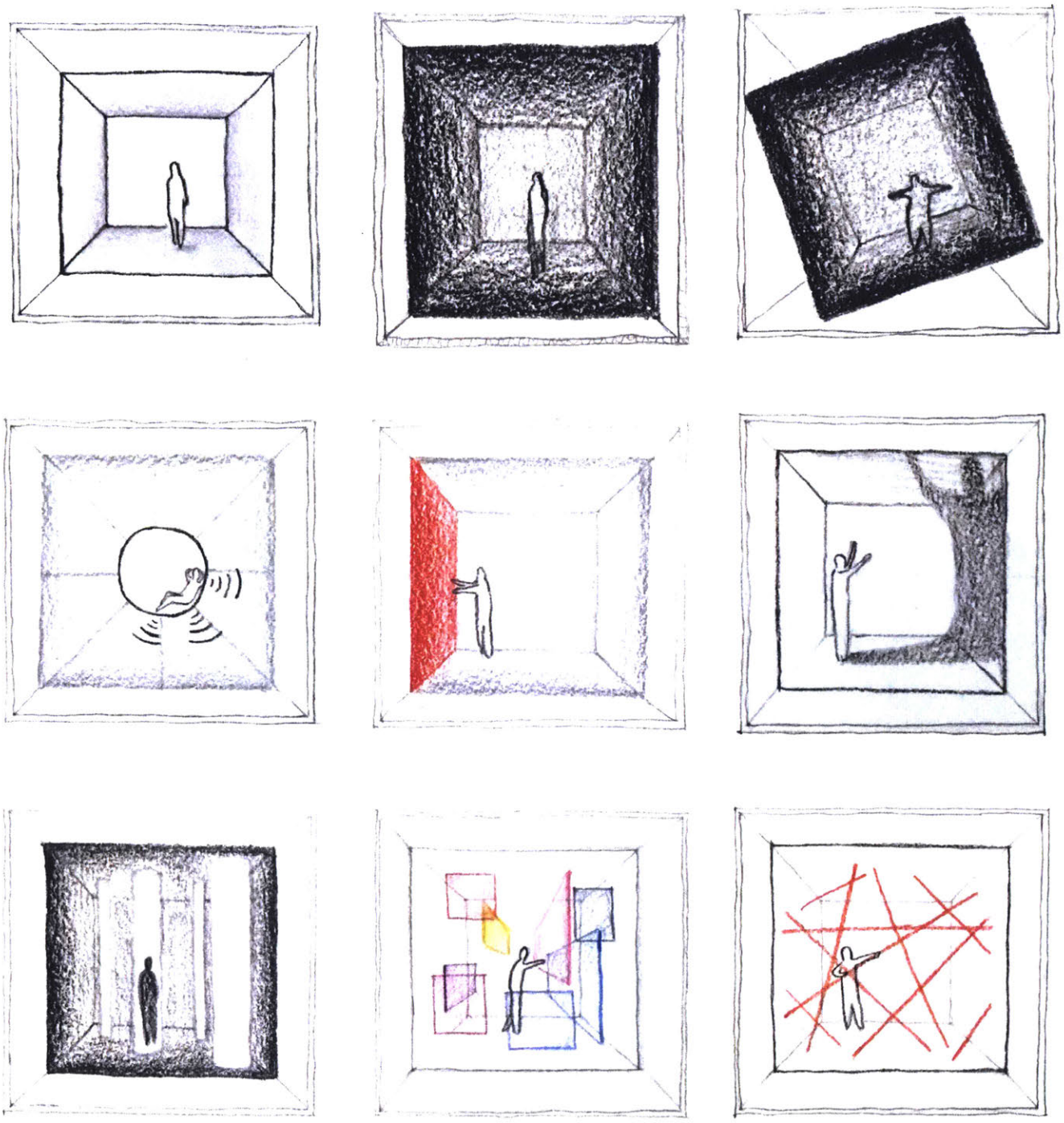
II.I SHELL | *Spaces That Perform Themselves* starts with the idea of an ever-morphing room that can host different spatial situations by changing along with the varying conditions of a musical or sonic composition. This action creates the idea of overlapping spaces: sound and architecture, both simultaneous containers of dynamic interactions. The spatiality of sound presents a continuous encounter between visible and invisible worlds connected by atmospheric matter and its vibrational capacities.

"Architecture as a discipline was founded around the claim of classical architectural theory that a visible object, a solid building, could literally resonate with the invisible harmonies of the universe and thereby act as a hinge between material and immaterial worlds."[18]

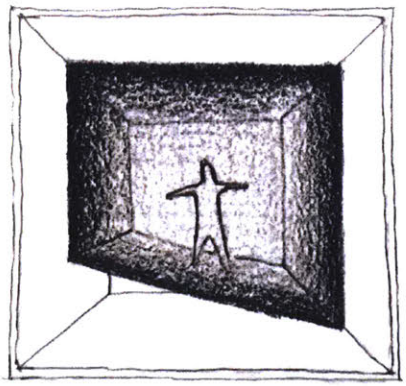
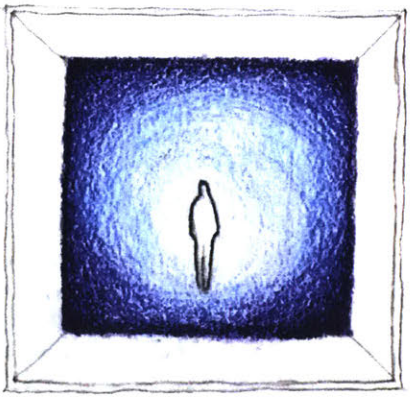
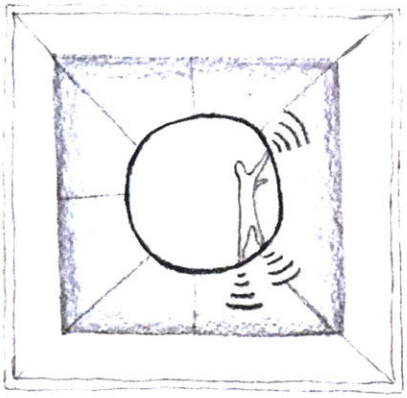
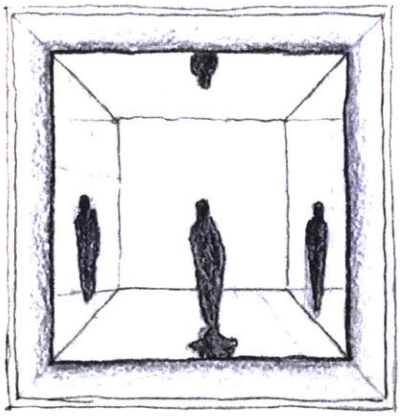
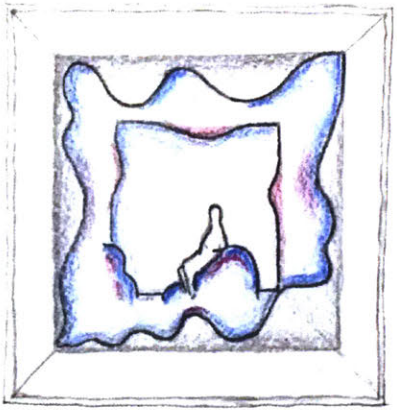
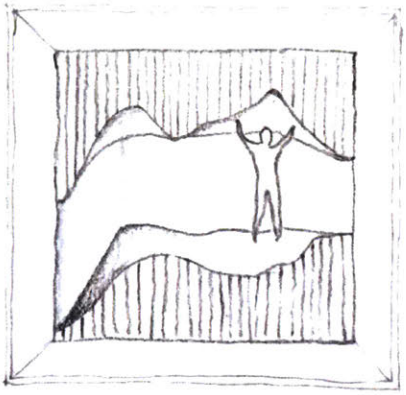
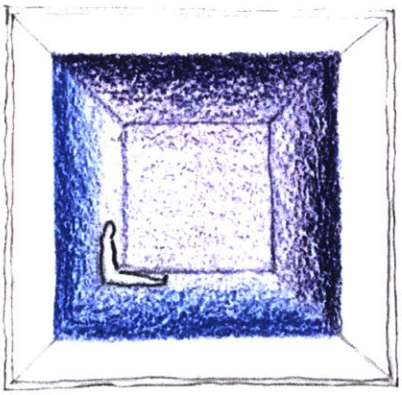
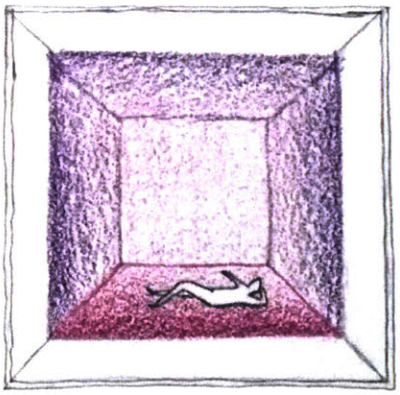
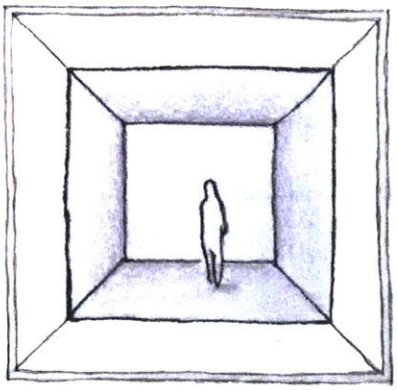
To achieve the conceptual plasticity of the performance of this room, there are a series of design decisions and needs that are taken care of. The first decision was to envision this room not only as a hermetic space people can access, but also as an object you can surround, touch and identify as a body. A body that people can encounter and relate with.

body

A body is a mass of matter that conforms the main part of an animate or an inanimate object. Some bodies are enclosed by an outside protective layer that can be made of different materials: organic materials like skin, fibers or wood, or inorganic materials like plastic, metal or glass. This protective layer exists when the body is not made by a homogeneous mass, but when it is conformed by many things in its inside. This enclosure acts as a container, it is what defines the shape of the body and what mediates the inner and the outer. In this chapter, this protective layer will be nominated as "shell". The shell of this project is its architectural structure, what contains the body and also what contains the experience.



3. Progression of spatial situations - a room that can become many rooms

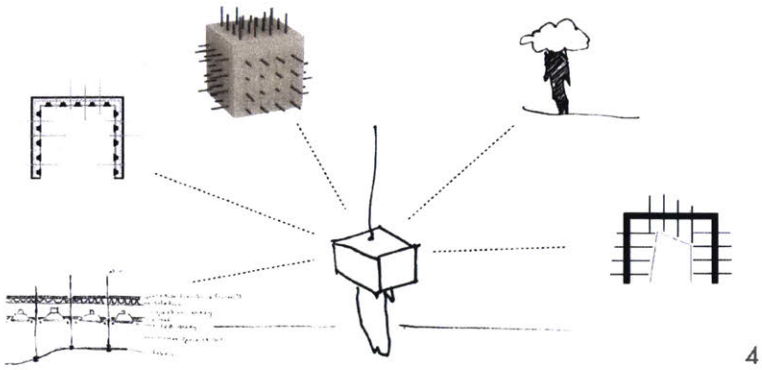
The conception of this room started with the idea of creating one of the most essential expressions of an enclosed architectural space: four walls and one roof. In other words, the conceptual genesis is an empty cube without a bottom. A cube's pureness and austerity sets the perfect scenario for future changes and deformations. The cube is the initial state and structural shell from which any intentioned changes will lead to diversified spatial situations. In order to create a personal immersive experience, this cube needs to host an individual inside. For the purposes of this thesis, it was decided that the size of the room should be as small as possible, confining it into a 6' x 6' footprint.

In order to use less space for this installation, the cube is hung from the ceiling, thus avoiding the need for doors and other interstitial elements. This action also exalts the cube as an important element and highlights its presence in the space. The cube has no bottom, leaving an opening beneath so that a person can enter it by kneeling down and emerging into it. Once inside, the positioned individual will find him or herself immersed into the most basic and essential shape: a cube.

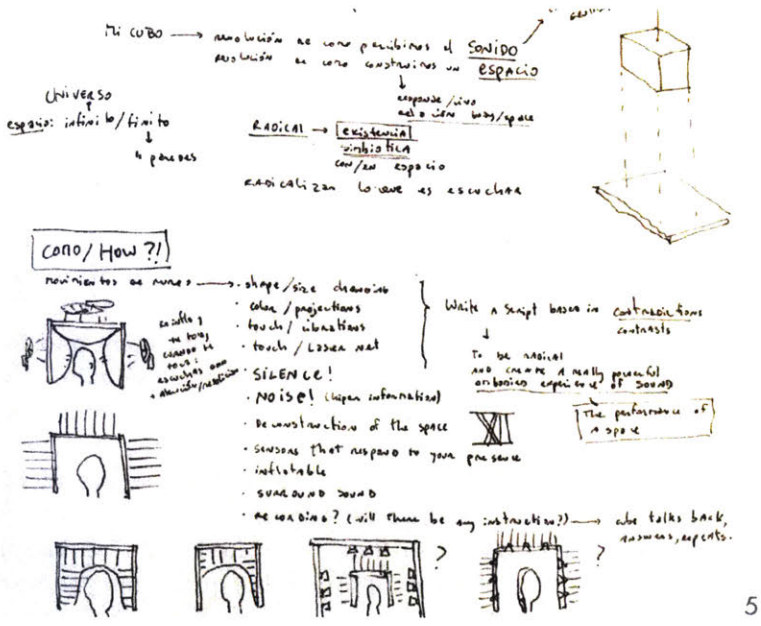
The five faces of the cube feature a mechanical system of rack and pinion, which engages clear acrylic rods to actuate flexible fabric walls on its inside. These walls will adopt different shapes and positions creating a malleable room. The fabric not only is the dynamic enclosure of the inside walls, but also acts as a screen to diffuse the light and color of LEDs behind it.

The movement of the walls and light projection will happen on the inside of the cube, as part of an intimate and personal experience that takes place in the cube's inner relational bubble. It is interesting to observe that the shell

4. First conceptual sketches
5. Brainstorming sketches



4


Mi CUBO
SONIDO
ESPACIO
Universo
espacio: infinito/finito
RADICAL
existencial
simbiótica
CONO/ HOW ?!
SILENCE!
NOISE!
Walk a script based in contradictions
contrasts
The performance of space

5

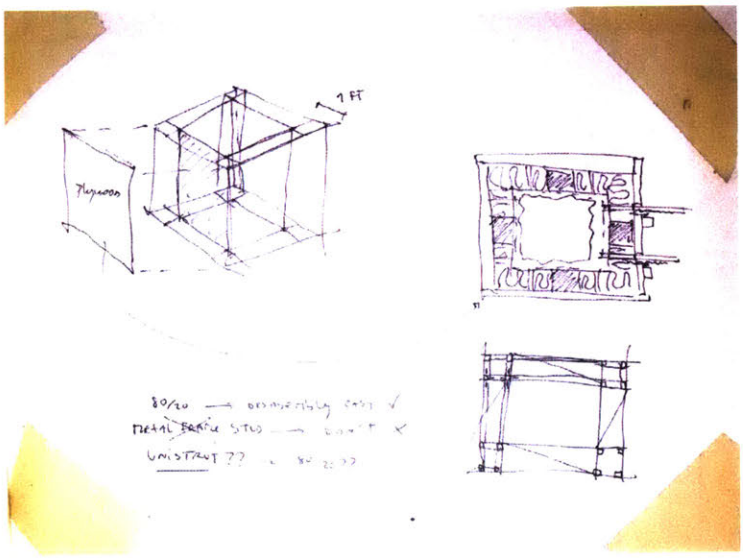
body

mediates inner from outer, separating both experiences and relational spaces. In the outer bubble, the cube won't morph, it stays shaped as a cube. But the clear acrylic rods that actuate the inner fabric walls are physically present on the cube's facade. So even if the cube does not mutate on its outside, the rods are actively moving in and out, they are like limbs that re-shape the cube's projected silhouette. Also, light travels through the acrylic rods, so if there is a specific light or color inside the cube, the rods will display it on its outside end too. Both of these actions serve as a communication tool, where the rods are announcing at the outside of the shell that something is happening on the inside. By doing this, the cube is no longer a hermetic inanimate box on its outside, but it becomes an intriguing body of movement, one that doesn't reveal everything but suggests that something is happening on the inside.

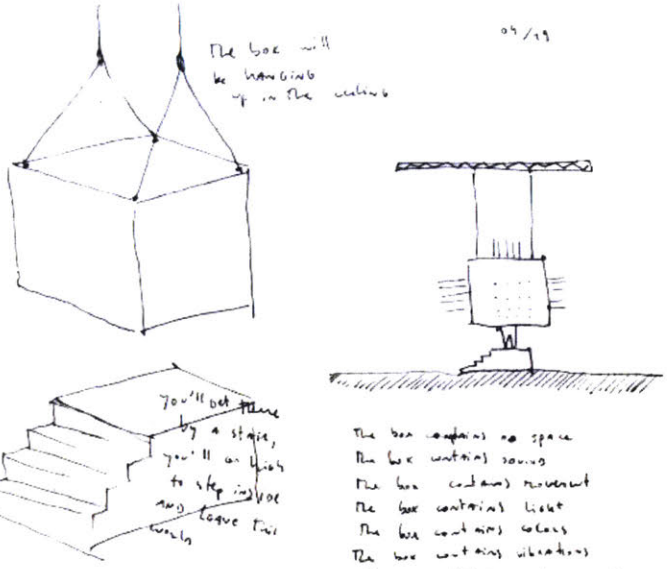
The cube floats over a platform that is placed beneath it on the floor. This platform is the projection of the cube's missing bottom, completing the cube's configuration in a de-constructed manner. The platform not only sets a floor that is part of the cube; it is meant to contain the experience at the level of the user's feet. The platform is covered with a mirror; it is a reflective surface that accentuates the immersion of the floating cube. Half of the individual's body will be inside the floating cube and the other half (mostly the legs) will be outside the cube. The main objective of this reflective surface is to confound the limits of the cube, by reflecting on the floor the movement and colors of the other walls. The other objective of the platform is to vibrate. Sounds are processed and fed to a low frequency transducer that is attached to it. The idea is to create a sense of physical sound that goes from your feet to your whole body. This way, the platform is a key part of the construction of the immersiveness of the cube.

body

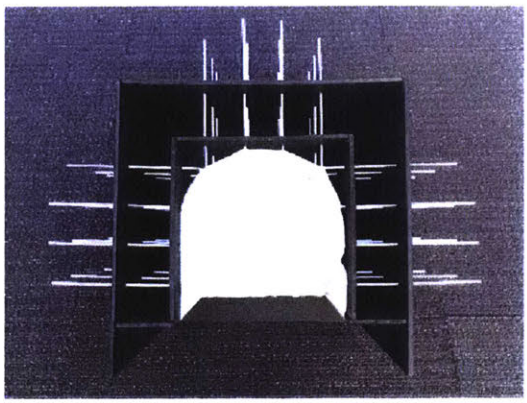
6. Structural sketches
7. Cube sketches and objectives

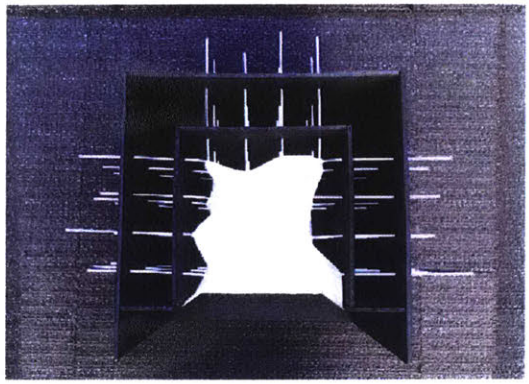

1 FT
Plywood
80/20 → DISASSEMBLY EASY ✓
METAL FRAME STUD → DON'T ✗
UNISTRUT ?? → 80/20 ??

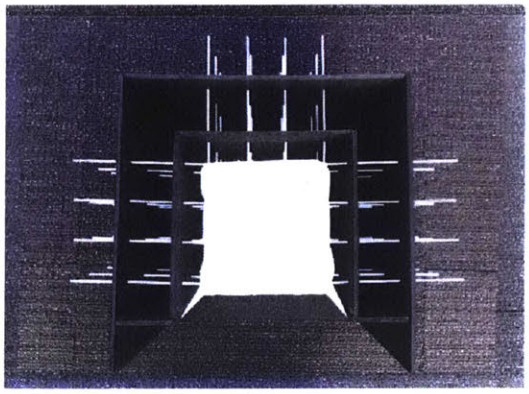
6


09/19
The box will be hanging up in the ceiling
You'll get there by a stair, you'll on foot to step in your and leave the work
The box contains no space
The box contains sound
The box contains movement
The box contains light
The box contains colors
The box contains vibrations
The box contains a choreography
The box contains a body
The box contains a relationship
The box contains an experience

7

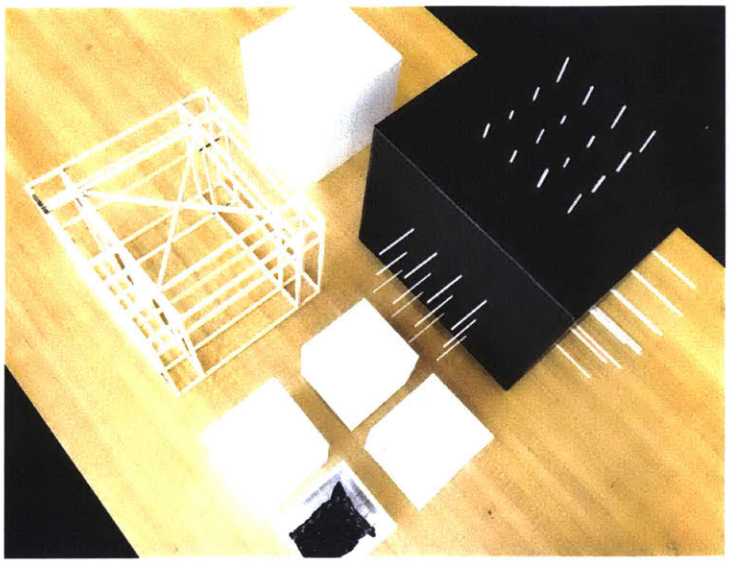




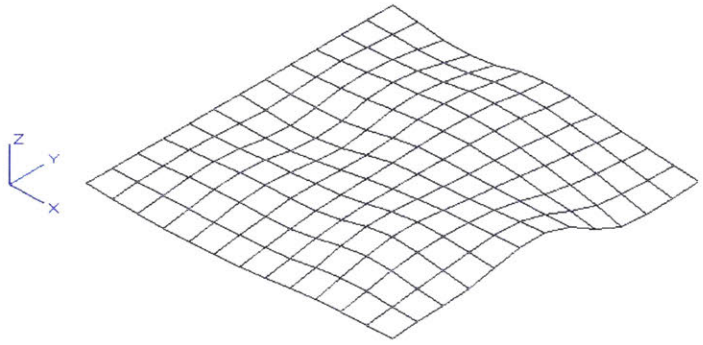


8

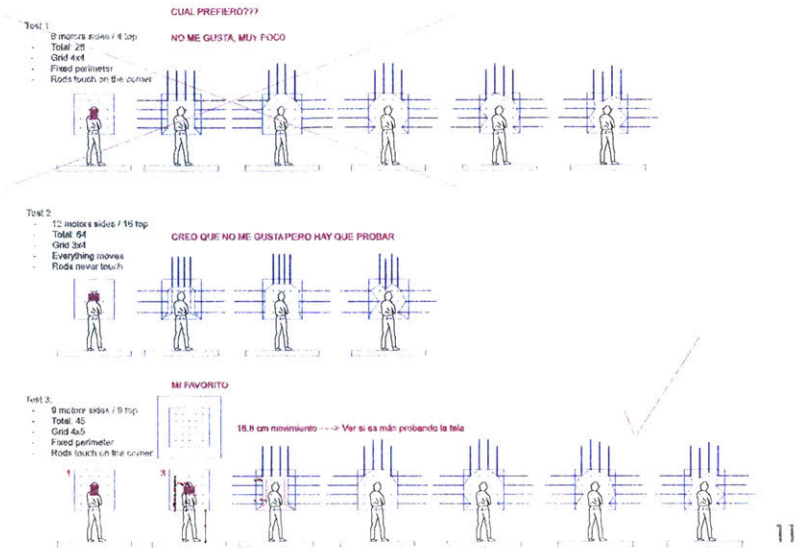
8. Re-shapeable room study
9. Study models for movement and structure
10. A surface is not necessarily a flat thing



9



10



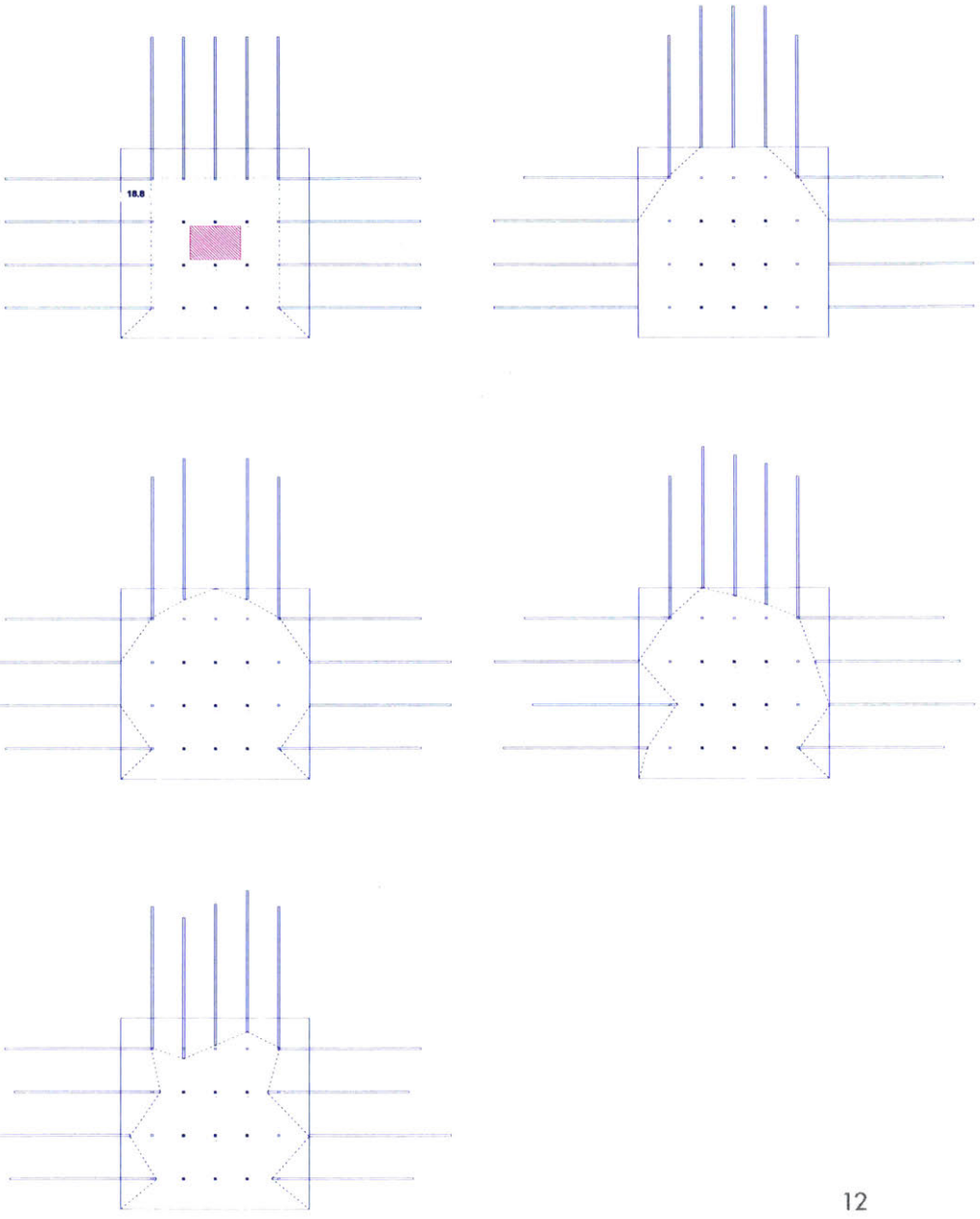
11

body

The decision of using a grid of actuating rods for the system's kinetic ability was taken because the equally distributed bars provided a simple module repeated to create the complete mechanical system, as well as providing a flexible and programmable surface that can achieve any position on the same axis. This decision provides a "blank canvas" where everything can happen. Now that the cube is built, it is possible to think about different combinations, understanding that they will achieve more specific actions.

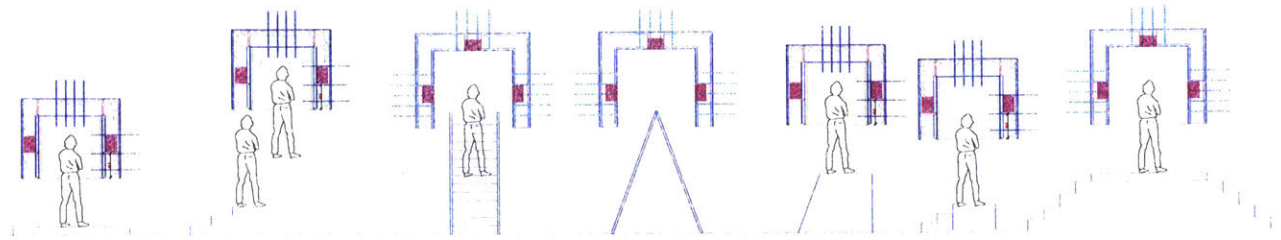
The resolution of the actuation rod's grid was defined after testing many configurations. The final density and the disposition of the points were chosen to provide more flexibility and expression to the system. Also, the current distribution allows the presence of other elements on the wall, such as speakers and LEDs.

11. Rod configuration and resolution study
12. Possibilities of movement, bi-dimensional study



body

yboq



ESCALAR, SUBIR, ENCONTRAR

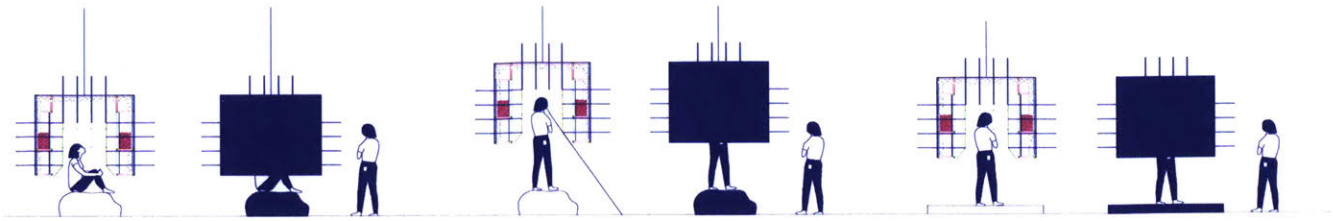
body

A preliminary decision of how to encounter the cube was needed at this stage of the design, because it could affect and change other factors and elements. At least an intention of how the body was going to be inside of the cube was needed.

These ideas provided a first projection of setting up the encounter between the human body and the cube's body. The initial concepts were concrete and straightforward: the human body needs to enter the cube and remain there for an individual performance. The human body will perform the poetic act of "leaving his/her world" to enter the cube's interior, which presents a "new world" with different rules and dynamics.

A physical act needs to take place to mark the in/out of the world. These first explorations were observing the possibility of "climbing" to do this: *escalar, subir, encontrar:* climb, rise, encounter.

13. Escalar, subir, encontrar study
14. Dejar, entrar, encontrar study

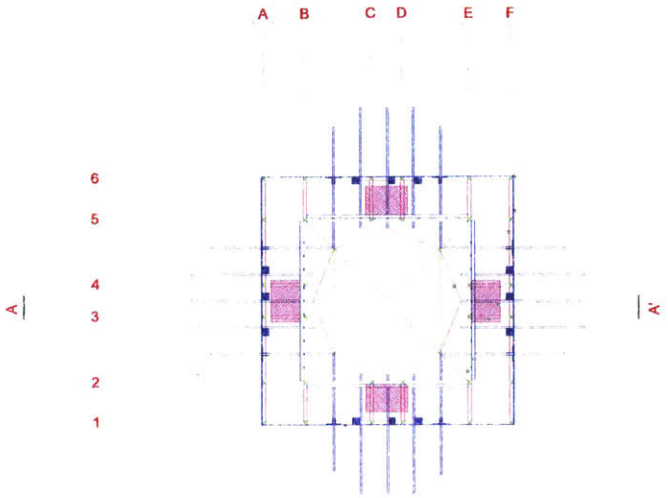


DEJAR, ENTRAR, ENCONTRAR :)

Another option was more drastic and literal:
***dejar, entrar, encontrar:* leave, enter, encounter.**

This second option was chosen. The action of leaving was represented by the bodily action involved when entering the cube. The body is forced to kneel and then emerge into the cube, which suggests the idea of coming from the ground and rising into a new world.

*During the design process, I realized I was using a very standard and insipid CAD block for the person inside of the cube. So I decided to draw a CAD version of me, so I virtually could be there from the beginning, to supervise and understand the design decisions from every angle.



Wood corner angle 1/4 painted white

Exterior finishing
3/4" Plywood Board
Painted White
CNC cutted for rods

Horizontal beam
80 / 20, 1", 10 Series

Inner fabric wall
4 way stretch spandex

Speaker U12

Speaker shaft structure
80 / 20, 1", 10 Series

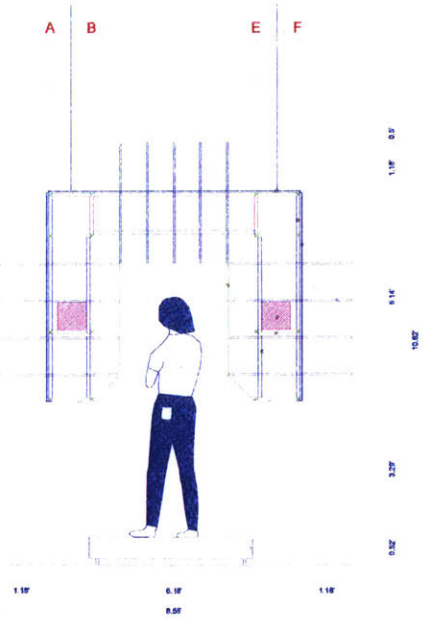
LED wall
Foam Wall with CNC
cutted holes for rods
LEDs glued to wall

Horizontal beam
80 / 20, 1", 10 Series

1/2" Clear Acrylic
Square Rod

15

body



Hanging point

Vertical beam
80 / 20, 1", 10 Series

Exterior finishing
3/4" Plywood Board
Painted White
CNC cutted for rods

Inner fabric wall
4 way stretch spandex

1/2" Clear Acrylic
Square Rod

Speaker U12

Speaker shaft structure
80 / 20, 1", 10 Series

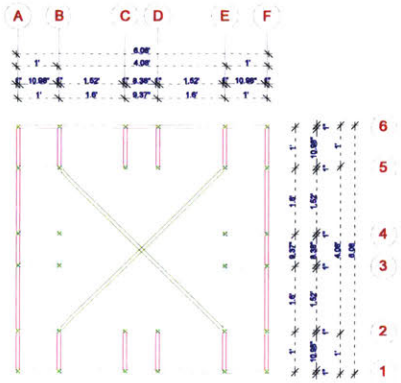
LED wall
Foam Wall with CNC
cutted holes for rods
LEDs glued to wall

Vibrating Platform
Wood structure painted white
0.125" Acrylic Mirror surface
Low frequency transducer
attached on the bottom

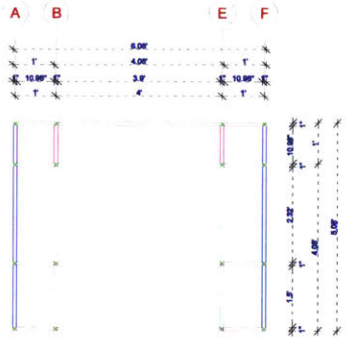
16

body

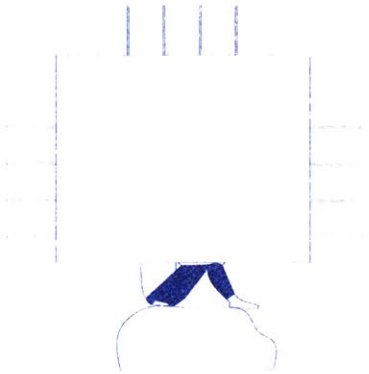
15. Architecture Plan
16. Section A-A'
17. Structure Plan
18. Structure Section A-A'



17



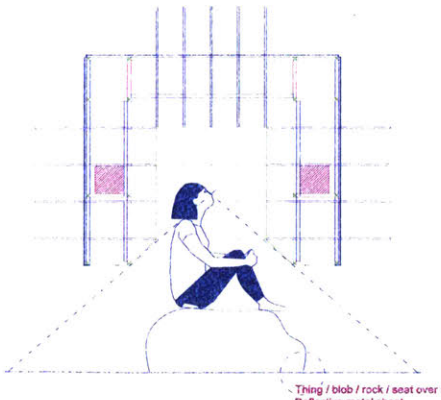
18



19

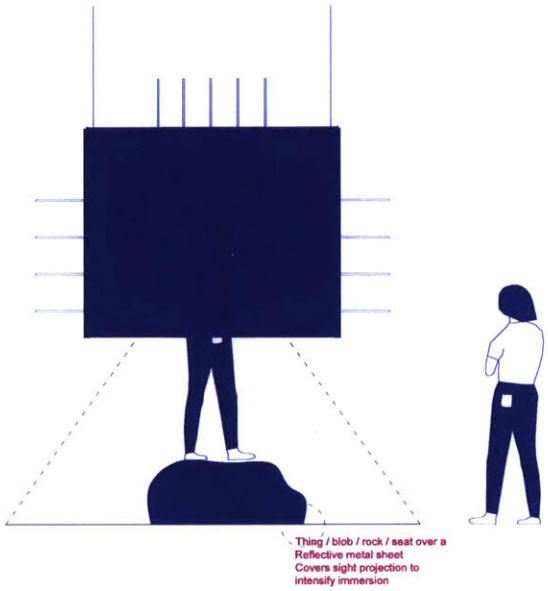
body

body



20

Thing / blob / rock / seat over a
Reflective metal sheet
Covers sight projection to
intensify immersion



21

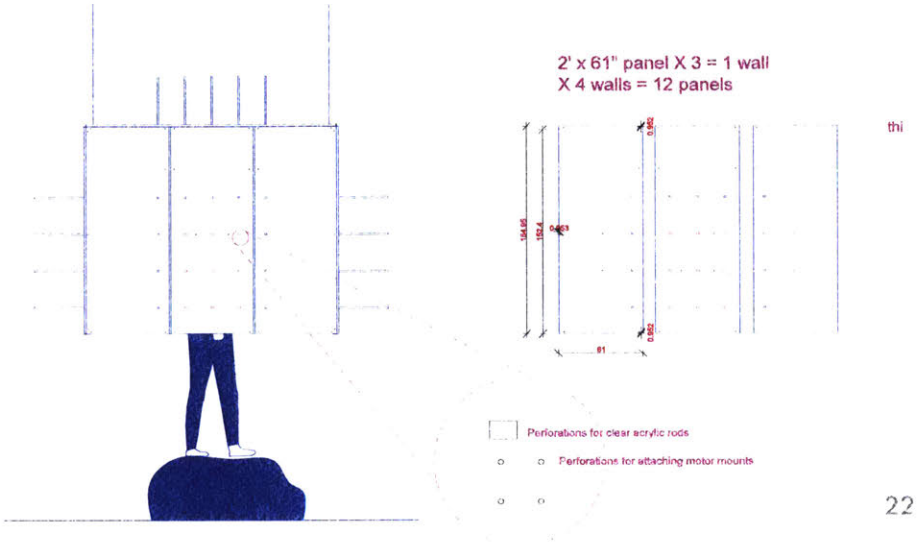
body

body

A continuous floor masks the peripheral vision from the inside of the cube to the outside world. The floor has to respect at least the specified lines on the drawing. This floor will allow a better sense of immersion and the creation of a controlled environment.

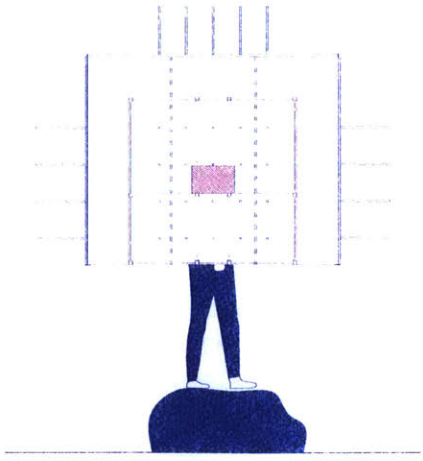
The irregular blob shape over the floor was an element that didn't get into the construction phase, though I still find it interesting and more organic than a rectangular platform. This blob is a rock that grounds the foundation of the experience at the feet/earth level.

19-20-21. Floor mask + rock + body studies



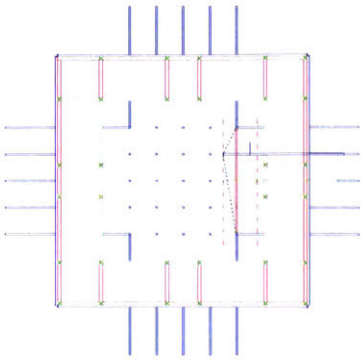
22

body

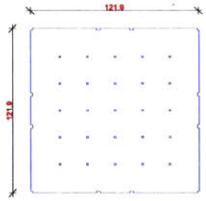


23

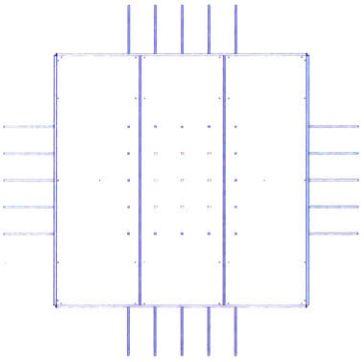
22. Exterior lateral wall design
23. Interior lateral wall design
24. Interior ceiling design
25. Exterior ceiling design



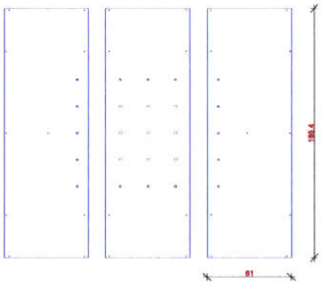
4' x 4' panel
X 1 wall = 1 panel



24

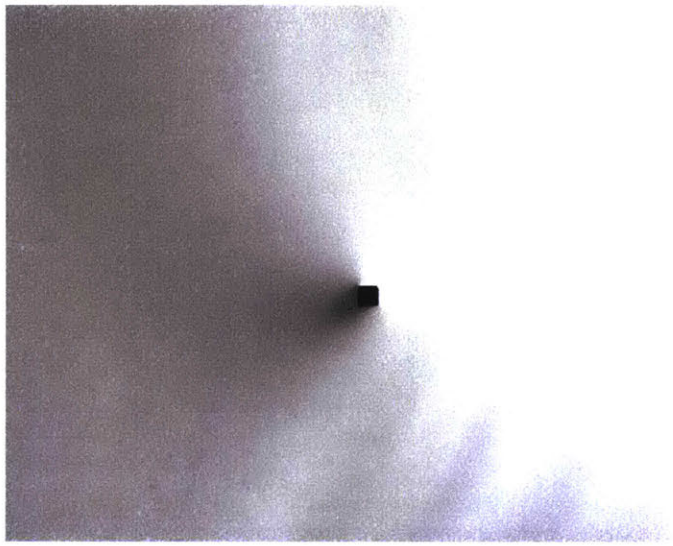


2' x 73" panel
X 1 wall = 3 panels



25

The material is dimensioned for fabrication and construction. The walls were milled with a CNC router machine to have a perfect position of the perforation for the installation of the motors and rods.



26

27

26. Fabric wall moving out
27. Fabric wall moving in (or on the opposite direction)

The inner walls are made of 4 way stretch fabric. The inner fabric walls are the inner skin of the cube's shell. Skin is an organ of communication and permeability; the cube's fabric walls are conceived as programmable skin.

The fabric reacts very well to the rod actuation. Its flexibility allows being stretched in and out without affecting, damaging or rippling the fabric. Also, this material provides a very elegant combination with the array of LEDs disposed on the backdrop of the wall. The fabric helps diffusing the light and acts as a screen for its homogeneous projection. This layer hides the LEDs and sets up a uniform and controlled light environment.

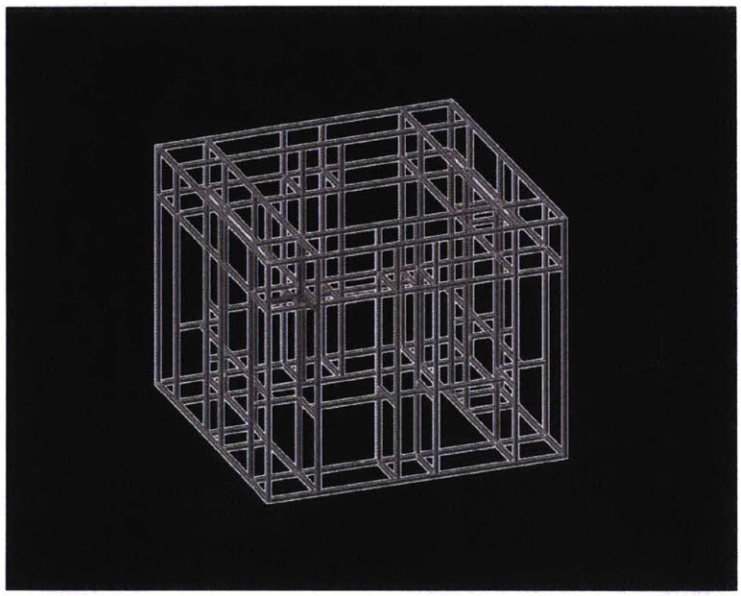
The fabric is installed at a "middle" position. This means that the fabric can be actuated forward and backward from that middle. This position provides a positive and negative expansion of its geometry. Only 1 point of the fabric is attached to the central rod.

In the beginning, all the rods were going to be attached to the fabric, but after many tests and prototypes, it was observed that only the central rod made a big difference on the wall's behavior.

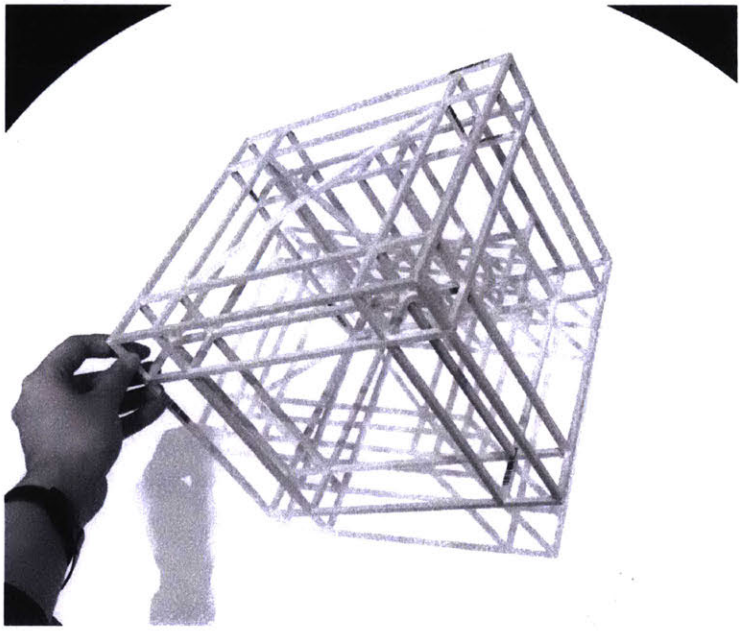
Perforating the fabric to attach the rods was not a clean solution, and gluing the rods to the fabric was not resistant nor clean. So the solution for connecting the rods to the fabric is provided by using strong magnets. There is a magnet on the rod and then one on the fabric. This provides a clean surface. Every fabric wall only has one square magnet at its center. All the other rods actuate the fabric towards the inside of the cube, leaving no trace when the fabric goes back to its initial position.

Also, the magnet hosts the capacitive touch sensor that makes the system sensitive and interactive. This feature will be exposed further on the next chapter.

body



28



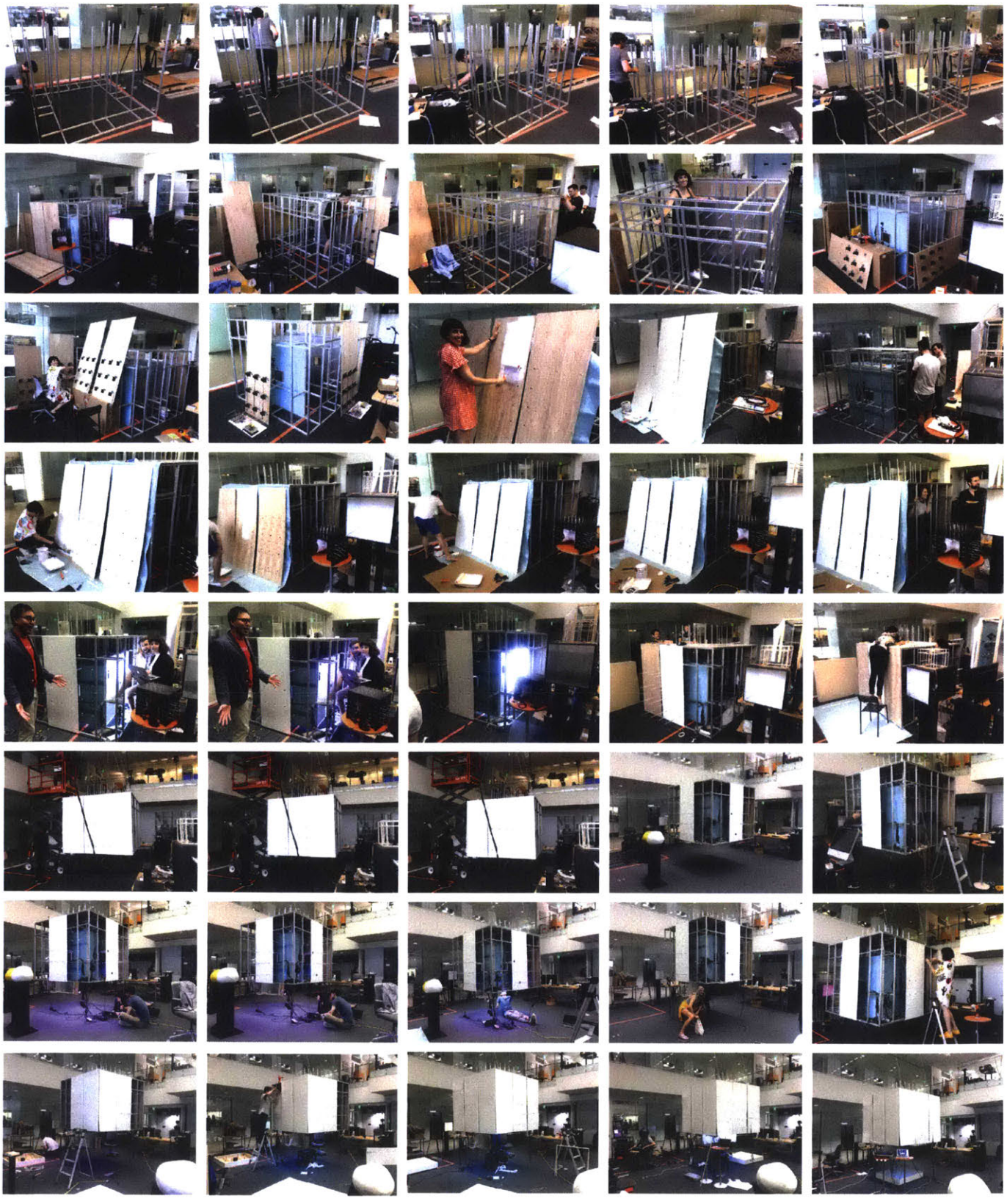
29

28. Structural digital model
29. Structural physical model

Once the design and primary needs are defined, the structure can be created. For the structure, it was decided to use 1" 80/20 aluminum profiles (10 Series). This structural system gives flexibility and mobility in the sense that it is easy to assemble and disassemble. It is also very light in comparison to other materials, and still very robust and rigid.

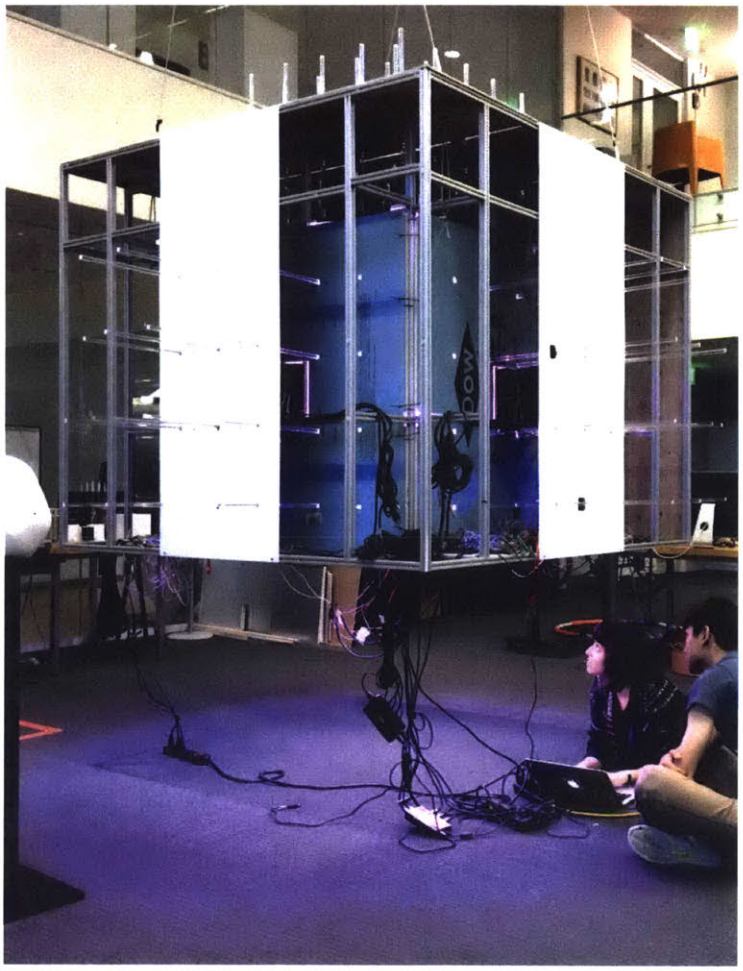
The biggest challenge for this element was that, even if many structural models were made, it was not really calculated to be hung. It was decided to add a few extra inner beams to stiffen the structure and make sure it will resist the loads once hanging from the ceiling.

30. Construction of the cube, from the first foot print on masking tape on the floor to the suspended cube ready to work.

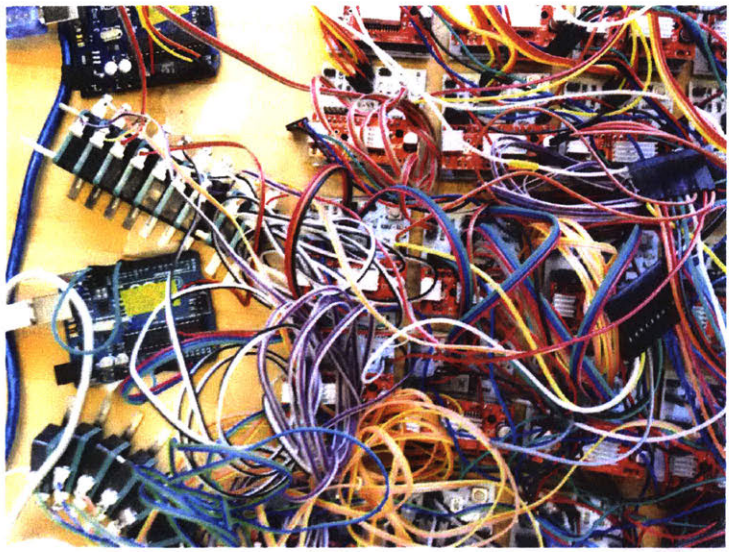


31

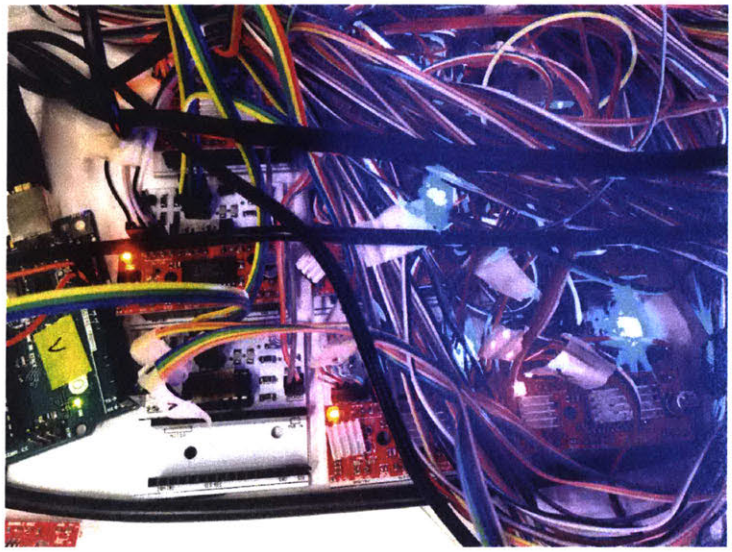
31. Cube before floating
32. Floating cube programming



32



33



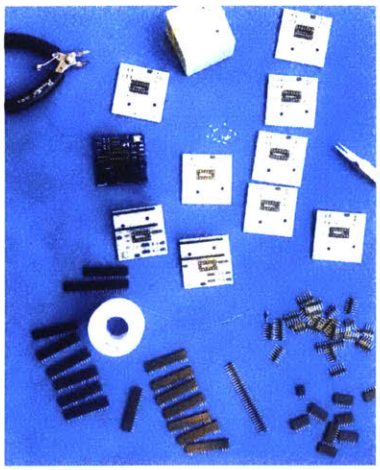
34

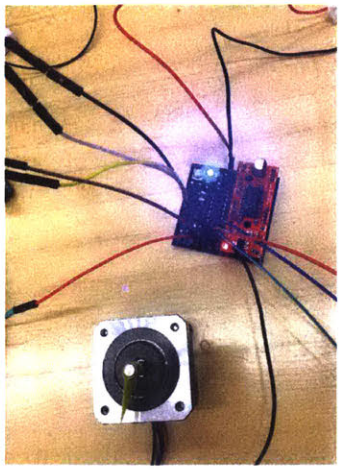
II.II GUTS |The guts of this body are constituted by all the systems inside the shell. These systems are the ones that will power and give functionality to the cube. All the cables, micro-controllers, connectors, power supplies, motors, LEDs, boards, and different components act like organs and veins for the cube's body.

Four primary systems give life to this dynamic environment. First of all, the Motion/Mechanical System that consists of all the parts that generate physical movement of the walls. The Sound/Vibratory System provides high fidelity spatialized audio inside the cube from distributed sources; this creates a controlled scenario for an embodied perception of air vibrations. The Light/Optical System opens the possibility of composing with light and color. Finally, the Sensory/ Reactive System is what gives the room its interactive ability. These four systems working together are what power the multi-sensory aspects of the cube and give shape to its dynamic behavior.

body

33. Mess - Motor system cables
34. Burned Attiny during system connection





35 - 36

37

1. Motion / Mechanical system

Every wall contains 9 Nema 17 stepper motors to actuate the flexible fabric on the inside of the cube. There are five walls in total, which means that the mechanical control system consists of 45 simultaneous stepper motors. To achieve a fully functional and stable system, every motor control board is conceived and designed as an individual module.

Each control board module has an Attiny84 micro-controller as its main brain and identifier, and also contains one stepper motor driver, as key components. After testing many options, the stepper motor driver called EasyDriver was selected because it proved to be conveniently simple and flexible, robust enough under high temperatures, and relatively silent. Once the components were defined and working, the boards were designed in the PCB layout & schematic software Eagle. Around 60 boards were manufactured in China and then hand soldered and tested at the MIT Media Lab.

All the motor modules (motors + control board) are interconnected and controlled via I2C bus communication. This means that every module is independent and has its own micro-controller and address tag, but they are all sharing information on a systematized stream. Since every motor has its own address tag as its own identification number, it is possible to send a long stream of information and instructions, but every motor will get only what is addressed to its individual tag. This networked platform allows all the motors to be synchronized with each other and work simultaneously.

body

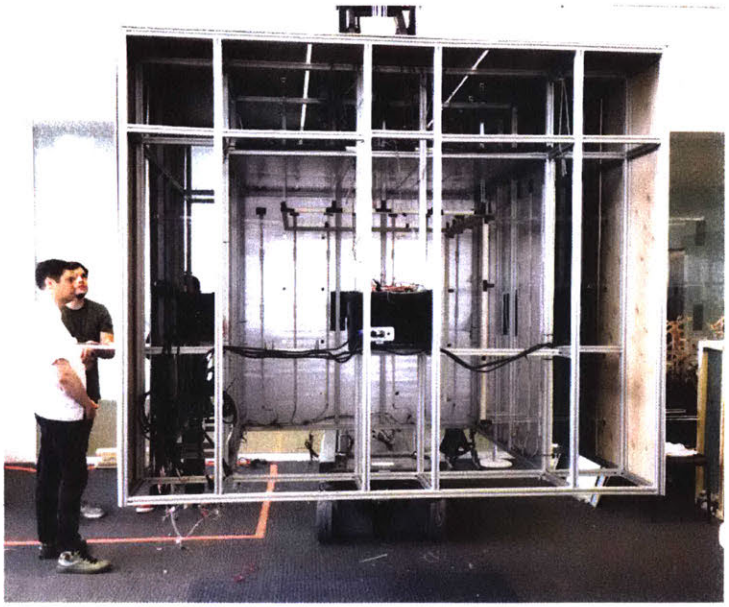
35. Motor's control boards ready ti be soldered
36. Motor control board controlling motor successfully
37. Motion System working over a table before being connected and installed in the cube.

Every wall has an array of 9 motors, and even if the 45 motors are interconnected, they are organized into five groups of 9 motors, 1 group per wall. This way every wall can have its own power supply and independent inspection shaft in case of any particular wall malfunction. The information is then separated into five streams, using 1 Arduino Uno for each wall to send the instructions to the motors.

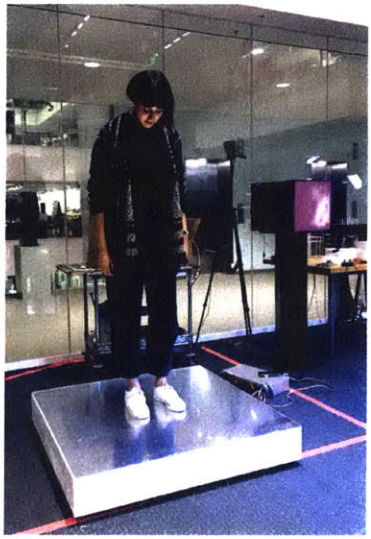
Once the motors move, they can actuate the acrylic rods. To do so, every motor has a 14-T pinion gear, and every rod has the complementary 32-pitch aluminum rack. The racks were custom made in the MIT Media Lab Shop with a Water Jet Cutter. This helped to make racks with specific dimensions and controlled weight. Every motor is attached to the external walls of the cube with a motor mount, and every gear is placed at the designated position in order to be actuated. The mechanical system works well and very smoothly, even though it is noisy and loud. To attenuate the resonance of the surface material when the motors are working, a high-density rubber piece was placed between the motor mounts and the wooden wall. This diminishes the noise considerably, but the system is still loud. Every motor resonates when working, the sound they make is actually interesting; it changes pitch depending on the speed they move. This opens the possibility of actually tuning the motors and use them as part of the later composition.

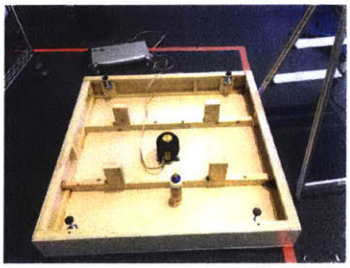
The rods actuate the inner fabric walls; each wall has 9 actuator rods and they are displayed at equivalent distances on a 3x3 grid. As mentioned previously, the center rod is the only one that is attached to the fabric. This means that this is the only rod with the capacity of pulling the fabric towards the wall, augmenting the size of the room by using its negative space.

Other critical components of the mechanical system are the homing switches. Every motor module has a switch that is attached to the outer wall. Every time the system is started, the rods move back to their initial state, i.e., they move back from the center of the cube until they activate the switch. The switch is telling them where position 0 is, i.e., where home is. This way all the rods are aligned at the same starting point; this is used for security purposes as well, so rods aren't overextended into potentially dangerous regions.

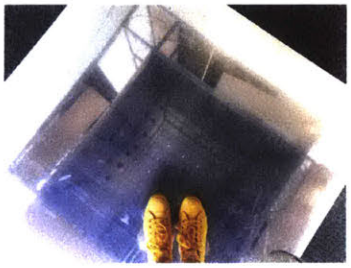


38





39



40 · 41

body

2. Sound/Vibratory System

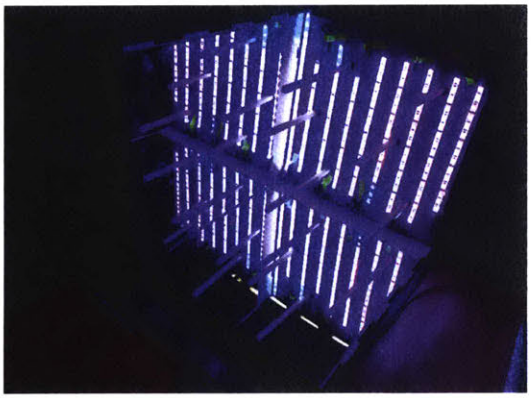
All four walls have a speaker embedded in the structure, behind the fabric, and a fifth transducer is placed beneath the platform. This way, the sound is spatialized in a 5.1 speaker system creating movement inside of the cube capable of guiding the motion by changing its sonic position from wall to wall. A 6th speaker was considered to be placed in the ceiling, though it was not installed to avoid structural modifications.

The speakers that are being used are JBL AXYS U-12 speakers. These are high-end studio monitors that deliver high sound pressure levels, low distortion, and a highly accurate dispersion pattern. They offer an exceptional operating frequency range of 80 Hz to 22 kHz and a maximum peak SPL of 111 dB. This is a powerful set up, considering the size of the cube; this system ensures a high fidelity diffusion and optimal quality for the wanted effect.

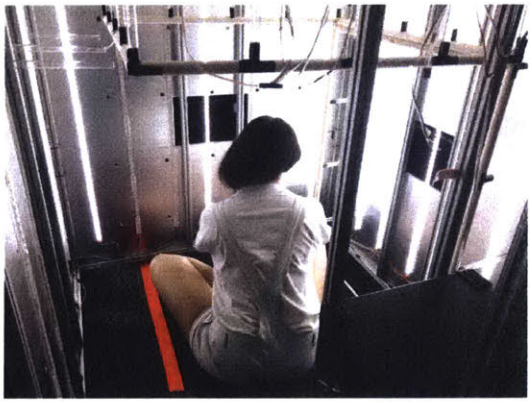
Each speaker allows an individual sound transmission, enabling the user to experience each side independently, or in any combination needed to create the intended effect. Additionally, since the perceivable sound is primarily heard from the wall speakers, bass vibrations can be composed and experienced with the sub-bass vibrations of the platform.

Since the user is free to move and rotate her/his body within the structure, the experience will challenge their accustomed stereo experience by disorienting the user with sounds spiraling around, without a specific L/R orientation. Furthermore, to rally a new experience of sound and space, the structure allows for even vibrations of the platform, without perceivable sound.

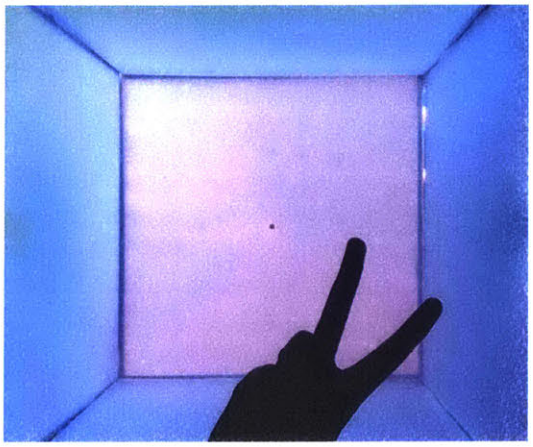
38. Suspended cube with speaker on the wall
39. Low frequency transducer (Buttckiker) installed on platform
40. Buttckiker first test
41. Platform from above



42



43



44

3. Light/Optical System

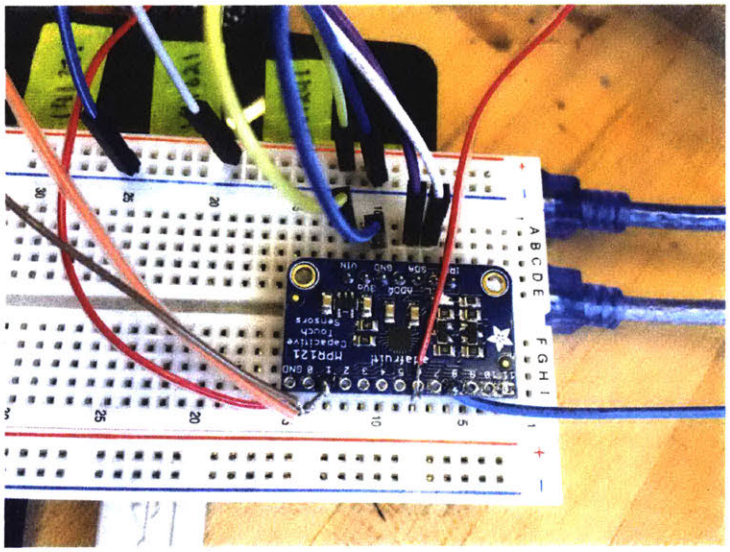
An array of LEDs is embedded in the structure to add the dimension of light, color, and brightness.

Every wall has seven digital LED strips; every strip has 60 LEDs and measures 1 meter (3.3 ft). Every LED strip is installed on the wall with around 12 cm of separation between them. A diffuser layer is placed on top of each strip, so once the fabric is installed, the light diffuses uniformly over it. The fabric also helps to diffuse the light and acts as a screen, without revealing the strips or the LED dots to the inside of the cube. To achieve this, the fabric also needs to be installed at a minimum of 3 inches away from the LED wall.

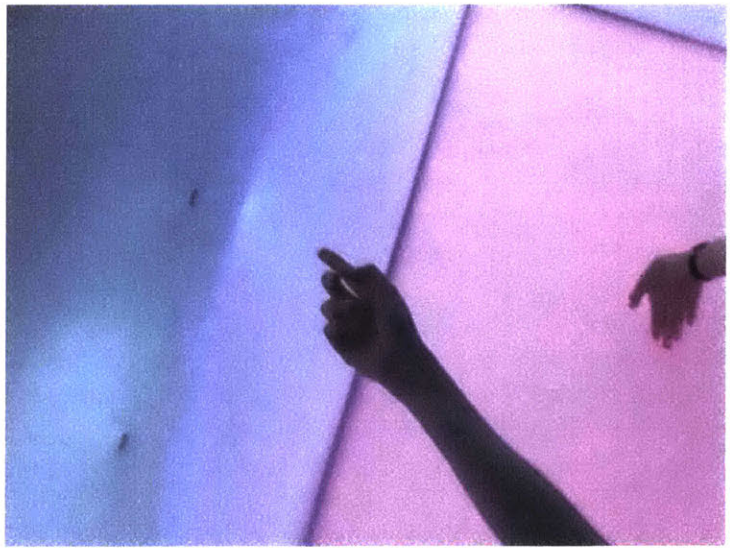
To control the strips, each wall has a micro-contoller (Teensy 3.2) and an OctoWS2811 Adapter for Teensy. The LEDs are connected via ethernet to the OctoWS2811 Adapter to be able to be controlled by the Teensy. Every strip will be numbered and disposed on the wall from left to right, numbered from 1 to 7.

This setup enables the possibility of controlling synchronously or independently every wall, as well as every strip, and also every single one of the 2,100 LEDs.

42. Preliminary model for light study
43. Installation of LEDs on the cube
44. LED light diffused on inner fabric wall.



45



46

4. Sensory/Reactive System

The capacity of being interactive opens the possibility of improvisation; it gives the chance of triggering changes and making every performance unique, depending on the user's input. To do so, sensors are embedded on the cube.

After a lot of tests and experiments, it was decided to use capacitive touch sensors. Every wall has one capacitive touch sensor, which creates a system of 5 triggers. Every time the user touches one of the sensors, the light color will change on that wall, and it also triggers sounds diffused on that wall's speaker. This means that it gives the cube the characteristic of being an instrument. This is a straightforward and efficient interaction, where the user can add layers to the composition. This interaction is a first approach to the creation of a back-and-forth dynamic between the individual and the cube, even though this is at an early stage and needs to be studied in more depth and re-iterated to intensify the effect.

The capacitive touch sensor is placed on the five walls' center rods. Each of these rods has a magnet for pulling the fabric into the negative space. This magnet also connects with the capacitive sensor: every time the user touches the magnet, the touch signal is transmitted through the electric field across the fabric. This sensor data is mapped to MIDI signals, which trigger sound and light on the wall that was touched. The magnet is placed at the center of each fabric wall; it is the only thing that disrupts the continuity and pureness of the material, which makes it a focal point on every wall, drawing attention and being analogously "magnetic" to curious and tactile human beings.

The capacitive touch sensor came to the system after a series of tests with other sensors and interactions. The original

45. Capacitive touch sensor
46. Capacitive touch action

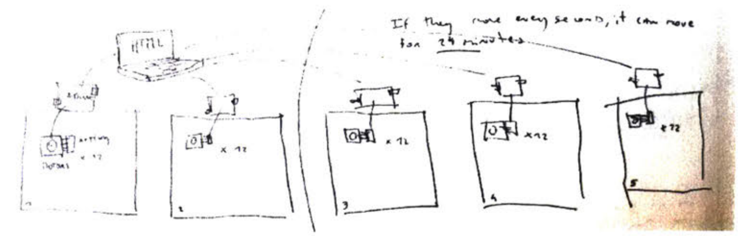
plan was to use combined sensors: 2 Microsoft Kinects and weight sensors. Both were intended to be installed on the platform; the Kinects on opposite corners and the weight sensors at 5 different points of its surface. In this original plan, the Kinects were meant to identify the user's gestures. For example, if the user touches a wall, defining which wall and what part of the wall. This data was mapped to affect and modify the movement of the motors; for example, the wall would move back when being touched, getting closer to the individual. The weight sensors were planned to be carefully calibrated to perceive movements produced through weight shifting. They were meant to situate the user's position on the platform and depending on that, change the sound source to be closer to the user.

Unfortunately, these sensors are not used in the final version. During the experimentation process, both sensors were tested and mapped to get the expected reactions. Both worked, though it was decided not to use them. This decision was taken because when trying the sensors, even if they were working correctly and reacting the way they were meant to, the problem was not the sensors, but the desired interaction. Every interaction made sense by itself, but when thinking about the bigger plan on the complete composition, their outcome wasn't clear, and the reactions got lost among the performance. This made that the effort of installing the sensors, calibrating them and mapping them to be not worth it, at least not for this piece and at this stage of the project.

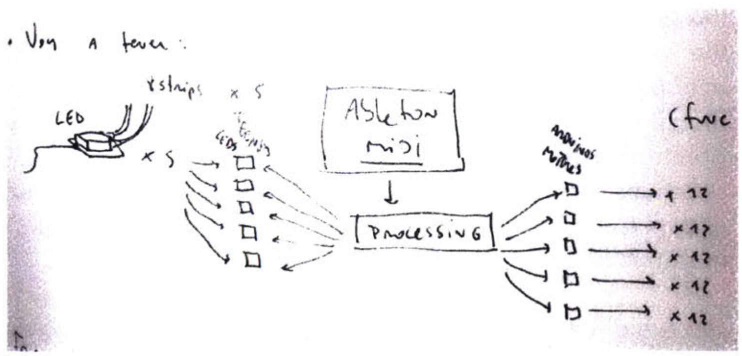
The biggest problem with the Kinects was that every time the motors reacted to the gestures of the individual, they changed the composition. Since the motors have a pre-constructed choreography, if you change that it would break the sense and flow of the composition. Imagine one wall was choreographed to move forward and a few

seconds later move back. If in the same time that the wall is going forward, the user's gestures change the behavior of that wall and make it move back, then the wall will try to move back again and force the whole mechanical system. This action will also change the compositional objective of the wall moving forward instead of going back. This affects the behavior and creates a break of the meaning between the musical intention and the motion. At this point, this action will take away from the whole composition more than it adds to the user's experience. This exposes the bane of interactivity and the importance of assigning the correct reactions. There are ways to create a more intelligent system to make this work; this will be something to explore in a next phase.

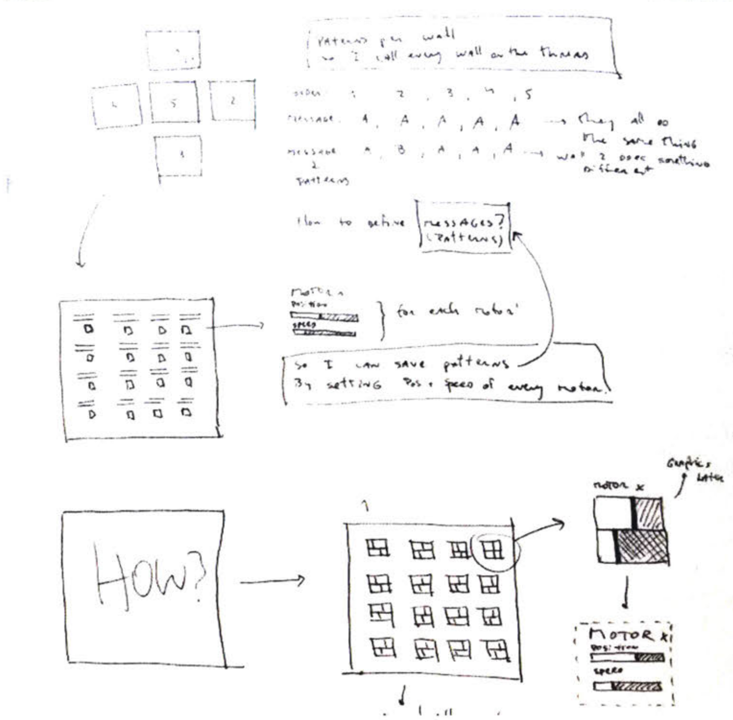
The weight sensors were discarded mainly because of the final dimension of the inner space in the cube. The room ended up being a few inches smaller than the original design. This was due because the inner fabric walls needed to be further from the aluminum structure to create a bigger negative space, so when the central rod goes out, it gives the perception of opening up and creating a spherical room. The amount of movement over the platform decreased to a point where changes were not enough to make the interaction meaningful.


If they move every second, it can move for 24 minutes
x 12

45


LED
x 5
Ableton
midi
PROCESSING
x 12

46


for each motor
So I can save patterns
By setting Pos + speed of every motor
HOW?
MOTOR X

47

body

II.III BRAIN | The computational structure that brings this system to life is an interconnected set of elements that receive musical data and create different synchronized outputs. A graphical user interface (GUI) control platform is designed to present a tool primed for movement composition alongside the other aspects of the spatial choreography. This control platform communicates software - a DAW (Digital Audio Workstation) with Processing - to send synchronized data (MIDI) via serial communication. This enables the mapping of different sound/musical parameters to pre-programmed output patterns for controlling the motors and lights. The system can be either entirely reactive to the music, or controlled in real time. This opens the possibility of a mixed use, promoting further experimentation, creative processes, and customized outputs.

The four Systems that determine the cube's functionality are triggered from the same software. This permits an organized and easy way for the mapping of all the elements, which facilitates the composition and creative processes. Any DAW software can be used to control this system, as long as the MIDI channels are linked to the code (in this case, the software used is Ableton Live). The control platform and mapping were done in Processing.

The GUI created for the motor control consisted of having an individual set of sliders for every motor. This way they are conceived as a modular system, where every module can act independently. Each module consists of two sliders, one to control the motor's position and the other to control its speed. This gives the possibility of telling each motor where to go, for how long, and at what speed. The sliders allow the control of a single motor in real time; it is also possible to create buttons that control several motors at the same time. The objective of these tools is to facilitate an easy and fast way of testing and observing different

45. Information flow to control the motors
46. Mapping schemes Ableton Live - Processing - LED - Motors
47. Motor's control interface sketches

behaviors for designing patterns of movement. The patterns can consist of the simultaneous control of the 45 motors, or only one motor, or any desired combination.

Once a set of patterns is created, it is possible to orchestrate them, so they are performed from a timeline along with a musical piece. To do so, a MIDI track reserved only for the motors is created in Ableton Live and mapped to the channel specifically assigned for the motor control in the Processing code. In the code, every movement pattern is represented by a MIDI number. This means that every time that the MIDI track on Ableton Live plays a particular MIDI note, the pitch of that note will trigger a specific pre-designed pattern. This is how the motors' movement is directly mapped to musical data and how it is synchronized with other audio and MIDI tracks on the same session's timeline.

A very similar method is used for controlling the LEDs. The control is programmed to be done via MIDI values, just like the motors. This means that the lights are reacting to MIDI notes, so a MIDI track specific for each LED wall needs to be created in the DAW to trigger the light composition. This works by pre-assigning MIDI values to a specific light and color output. This is done in Processing, on the same control program used for the motors.

Through serial communication, every time the LED composition is played, the MIDI values disposed on the timeline are sent from Ableton Live to Processing and from Processing to the LEDs' micro-controller (Teensy 3.2), activating lights and colors depending on the MIDI composition.

Just as in the motor system, this works in real time with no delays or latency. That way, this method enables a perfect

synchrony between the different layers on the session, creating a perfect blending between musical composition, movement patterns and light/color output.

The capacitive touch sensors are also mapped through the same Processing program. Even though this is a similar mapping than before, meaning that information is sent between Processing and Ableton Live, it works differently, since now the data is sent the other way round. In this case, instead of having MIDI values sent from Ableton Live to Processing, the MIDI values are received from Processing and routed to Ableton Live. This change is due to having sensors bringing information in, instead of sending information out (motors and light).

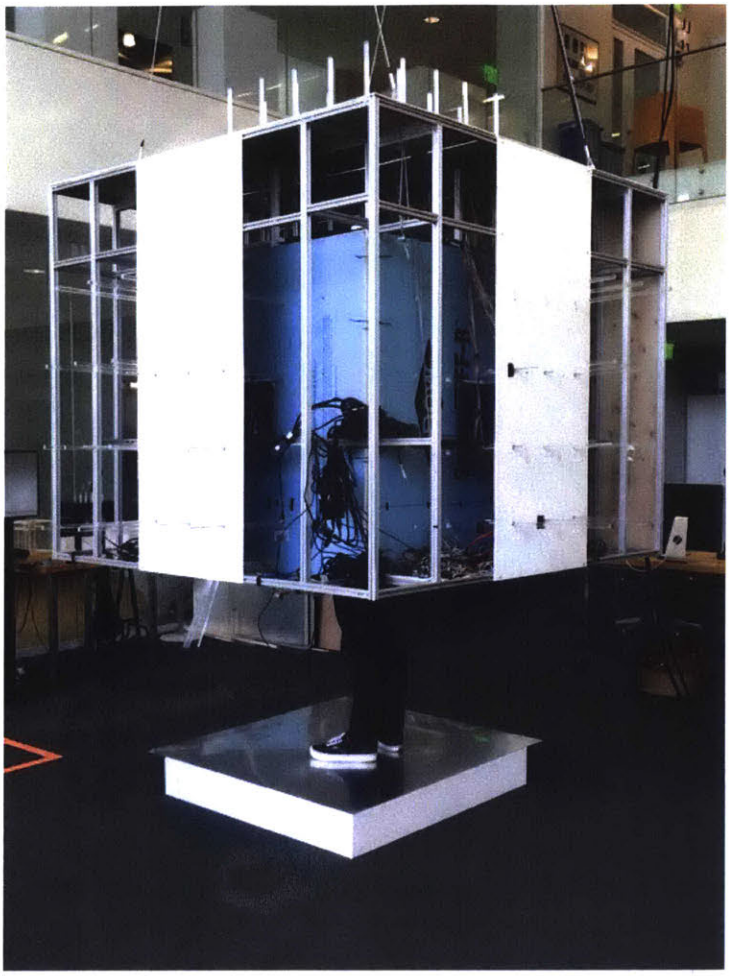
The sensor data is received in Processing and from there are sent to a specific MIDI track on the DAW. This track has the possibility of having a MIDI instrument assigned or hitting a sample trigger. This way, every time it receives a value from the sensor data, a particular pitch or sample will be played.

This unified control program delivers an easy way of having customized changes create different reactions and new behavioral patterns.

The sound output is done differently; it doesn't go through the Processing program, but routes directly from Ableton Live. The composition is performed through 5 different audio channels. The channel differentiation allows the composer to create an immersive spatialization of sound and be able to change the sound position among the speakers. To do this, every speaker is assigned to a different Send function on the software. Then every track is automated to be diffused through the different Sends at diverse moments of the composition. The four U12 speakers on the walls are

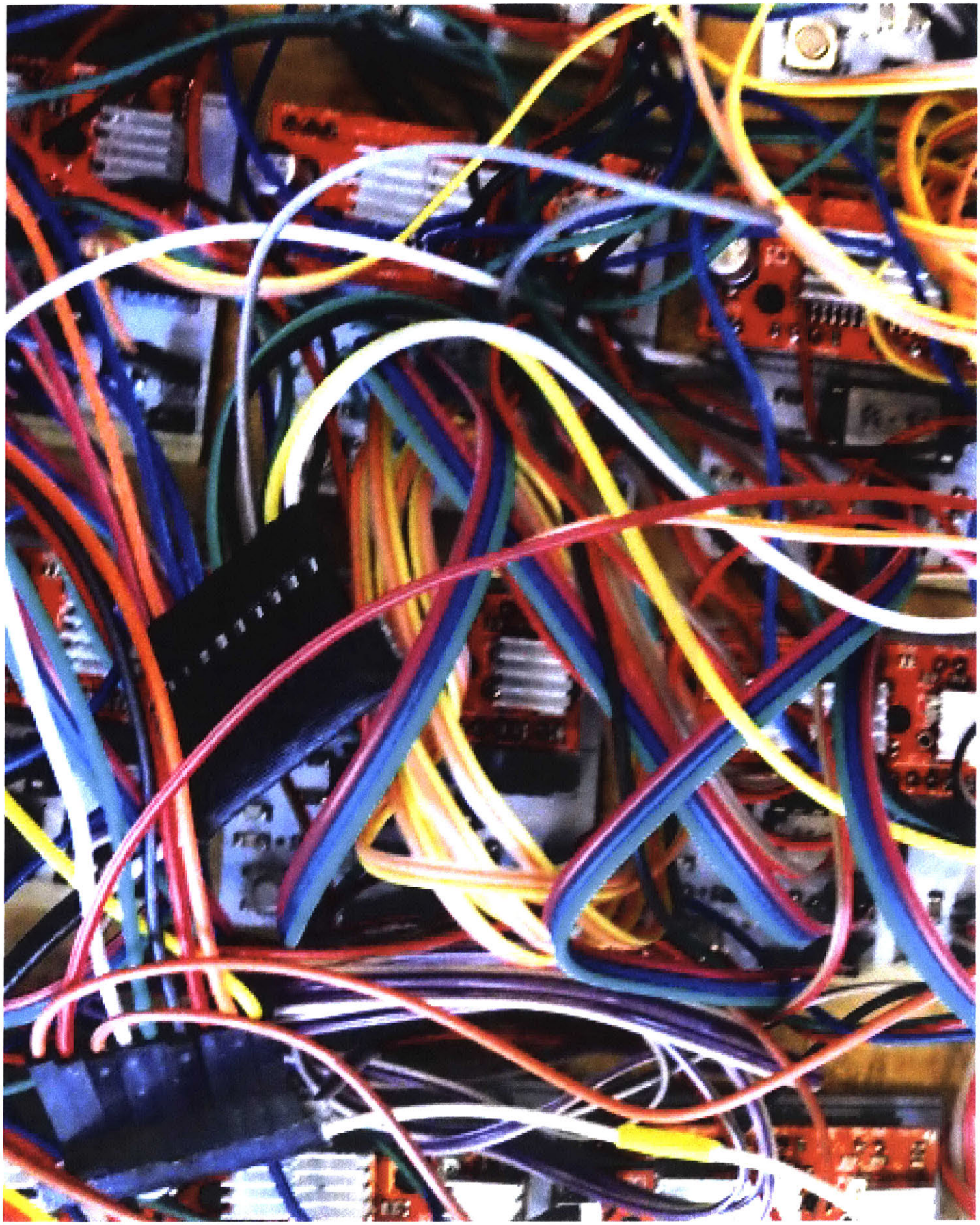
fed through a Motu 8M audio interface, and the Buttckiker (low-frequency transducer) on the platform goes through the Motu M8 to a high density 3000 Watt power amplifier. This completes the computational structure that powers the cube, giving rise to an interconnected system of different elements that transforms an unanimated object into a dynamic body.

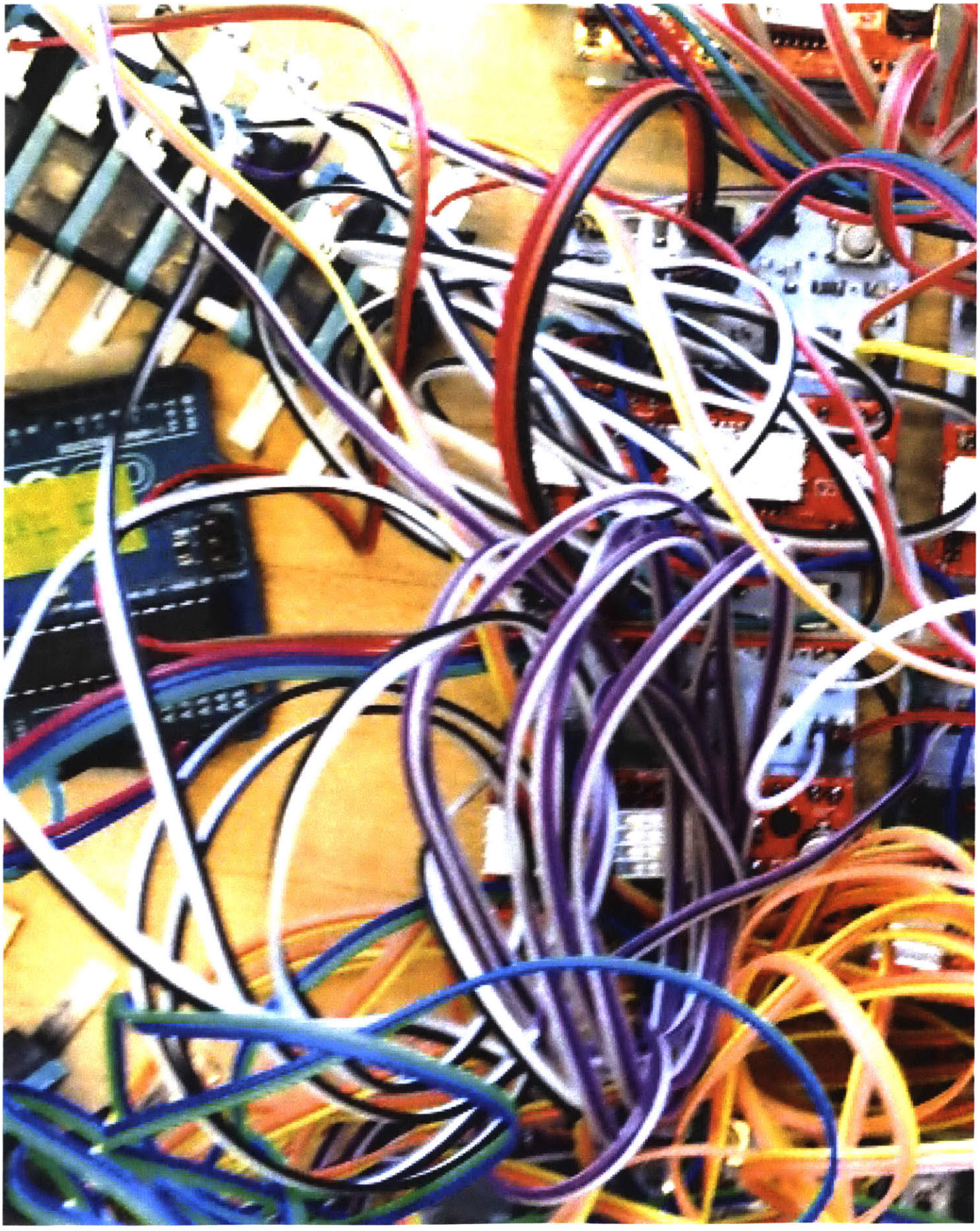
body

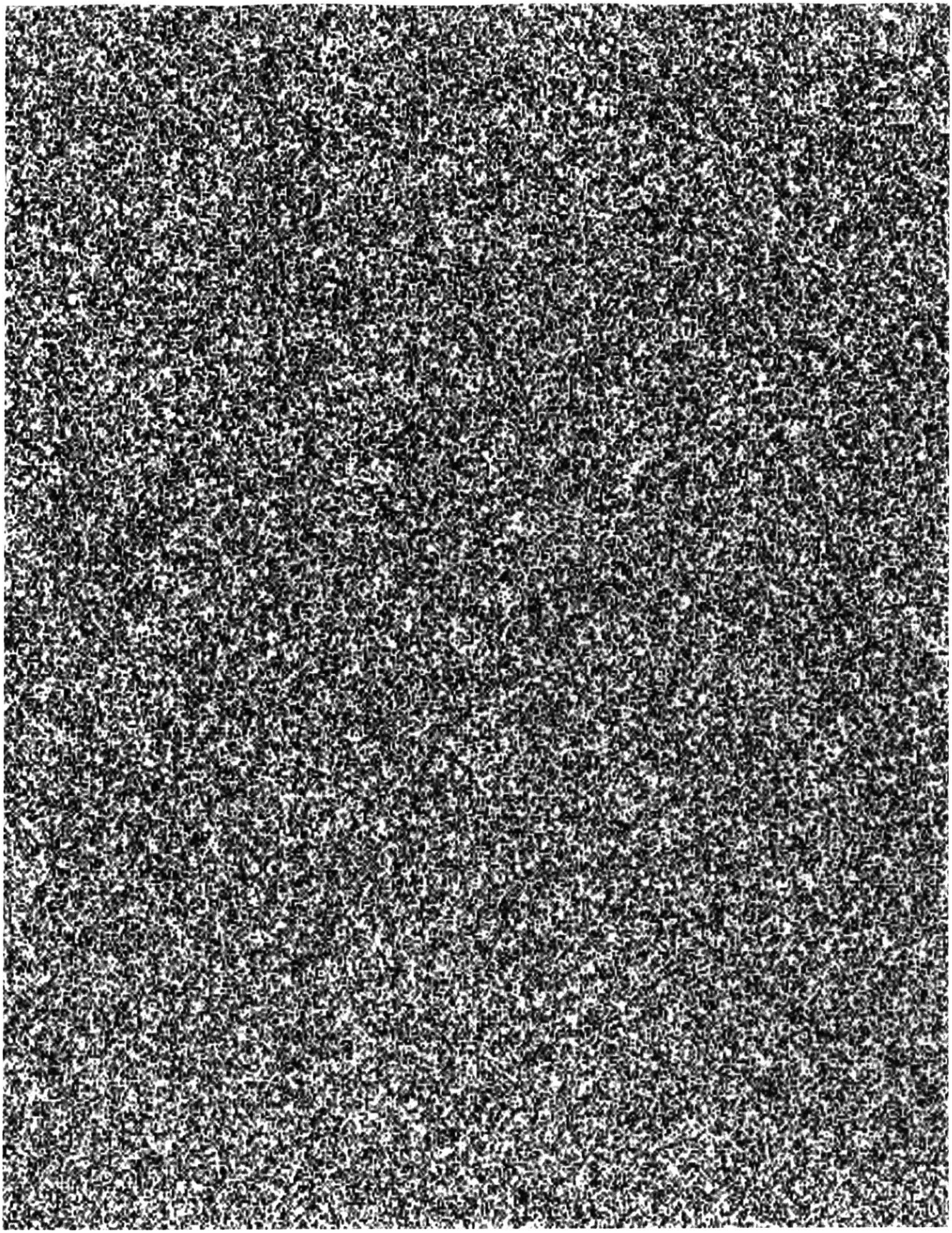


45

45. Human being inside of the cube in process







The architecture of a relationship

III.I PERSONALITY | Mapping has been an important tool in electronic music, since this is where personality comes from. The following chapter exposes how the mapping philosophy is done on this case. Even if the cube's body is a concrete and rigid object, what constitutes its personality is light and ethereal. As author Donna Haraway wrote:

"Our best machines are made of sunshine; they are all light and clean because they are nothing but signals, electromagnetic waves, a section of a spectrum, and these machines are eminently portable, mobile—a matter of immense human pain in Detroit and Singapore. People are nowhere near so fluid, being both material and opaque. Cyborgs are ether, quintessence."[19]

To deliver a compelling experience, the cube requires the capability of being expressive to communicate, connect and engage. The musical parameters are carefully mapped to the electronic elements of the system. This opens an extensive exploration of cross-modal perception, ranging from sound and color perception, light awareness to vibrations, acoustics and space modulation. All these elements are what will construe the cube's personality. In other words, its distinctive character will emerge from the combination of its expressive elements.

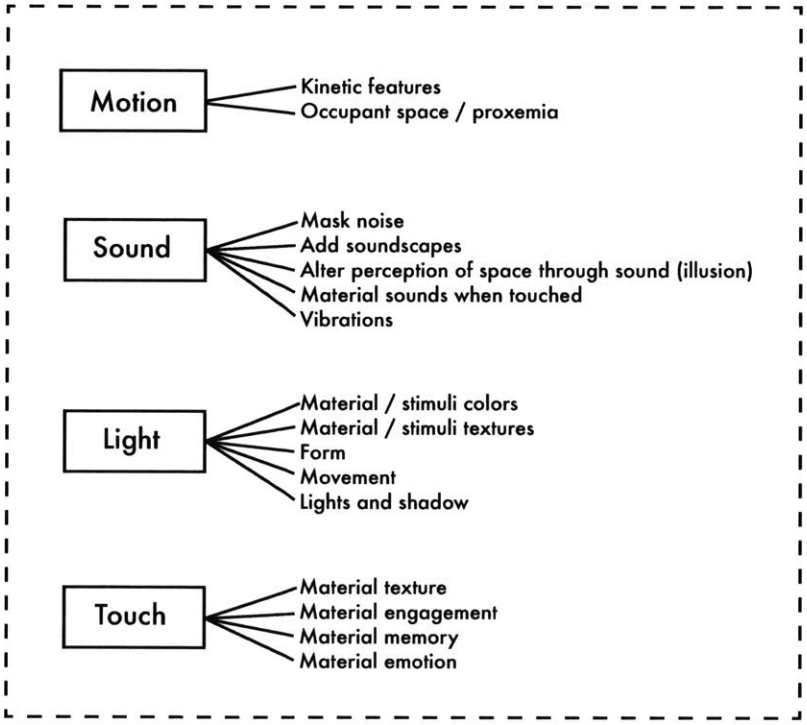
The main objective of the future composition is to create a unified understanding of sound and other spatial stimuli. The sound will change when the structure of the cube changes, and also the other way round, space will change along with the sounds. For example, if the space is small and intimate, the sound will be small and intimate: the walls will only "whisper". However, if the space grows to its maximum size, the size of the room will change sonically, unfolding into resounding reverberations relaying the feeling of being transported to the inside of a cathedral. Through these

noissərqxə

mappings and distinct undulations, Spaces That Perform Themselves reveals an electroacoustic interaction that takes one through different sonic scenarios.

The choreographic abilities of this environment are essential to creating a cohesive composition capable of building a personality. This is a tool to empower the sonic-spatial composer to create a piece of unified sensory modalities. Thus, it is in the composer's hand to designate a balance between every single element. This tool will likely augment the thought process surrounding musical composition, expanding it to concepts of movement, vibrations, light, and electroacoustics. Through this methodology, a new compositional experimental model emerges, one where no element comes first, and everything is created together synchronously. By doing this, it is possible to create different effects, emotions and as in Bryon Gysin's Dream Machines, achieve varying mental states through calibrating particular frequencies of sound and light.

The personality of the cube is given by each one of its parts working together. To unveil this character, it is fundamental to understand the phenomenological objectives of each one of its Systems. This will give clarity of the creative possibilities and set up the context for the composition.



Perceptual Characterization of the Cube

1. Motion / Mechanical system

Architectural spaces are containers of experiences and different levels of interactions. Interactions between bodies inside of the space and bodies interacting with the space.

When a room changes and is unpredictable, we need to re-map how we relate to it. How it becomes a body is how it is given agency and presence, it changes the way we confront it. This modifies our own spatial presence in a new dialectic manner. This means that the movement of the room triggers new perceptual associations and perceptual dispositions towards the room. "However brief we suppose any perception to be, it always occupies certain duration, and involves, consequently, an effort of memory, which prolongs, one into another, a plurality of moments."[20]

Bringing motion to the performance of the cube is a way of including a visual and physical representation of the sonic situations. The cube embodies a dance that alters its geometry, dimensions, volume, and proximity to the human on its inside. The motion carries a direct connection with the kinesthetic sense of the cube and visual sense of the user. Humans are visual beings, often trying to understand things from a distance and observe remotely before involving touch and its vulnerability. "Our vision of the world is far more complex than the mere activation of the visual part of the brain. Vision is multimodal; it encompasses somatosensory, emotion-related, and motor brain networks, and this activation plays out in endochrine systems and more. (Images can make you sweat.) The observation of touch triggers the somatosensory cortex. The observation of the expression of emotions and feelings activate limbic and emotional-related brain regions. Motor neurons not only cause movements and actions but they also respond to body-related visual, tactile, and auditory stimuli, mapping

expression

the space around us, the objects at hand in that very same space, and the actions of others. Cortical motor networks thus define in motor terms the representational content of space, objects, and actions."[21]

Spatial experience is never a fragmented phenomenon; everything that rises from it comes from the combination of the diverse sensory elements around us. So even if the cube's dance is perceived as a visual stimulus, it changes the emotional setting of the human inside. It will create different situations that will be perceived visually, but that will trigger different emotions, as well as bodily positions and dispositions. The human brain will react to the movement of the cube and will re-wire the way we understand and relate with spaces, creating a new perceptual model of dynamic behavior, instead of taking for granted its initial configuration as a permanent physical state. Spatial recognition is usually done immediately; our brains know how to understand a space and its dimensionality; this way our bodies can be there at ease without even thinking about it. As Marvin Minsky said: "We are less aware of what our minds do best."[22]

By challenging this way of thinking, our minds will expand to include the dimension of time as part of a room's configuration. Having a room changing in a dynamic way opens the encounter of an architectural system that is designed not to accomplish a purpose, but to create an effect.

2. Sound/Vibratory System

In this system, sound is the genesis and the power for every action. It is what articulates all the other sensory stimuli. Usually, for human beings the sense of audition is

less fundamental than the sense of vision or touch. Even though the sonic phenomenon is an important tool for understanding our context, dimensions, materials, and distances. Sound places us in the world. There are many theories of how sound is physical and creates a link between the material and immaterial world. This is what ties sound to an extensive discourse as a creator of material affective memory.

The spatialization of sound through multi-channel diffusion brings a primary element of the compositional imagination: the localization of sound in physical and perceptual space will relocate the individual in diverse perceptual scenarios and physical/tactile situations.

Sound is actually the resonance and vibration of matter, of particles of air or other materials. Within Husserlian phenomenological thinking, the material aspects of sound makes it a valuable tool of auto-affection, because it involves touch. Thus sonic phenomena is material and has spatial presence. "The most important sense in our body is touch... Hearing is linked to touch from a phylogenetic perspective (inside of the lateral line organs of a fish, destined to the reception of pressure stimuli of ultrasound, then evolved into amphibian's auditory organs, and later into our ears) and from a ontogenetic perspective (the vibrations of sound reach the fetus through the capture of the amniotic liquid's pressure over the epidermis; during the prenatal phase we can talk about a "global ear", an approach of hearing with all the skin). Thus, drawing a "haptocentric" vision of human sensitivity, where the tactile contact is the source of synesthetic associations and human being's affective associations."[23]

When sound moves around us, it breaks down boundaries between material spaces and immaterial spaces, between

the visible and the invisible.

"... we can understand how sound as relational phenomena immediately operates through modes of spatiality, from the immediate present to the distant transmission, from inside one's thoughts and towards others, from immaterial wave to material mass, from the here and now to the there and then...
Sound thus performs with and through space: it navigates geographically, reverberates acoustically, and structures socially, for sound amplifies and silences, contorts, distorts, and pushes against architecture; it escapes rooms, vibrates walls, disrupts conversation; it expands and contracts space by accumulating reverberation, relocating place beyond itself, carrying it in its wave, and inhabiting always more than one place; it misplaces and displaces; like a car speaker blasting too much music, sound overflows borders. It is boundless on the one hand, and site-specific on the other."[24]

Sound carries dynamism and empowers the cube to guide the conversation with the individual inside of it.

The spatialization and temporalization of music will depend on the composer's ability to work with the dynamic characteristics of the sound material, as well as understanding the possible tensions that can be constructed with it. Music carries in its essence the elements of time, space, and matter. And most important, it deploys them in a viscous relationship with the listener, "... music reveals the dynamic depth of the space, not at a distance, how vision does, but at the inside of the most intimate proximity, as living depth."[25]

3. Light/Optical System

Adding this feature is relevant because it intensifies the physical movement of the walls by also creating movements with light. Also, the possibility of controlling color is an essential characteristic of the multi-sensory composition, since it comprises one of the primary sensory stimuli human beings have: the distinction of colors. This ability came with evolution, where humans developed a deeper sense of the visual by adding the layer of color.

There is a strong tradition of color and sound association. This was intensely studied on the beginning of the 20th century. For example, Kandinsky led a significant body of work by creating a language of colors and shapes to represent sounds and musical figures. During the times of the Bauhaus, these studies continued and are still an important subject around the arts, sciences and interdisciplinary practices. Many people have worked on the correlation between frequencies of color -or the visible spectrum- and frequencies of sound. Even Isaac Newton created a mathematical theory around this. Many others have created their own models and also studied color-sound synesthetes to understand the mapping of both sensory stimuli together.

Even though these are very appealing relationships, they are not totally consistent; thus color vision is not entirely consistent either. It changes and varies through different individuals. A standard human viewer has a trichromatic vision, though a few alterations can occur and alter the perception of color by having partial blindness, color blindness or tetrachromacy (a genetic modification presented only in women). This is why color-to-sound models are subjective and not very consistent.

It is important to mention that color not only helps us identify and differentiate things on a deeper level of the visual landscape but also has become a tool for emotional representation, meaning, and conceptualization. Recent theories are establishing that color came to us as a tool for social interaction, and that an important role of color is to convey emotional information. "It turns out that, for most things in the world, color is not a necessary cue for object recognition or for basic survival (as one could guess by how late excellent trichromatic color vision evolved in our mammalian ancestors – among mammals, only certain species of primates, such as humans and macaque monkeys, have excellent color vision; color alone is insufficient for most visual tasks)."[26] Studies have shown that "...skin color is clearly used for assessing how healthy humans might be, and other important socially relevant aspects of our behavior (such as picking up on anger or embarrassment). Although there is not much work on the subject, it seems likely (I think) that we use skin color to adjudicate social situations – to ascertain the relationships between people in new or evolving social contexts. Support for the idea that color was evolutionary advantageous for social communication is provided by spectral analyses of skin-color changes, which are much more apparent to primates who evolved trichromatic vision (such as humans) than primate dichromats. (Consistent with this hypothesis, trichromat primates tend to be bared-faced. See Mark A. Changizi, Quiong Zhang, and Shinsuke Shimojo, "Bare Skin, Blood and the Evolution of Primate Colour Vision," *Biology Letters* 2, no. 2 (June 2006): 217-21.)[27]

So even though color and sound correlation models are subjective, they still give us a tool or an extra layer to convey emotional information and materiality. On the cube, this allows us to augment further more the physicality of sound and its emotional effect.

5. Sensory/Reactive System

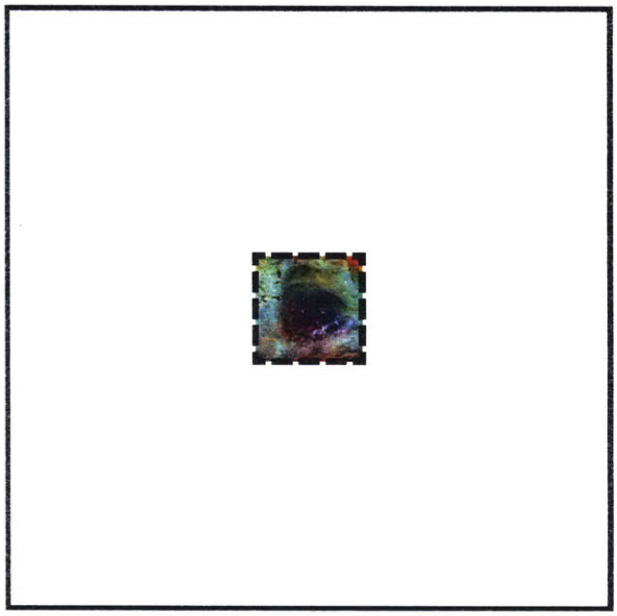
The tactile dimension implies proximity; it opens the possibility of physicality and a more direct relation. Touch is an action that takes place in the most personal sphere: touching something always implies being touched in return. It conveys closeness and at the same time vulnerability; it conceives sensuality as well as danger, among other emotions. The cube's Sensory System is reactive to touch at five distinct points. Though it can touch the user with all of its rods, this physical element makes the cube the character of being in power, of being sometimes scary, sometimes intimidating. This is why inviting the user to touch it is also a way of breaking down this notion of control, making the cube also vulnerable to the human body inside. This provides a relationship between action and reaction, it presents a dialogue, and it sets a dance.

It is important to refer to the concept of haptocentrism. This notion comes from Derrida's logocentric action of deconstructing the sense of vision (heliocentric or optocentric) as the primordial human sense and exalting touch as the main sense. The haptocentric paradigm establishes that "touch is the sense par excellence of auto-affection. Wherever there is flesh, Derrida seems to imply, there is auto-affection... Just as in *The Voice and the Phenomenon* three decades earlier, Derrida had outlined why Husserl's notion of the voice led to auto-affection ("speaking is hearing oneself speak"), in *On Touching* - Jean-Luc Nancy, carnal auto-affection of touch completes the picture ("touching is touching oneself").[28]

Following Derrida's ideas, a better relational body is constructed by heightening the sense of touch. This allows us to create tighter relationships since through physical contact, humans can create meaningful embodied affective

memories. Human beings are physical three-dimensional bodies that are expressed through the exchange of matter, using material interaction to build immaterial experiences.

expression



expression

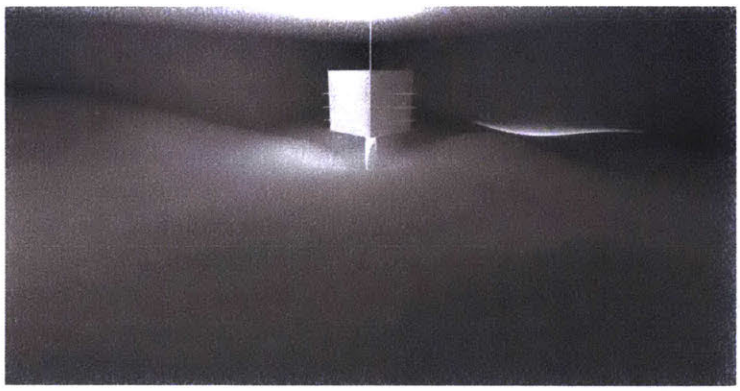
III.II SCENARIO | Every physical interaction takes place somewhere in the physical world. This statement seems redundant and evident, but it is important to clarify, since many of the things described previously could happen in a virtual or digital environment. This would completely abolish the objectives of this project, where the most important part is to bring sonic metaphors and spatial theories to an embodied form, to have presence in the physical world, and to convey meaning through palpable matter and embodied existence to this reality. This is why the contextualization of the interaction will be a key element to facilitate what will happen and what type of communicational or relational instances can emerge. The context can guide encounters and dis-encounters, it gives a setting for what can happen. This is why it is fundamental to design the scenario of the encounter between the human body and the cube's body.

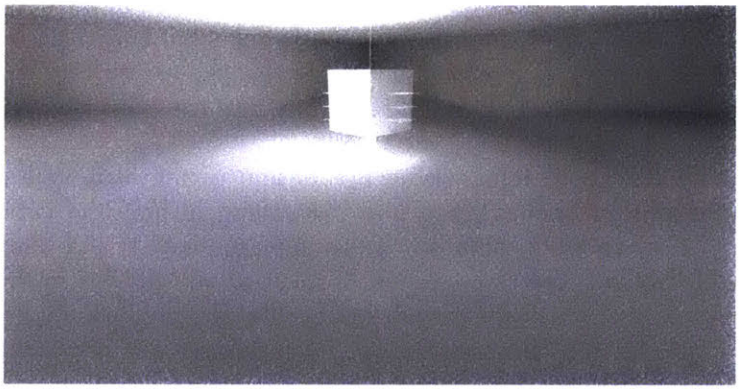
It is crucial to think about the design of the installation, the design of the space and the setting of how the cube is approached, entered, experienced, exited and then left behind. The importance to think about this lies in the necessity of giving a framework for the whole composition/ experience to be considered. This scenario will affect the way we reflect on the intimate choreography.

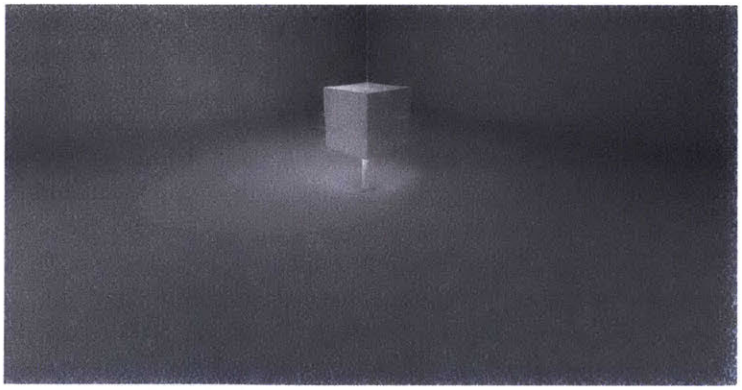
The following ideas are hypothetical; at this moment there is no fixed or defined venue for setting up an installation. So the following design expresses one of many possibilities for an optimal encounter. This will be one of many possible contextual situations, even though it gives strong guidelines to set up the cube and its *proxemics* in any future installation.

The cube has two different relational layers, one at its outside, in the outer sphere, and a very different one on the inside, on the intimate sphere. To be able to work with the inner, we need to define the outer. How is the human

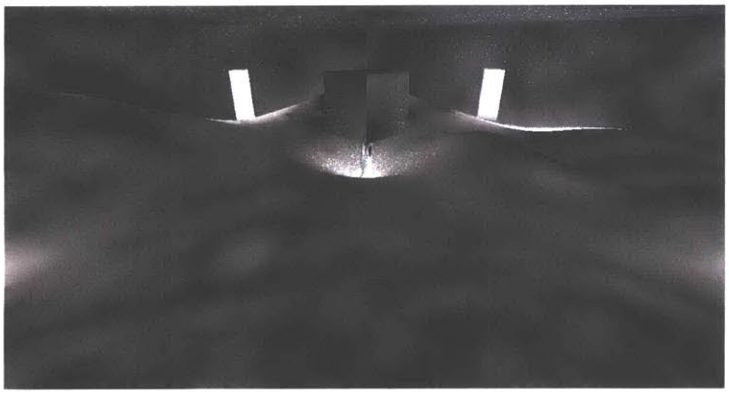
46. Conceptualization of the cube disposed on the bigger room.
Developed during conceptual and graphic brainstorming along with Chantine Akiyama

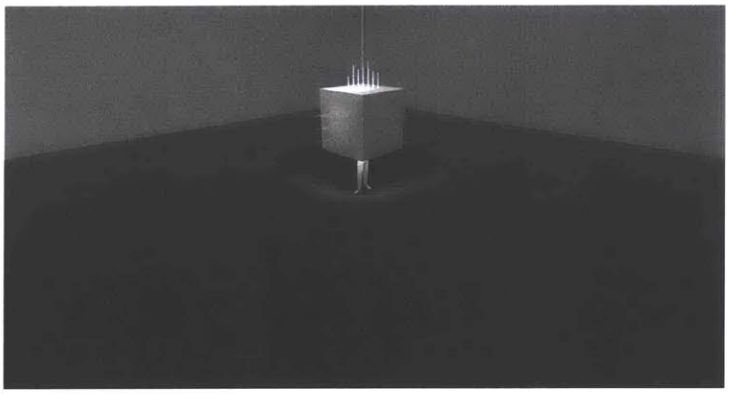


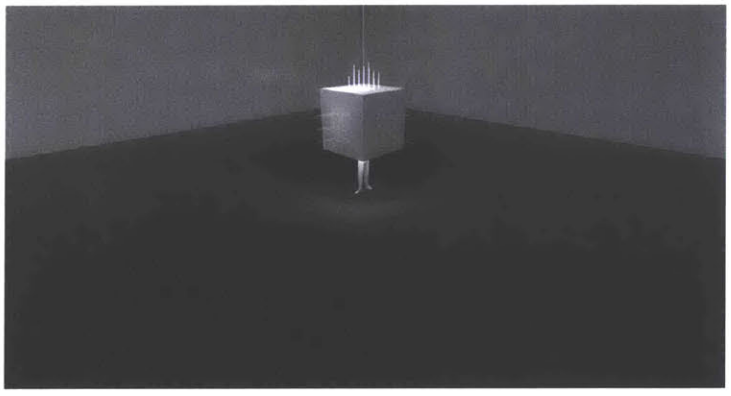




47. Possibilities for staging the cube
Developed during conceptual and graphic brainstorming along with Chantine Akiyama







expression

body encountering the cube and how it can allow for other bodies to be around in the meantime as the intimate and personal relationship is taking place? These design decisions can change the complete interaction. This contextualization defines an essential part of the cube's character and predisposition. It is very different if there is a line of people waiting for entering this machine, or if the context allows other ways of encountering it. This can make the cube shift from being a mere entertainment device to be a body you relate with.

To conceive this space, first of all, it's important to think about the effect that wants to be created and then set up the rules for that to happen. For example, there are few relational tools that can be used to contextualize this experience. I would say that the most important ones that were considered are: observation, expectation, proximity, anticipation, and permanence.

A big suspended cube is not easy to hide, this kinetic sculpture is then set at the center of a big room. Its presence is the focal point of this room. Not only because it floats, but because it moves. On this exterior of the cube, you can't see or feel all the things that are happening on its inside, but it gives a glimpse, it gives some clues to keep people interested. On its outside, the cube shows the movement of the rods, going in and out, revealing that something is going on inside. This dynamism transforms the cube into a hypnotic element at the center of the room. The mystery of its exterior performance is soothing, attractive and magnetic, like a central bonfire. It invites people around it to observe and get lost in a subtle pattern of movement. Also, the rods carry light, so whenever there is a color on the inside, it will be visible at the ends of the rods.

This exterior layer of interaction gives us the possibility to

noissərqxə

play with people's expectations. How to show something but not reveal its essence and final performance, so it is still sublime and unique when you enter the inner sphere of the cube. The control of distance helps to fulfill this goal. How to keep people close but not too close? What is the perfect distance for observation without giving the whole experience away? So maybe more than physical distance, it is important to create the perception of distance with other elements, such as floor design, sound, and lighting.

Thinking about the floor as an experiential dimension helps to extend the relational possibilities without adding walls or other elements. So the floor, in this case, is thought as a continuous layer of undulant situations that have the objective of keeping people at a certain distance and isolating the person inside of the cube, so the experience feels more individual and immersive. The floor gives place to a subtle collection of elements: it becomes a seat on the undulations, and also directs how somebody enters the cube. At the center of the room, right beneath the cube, the floor is lower. This presents a concave womb that hosts the person. The rest of the room's undulations are higher than the center, so individuals on the outside are at another layer of interaction. The undulant floor is thought as a soft material. The idea is to use a continuous thick layer of primode neoprene sponge. This way, the floor will be conceived not only as a constant thing that changes to create different interactions, but also it becomes a continuous mattress, inviting people to stay there and relax while looking at the central moving cube. Also, it changes the way people walk. It slows down the pace and the rhythm of proximity and interaction. This soft bouncy floor is a smooth behavioral element.

Having the floor is not enough to organize the room's behavior and invite people to observe and remain. There some fundamental elements at our disposition to be able to

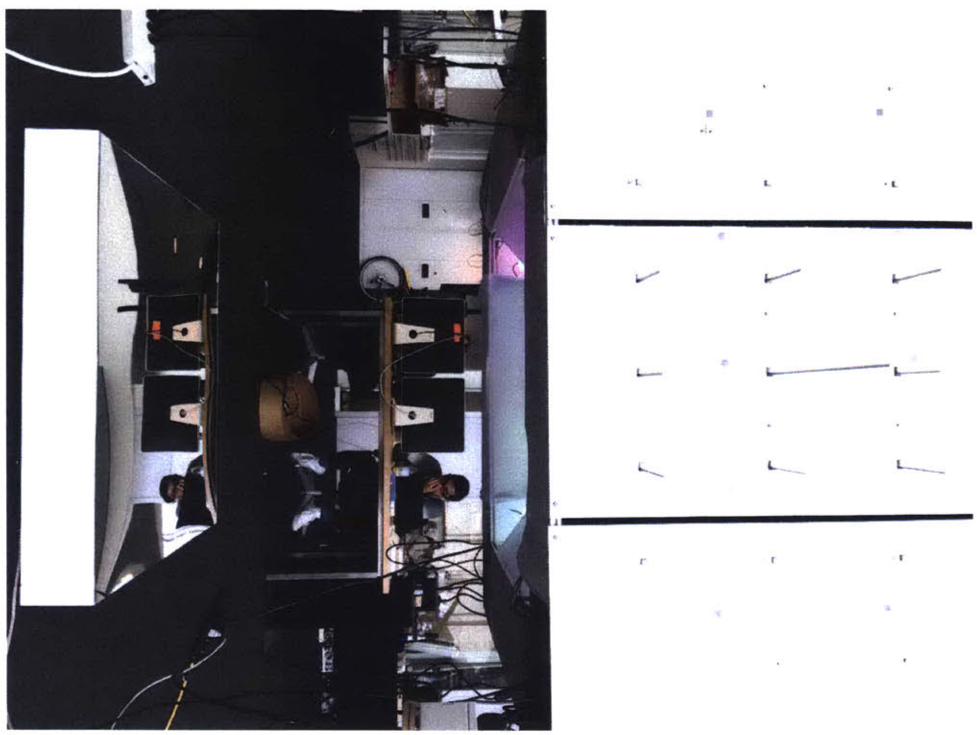
create a soothing and timeless atmosphere around the cube. One of these elements is sound. Sound has the capacity of changing time perception and creating an environment where people could tune into a relaxing mental state, like using the deep-relaxation Alpha wave (7.5-14Hz). Sound will also be used as a tool to create sonic distance between what is going on inside the cube and on the outside. It is planned to use sound as a masking tool by drowning the room in a drone equal to some frequencies of the inner cube composition; this way you can cancel some of the sounds and keep the mystery of the inner composition.

Light is another element that is considered. So many things will happen on the inside of the cube that having a preamble with very controlled light and sensory stimuli are fundamental. The light will be peripheral and very dimmed; just enough to move around the room and identify others around you. This way, when a person enters the cube, it is a transformative and revealing experience. Having a very controlled homogeneous and unchanging environment will create this effect and highlight the variety of situations inside of the cube. So the contextualization is not only about how you wait and observe the cube, but it is more about how your mind and body get prepared to enter it.

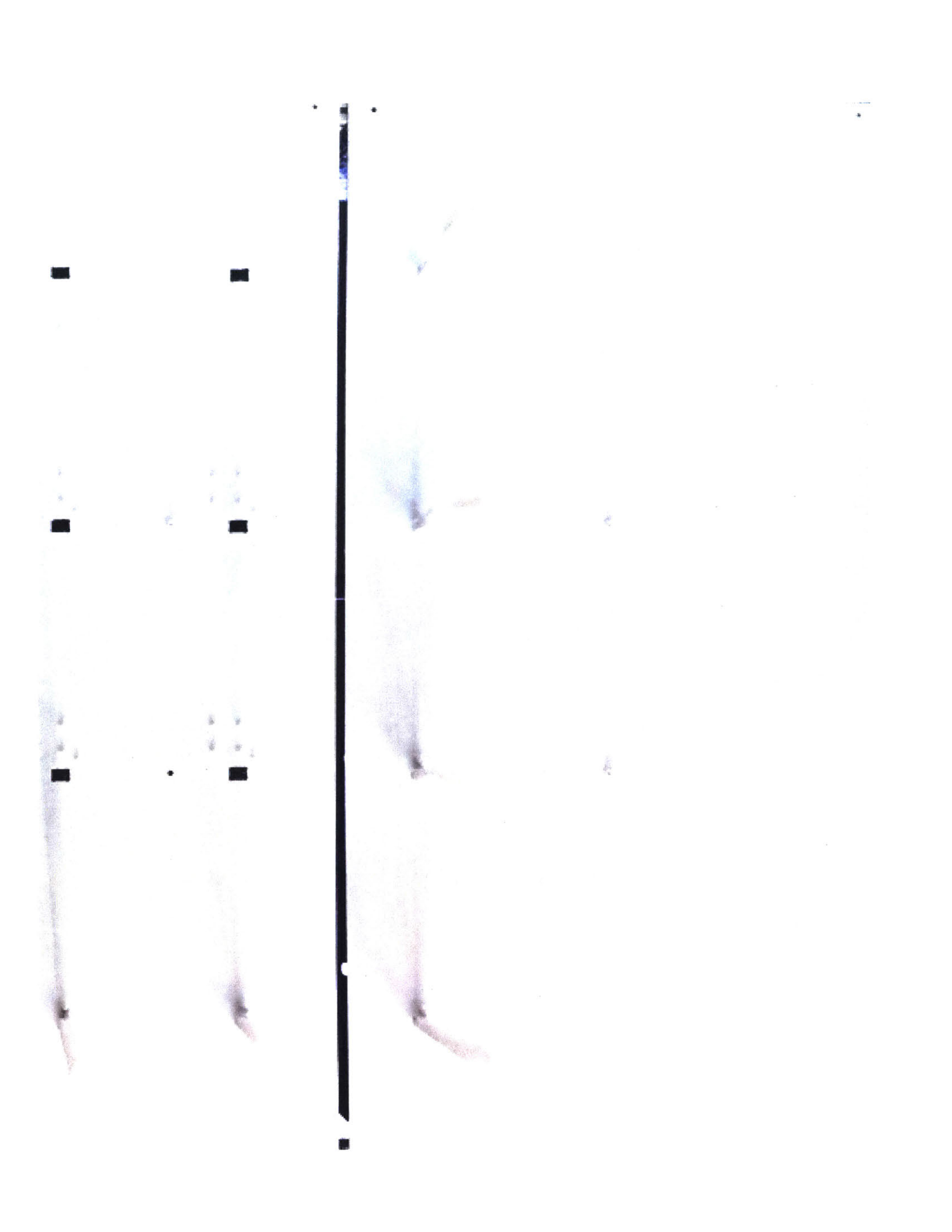
The setting and contextualization of the cube give the idea of floating in a trance, in a void before entering dazzling life itself. It is important to remember how a person enters the inner cube sphere: he will lean down and emerge into this new world, leaving behind the other world of others and communal silence. All these contextual elements set up the scenario of the composition enabling a healthy relationship between the people and the cube.

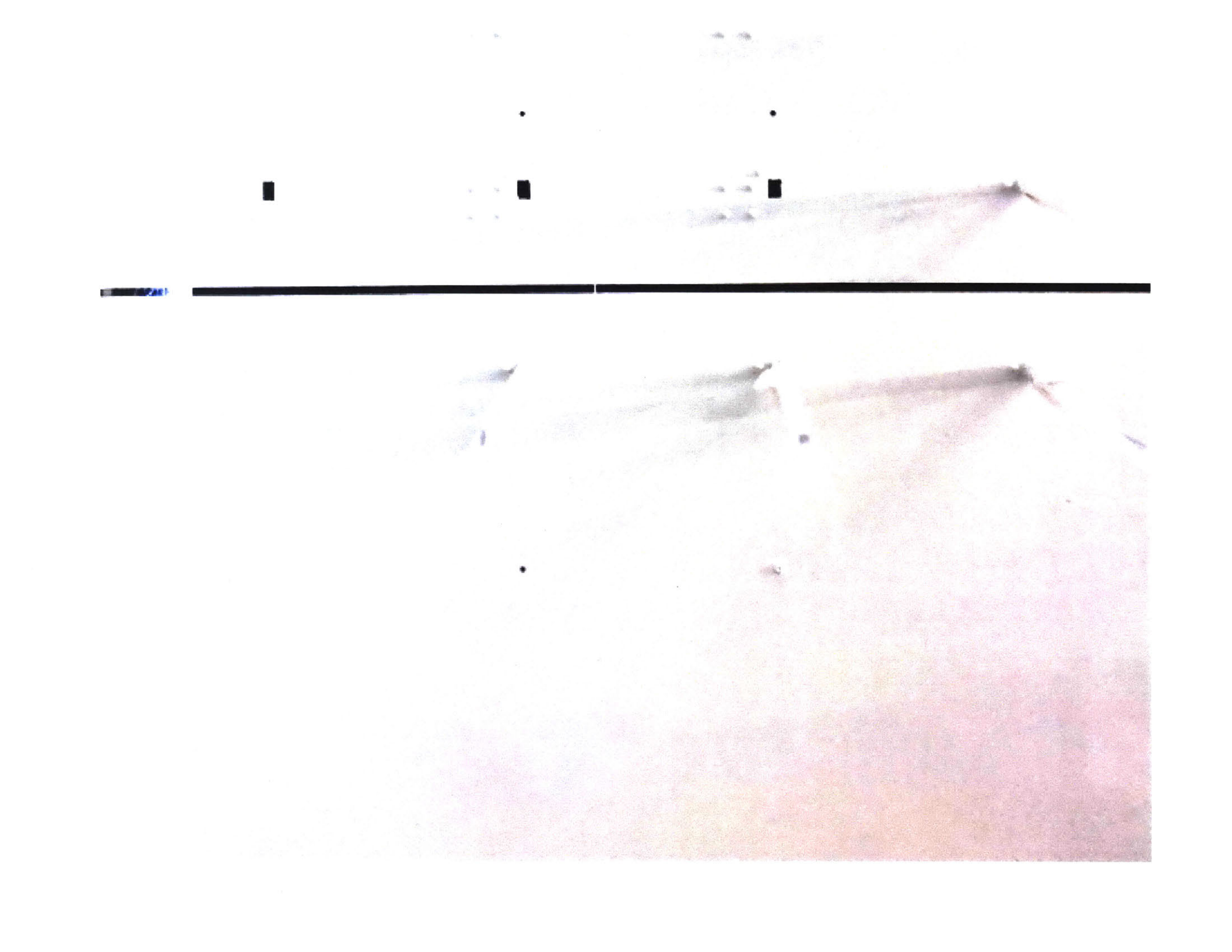
expression

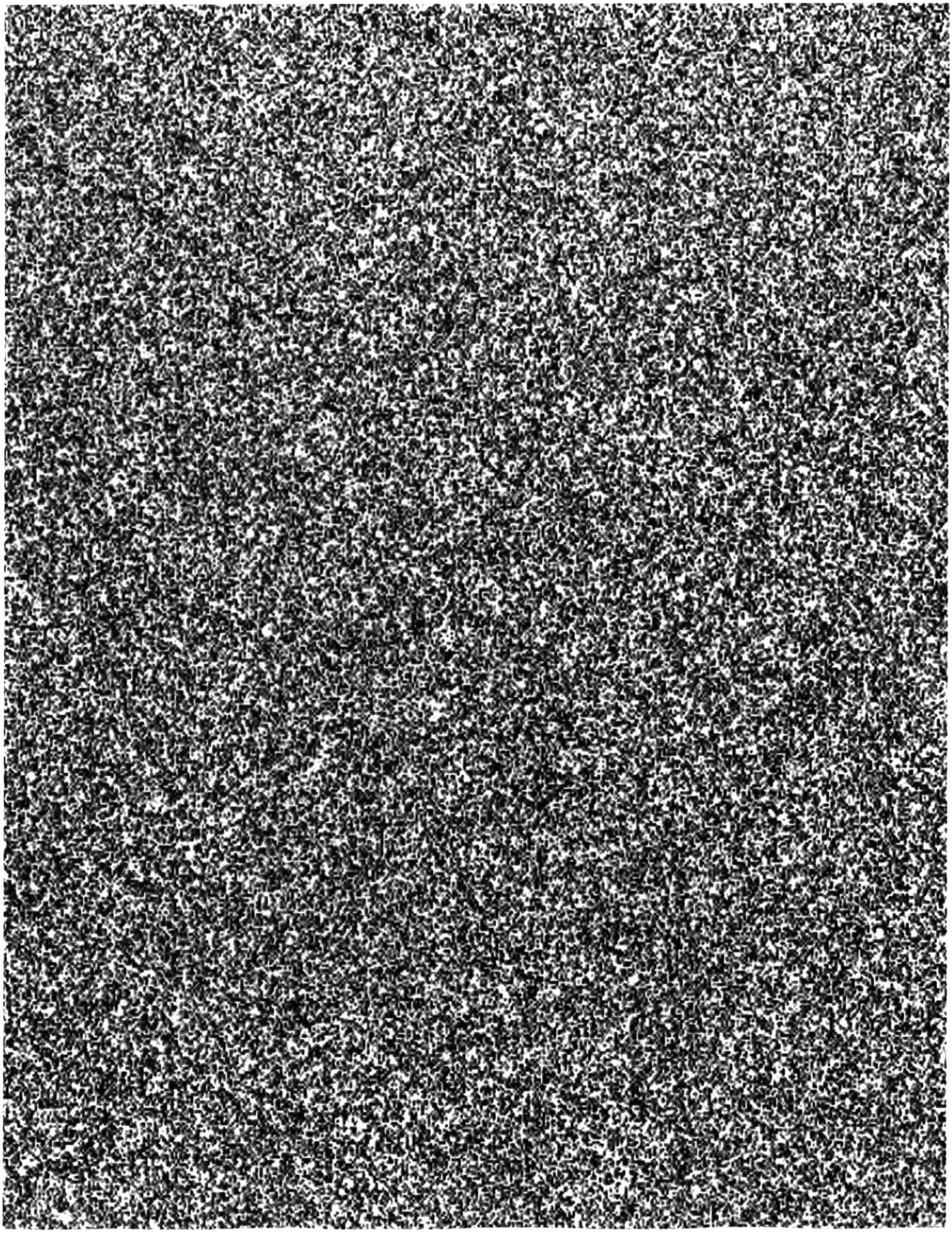
48. The cube floating and mirroring at MIT Media Lab, Opera of the Future group.



expression







The blueprint of an experience

" How could movements of deterritorialization and processes of reterritorialization not be relative, always connected, caught up in one another? The orchid deterritorializes by forming an image, a tracing of a wasp; but the wasp reterritorializes on that image. The wasp is nevertheless deterritorialized, becoming a piece in the orchid's reproductive apparatus. But it reterritorializes the orchid by transporting its pollen. Wasp and orchid, as heterogeneous elements, form a rhizome... At the same time, something else entirely is going on: not imitation at all but a capture of code, surplus value of code, an increase in valence, a veritable becoming, a becoming-wasp of the orchid and a becoming-orchid of the wasp. Each of these becomings brings about the deterritorialization of one term and the reterritorialization of the other; the two becomings interlink and form relays in a circulation of intensities pushing the deterritorialization ever further. There is neither imitation nor resemblance, only an exploding of two heterogeneous series on the line of flight composed by a common rhizome that can no longer be attributed to or subjugated by anything signifying. Rémy Chauvin expresses it well: "the apparallel evolution of two beings that have absolutely nothing to do with each other.""[29]

The concept of Rhizome presented by Deleuze and Guattari sets up the relational aspects of the dance between the cube and the person inside of it. The cube becomes a symbiotic environment, which gives and receives, that changes, that affects, that is changed and is affected, giving place to a transversal relationship; like a dance, an embodied dialogue. This new way of communicating with an architectural space evolves from an exercise of embodied cognition. The environment plays a formative role in the development of cognitive processes of the human on its inside. This person relates to a new type of room, one that is constantly changing, always demanding his attention,

relationship

telling a story and guiding an interaction.

The interesting thing about a relationship like this one is that it has no beginning or end. It takes place in the middle, on the encounter of the cube and the person. The aesthetic interaction goes from one to the other, feeding the system and transforming both of them (the cube and the individual) as limitless bodies of continuous transference.

The cube presents a set of territories that can create assemblages, uniting and articulating among them. All the sensory modalities are territories that can be presented and explored. So the performance or the relationship is constructed upon the idea of a constant territorialization and deterritorialization. This is given by the constant variation of situations and state changes, creating a loop of cycles ceding and gaining control. These territories provide the aesthetic material for this experience to be able to construct meaning.

The Cube is a room, a stage, performer, dancer, instrument and reactive, feeling body all at the same time. It can build a symbiotic relationship of giving and receiving. Essentially initiating a dance that reorganizes our relationship with the built environment by allowing an individual to step into the center of the construction and deconstruction of a space that performs itself.

How can an expressive environment like this one effect and change the way we compose music, spaces, and aesthetic experiences? How can the relationship with this room modify the way we interact with and understand the built environment?

relationship

IV.I CHOREOGRAPHY | "Choreography is tied to Biology. Choreography gets its start from something about our nature. It is grounded in our biology."[30]

In the previews chapters, all the compositional tools were presented as fragmented elements that need to be articulated to create experiential ensembles. This chapter presents the first attempt and sketches of this articulation.

The composition of the sensory choreography will unite three main parts: the human body, the cube, and the sensory stimuli. This creates a relationship between the three of them by combining them on a single unified construct.
This composition will combine different sensory stimuli that will transform the cube into a synesthetic synthesizer.

As previously mentioned, synesthesia has been a vastly studied topic among scientific and aesthetic research. Though, even if similar, the notion of kine-synesthesia has been less explored. As the researcher Francesco Spampinatto establishes, this concept applies to psycho-sensory-motor characteristics of sensory association.

"The body becomes the reader of the experience because the listening is accompanied by an empathetic micro-reproduction of tensive configurations in music, through out the embodiment of certain patterns of muscle tone: an "imitative micro-dance.""[31]
This *kine-synesthetic* characteristic adds motion. It brings the notion of kinetic to the conversation, and also adds the concept of physicality to the original synesthesia model.

The formulation of the sensory choreography implies the composition and disposition of situational elements on time, thus also on space. Time is never an isolated phenomenon, but it is the element that configures the dialog between

relationship

the content. Time appears at the moment of mediating the dialog of the parts. Time is the element that denotes the different material and affective aspects of the composition. This capacity of time gives it the particularity of providing a dynamic order, re-configuring static and flat elements into a set of physical and three-dimensional elements. This way, time transforms itself into a spatial factor.

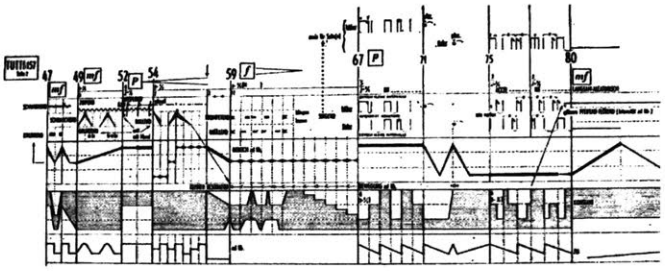
In addition to the importance of the notion of time, to create this composition, we need to consider also the concept of silence. Silence mediates and organizes the elements of the content, and is itself a part of the content. Silence is not only organizational absence, but it also is the element that can bring tension into the composition. It creates continuity and allows the chaining of events, combining them and translating them into a multi-sensory choreography performed in time.

relationship

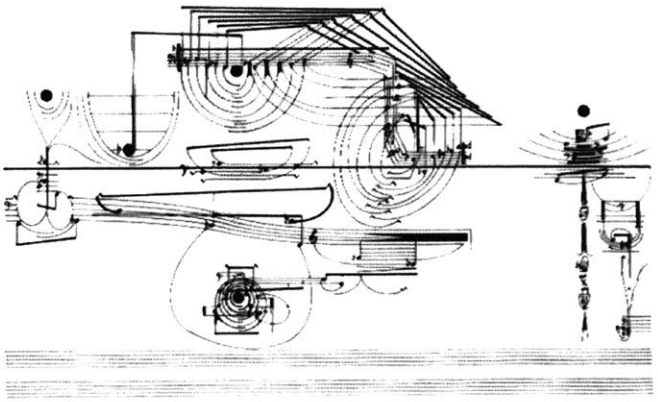
Spatial notation | Experiential score

Many people have invented their own customized notation system. In some cases, this exercise has been interesting in the sense that it augments and expands the production of knowledge and also by creating more intuitive systems, makes it possible to reach out with those tools to a broader community. In other cases, the creation of personalized notation systems has been necessary to express complex compositional ideas that don't fit the standard and to be able to include new elements. Some might be shown as linear sequences that include notions of movement, kinesthetic perception, and rhythmic patterns. New models of open scores and graphic notations have been popular to attempt to get closer to expressing the spatial realm in a time line of sequences. The majority of these experiments are very interesting from a graphic and architectural perspective,

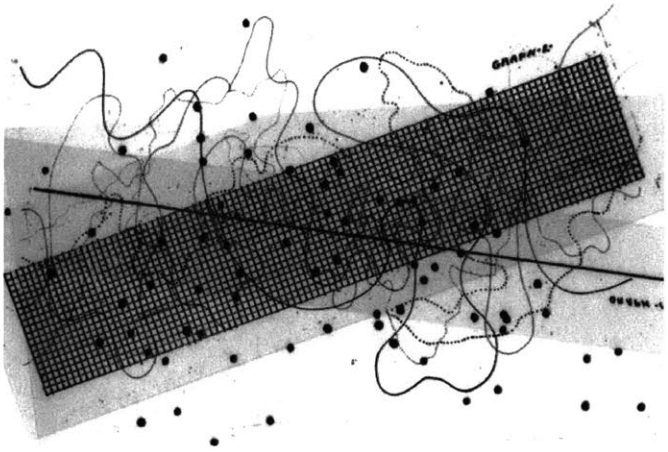
49. Karlheinz Stockhausen, "MIKROPHONY I" - 1964
50. Cornelius Cardew, "Treatise" - 1963-1967
51. John Cage, "Fontana Mix" - 1958
52. Brian Eno, "Ambient 1: Music for Airports" - 1978



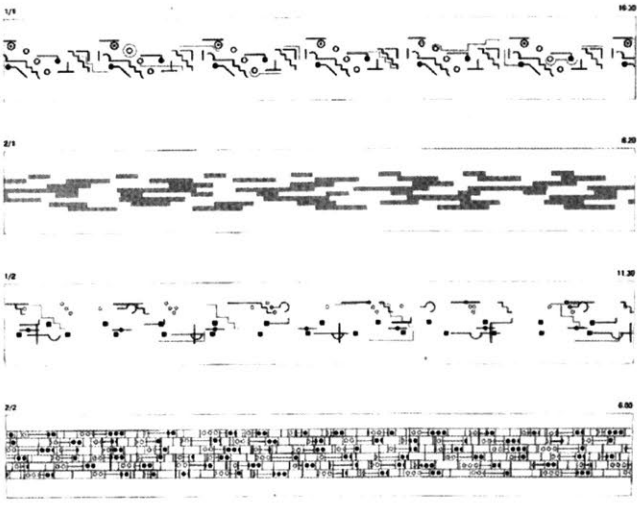
49



50



51



52

relationship

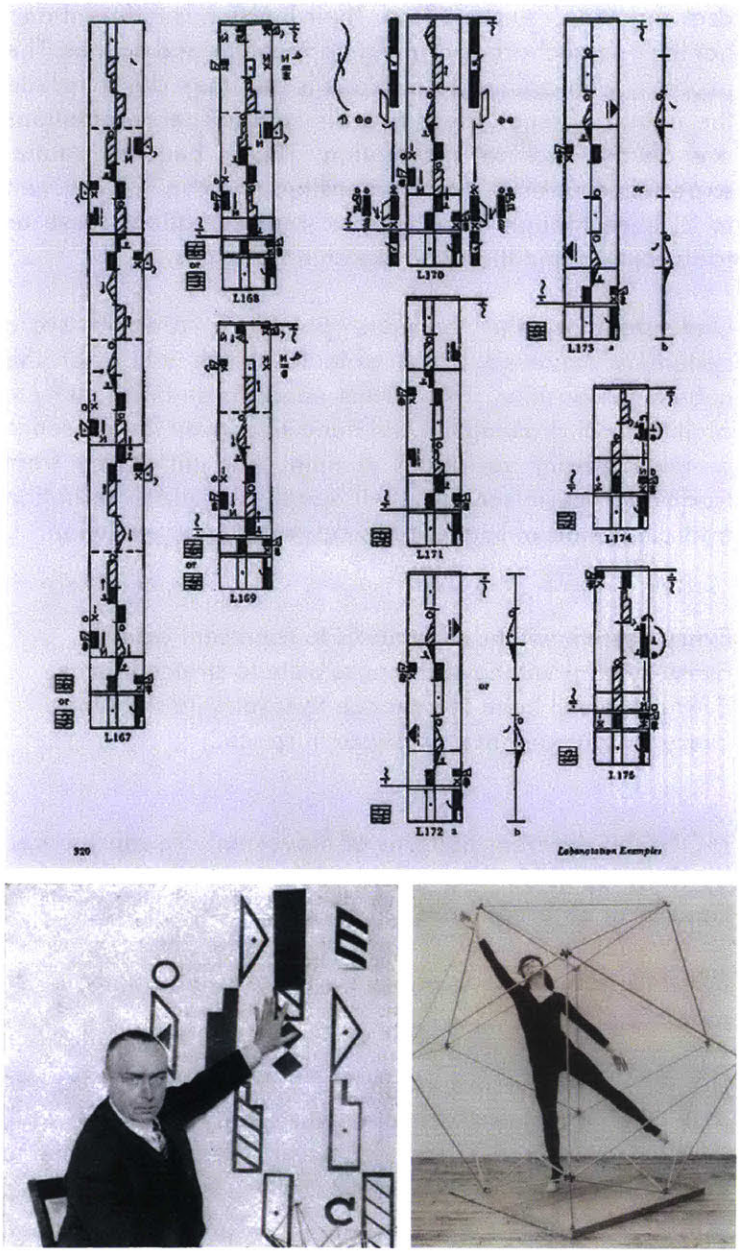
though in many cases they presented limitations and didn't endure in time because they were not meant to be universal, hence their objective was usually more expressive.
For example, composers such as Stockhausen, Cardew, Cage, and Eno created unusual graphical open scores for some of their work. They used these as a tool for expanding their compositions to others, in an experiment where they concede elements of control such as timing and movement. By creating these experimental subjective models, they inserted notions of indeterminacy and accident onto the composition.

A significant referent when talking about spatial choreographies is Rudolph Von Laban, and his method called Labanotation. This notation system was created and used to compose dance choreographies, thus spatial movement. In this system, four elements are combined in one symbol: direction, action, time, and the part of the body.

Though these compositional tools were interesting and useful to some extent, in reality they fail to convey the notion of movement. This is because dance or spatial movement is not binary and does not respond to the reductive patterns of the notation. Many choreographers are against these binary representations of something as rich as dance. Choreographic movement not only involves body memory, but it is also affected by its immediate context, by sound, and by every spatial factor in the environment. The flow of a multidimensional emotional system is very complicated, if not impossible, to represent in two dimensions.

Regardless, these experiments can be related to architectural and design drawings. Architectural plans are static representations of a building, and even if that building eventually hosts experiences and relationships, these

relationship



53. Labanotation examples

drawings don't express that. Their function is different and not the one of choreographing happenings and actions. The problem with architectural plans is that they don't include the notion of time. These two dimensional representations are always lacking information. This is because spatial experience exists in 3 or 4 dimensions and can't be reduced to 2, even though these graphic representations serve as tools for organization and sketching of ideas.

Understanding the previous points, a graphic score system is explored to be able to sketch ideas for the cube's composition. This system needs to be different from architectural drawings; it will need to convey the presence of multi-sensory variations in time. And differently from traditional music scores, it will need to include the notion and dimension of space, physicality and their evolution.

relationship

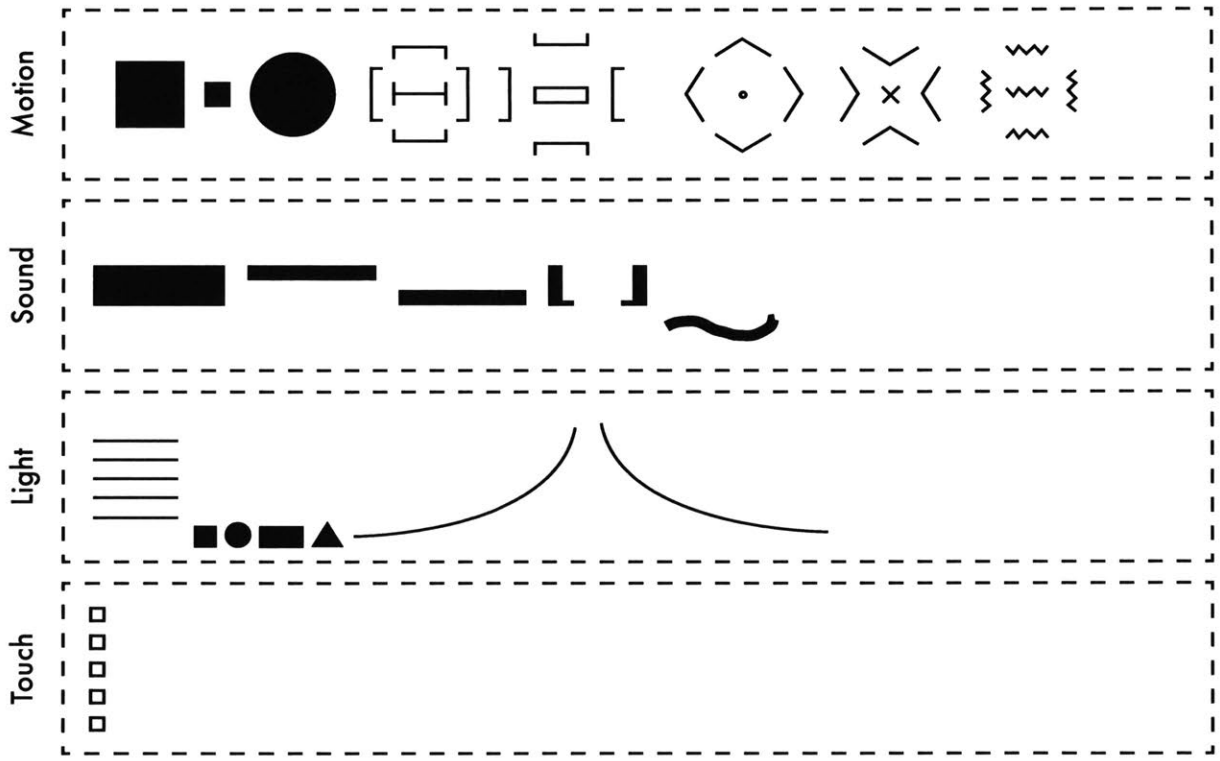
Every System will have symbols to represent actions.
Every symbol will have the possibility to stretch in time.
Every time will have the chance to layer with the other.
Every action will have presence in space.

MOTION: different patterns of movement are represented by these symbols: the whole space moving at the same time, or at different times, or each wall, or each rod.

SOUND: symbols activate every speaker differently, or all together.

LIGHT: every line represents the light activation of every wall, they can also activate every strip on every wall, or every single LED. The geometric shapes are there to designate the color: R ■ G ● B ▬ W ▲

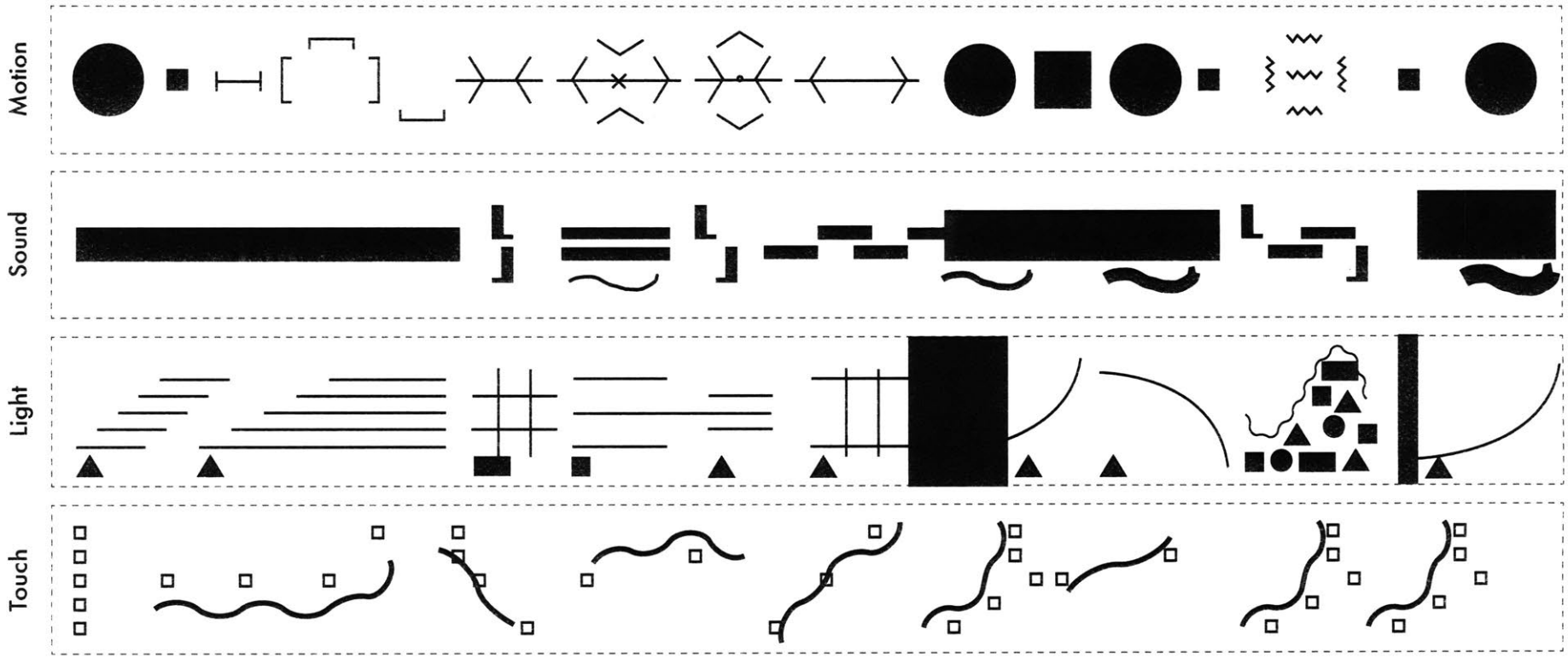
TOUCH: every position triggers the sensor on a specific wall.



relationship

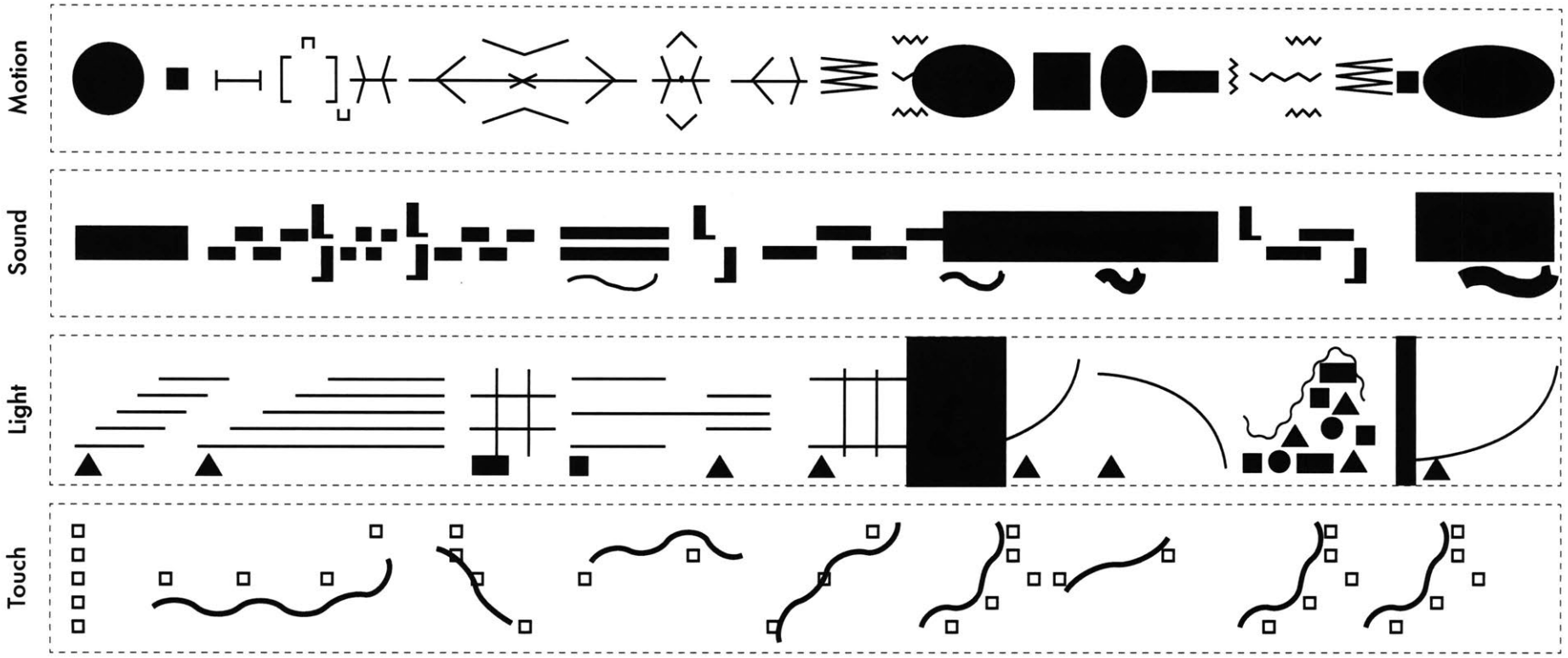
Each of these symbols have a specific meaning to convey motion, sound diffusion, light, and touch.

Layered multi-sensory composition on time line



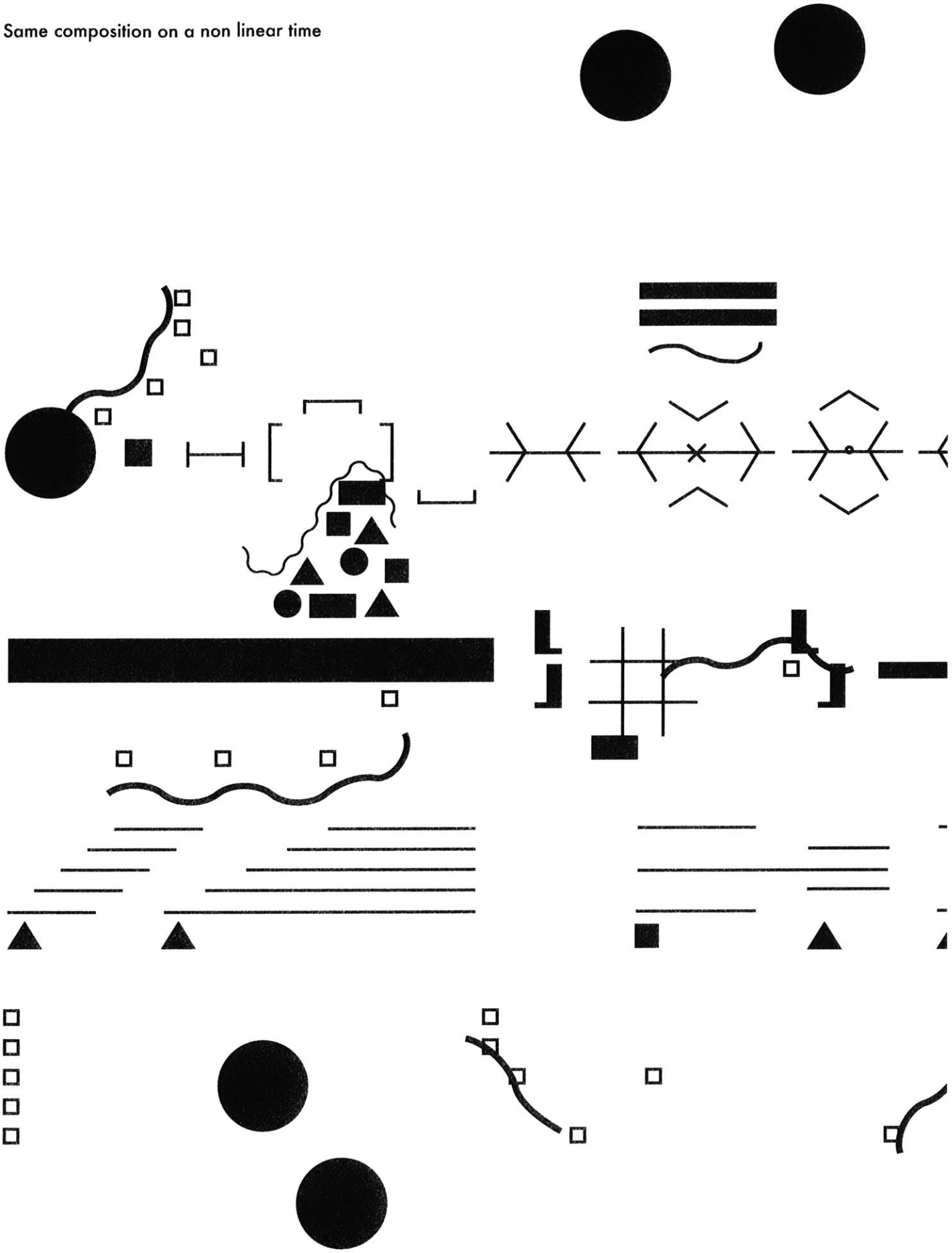
relationship

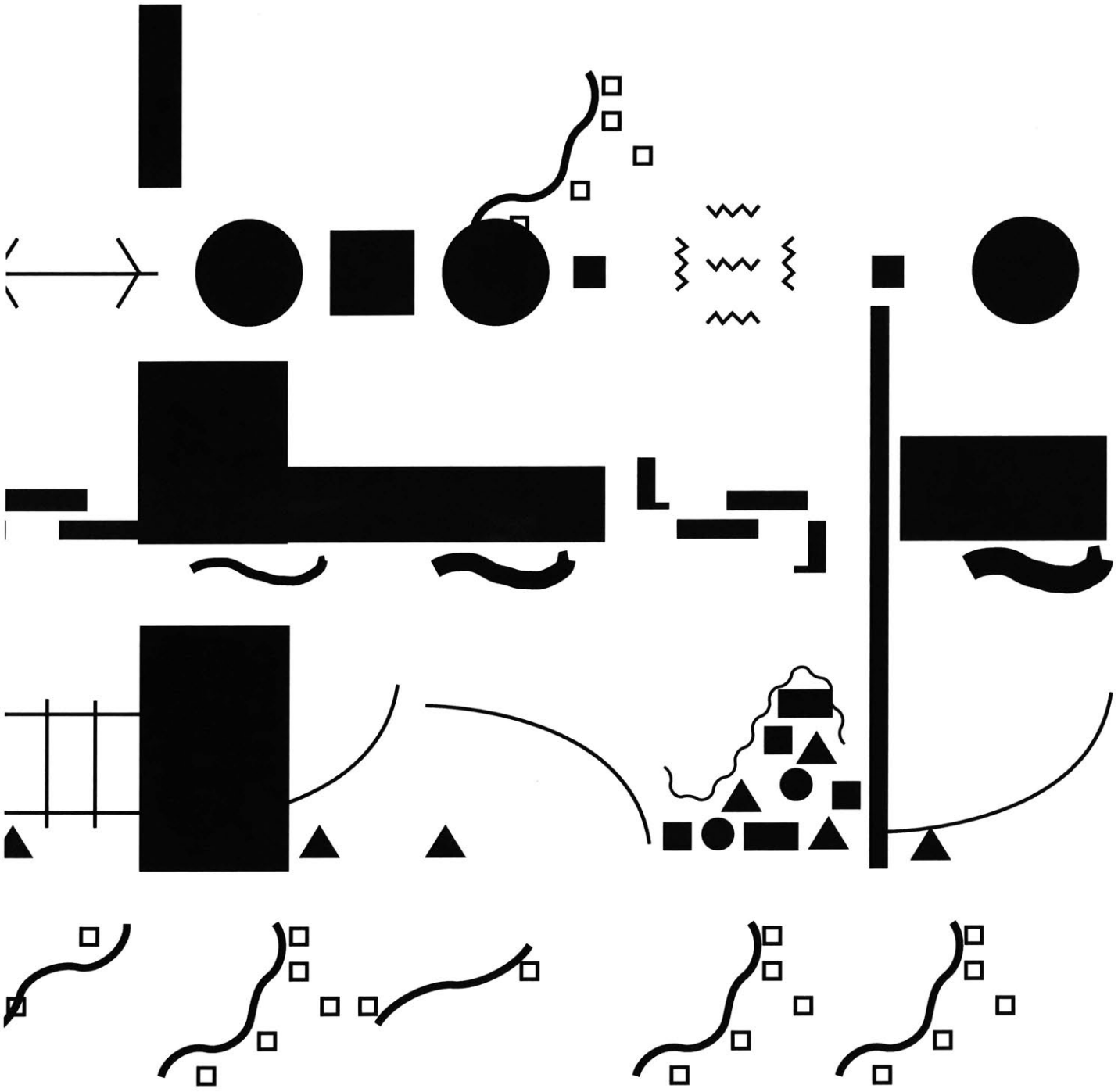
Same composition but now stretching and shortening durations of movements and patterns



relationship

Same composition on a non linear time



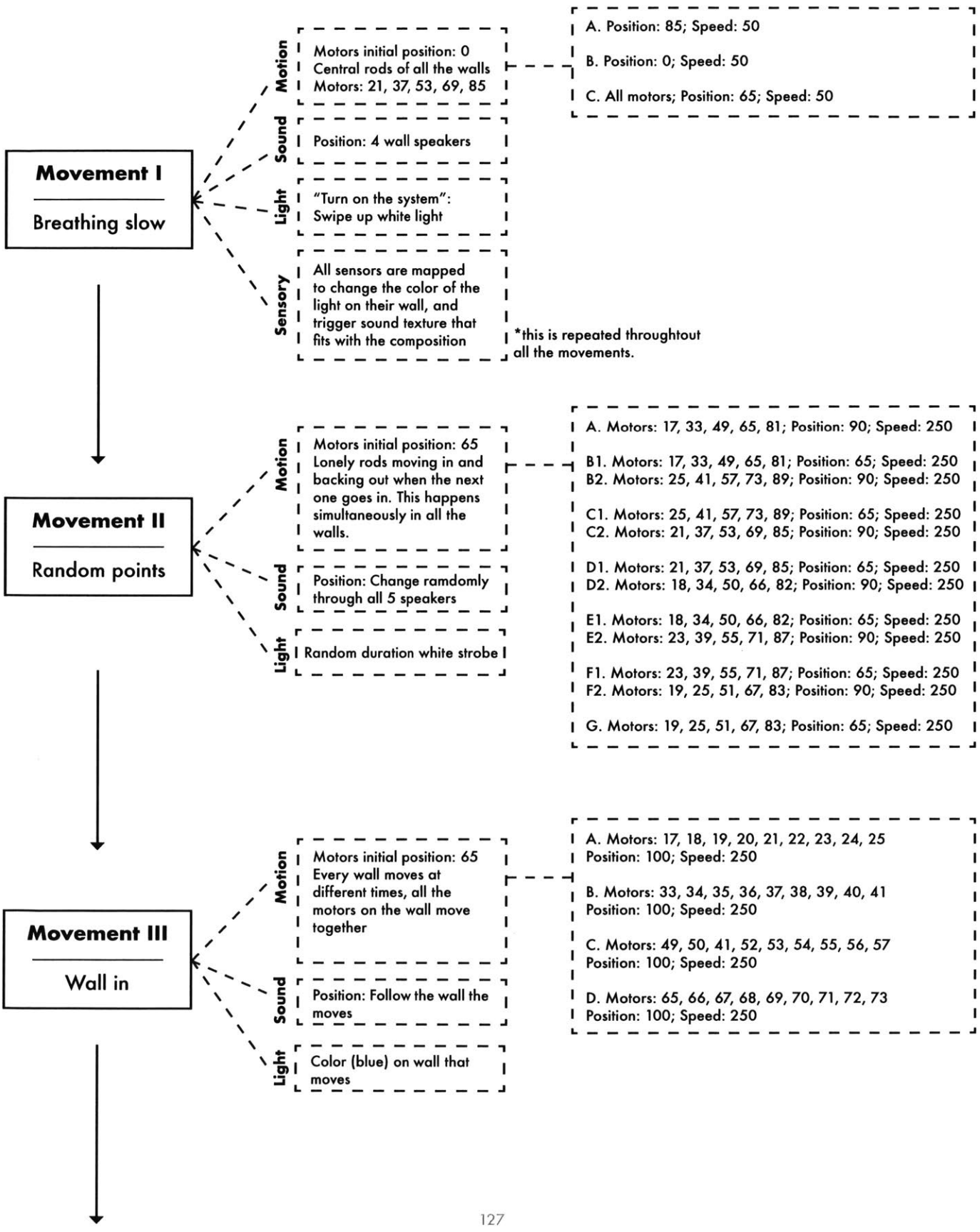


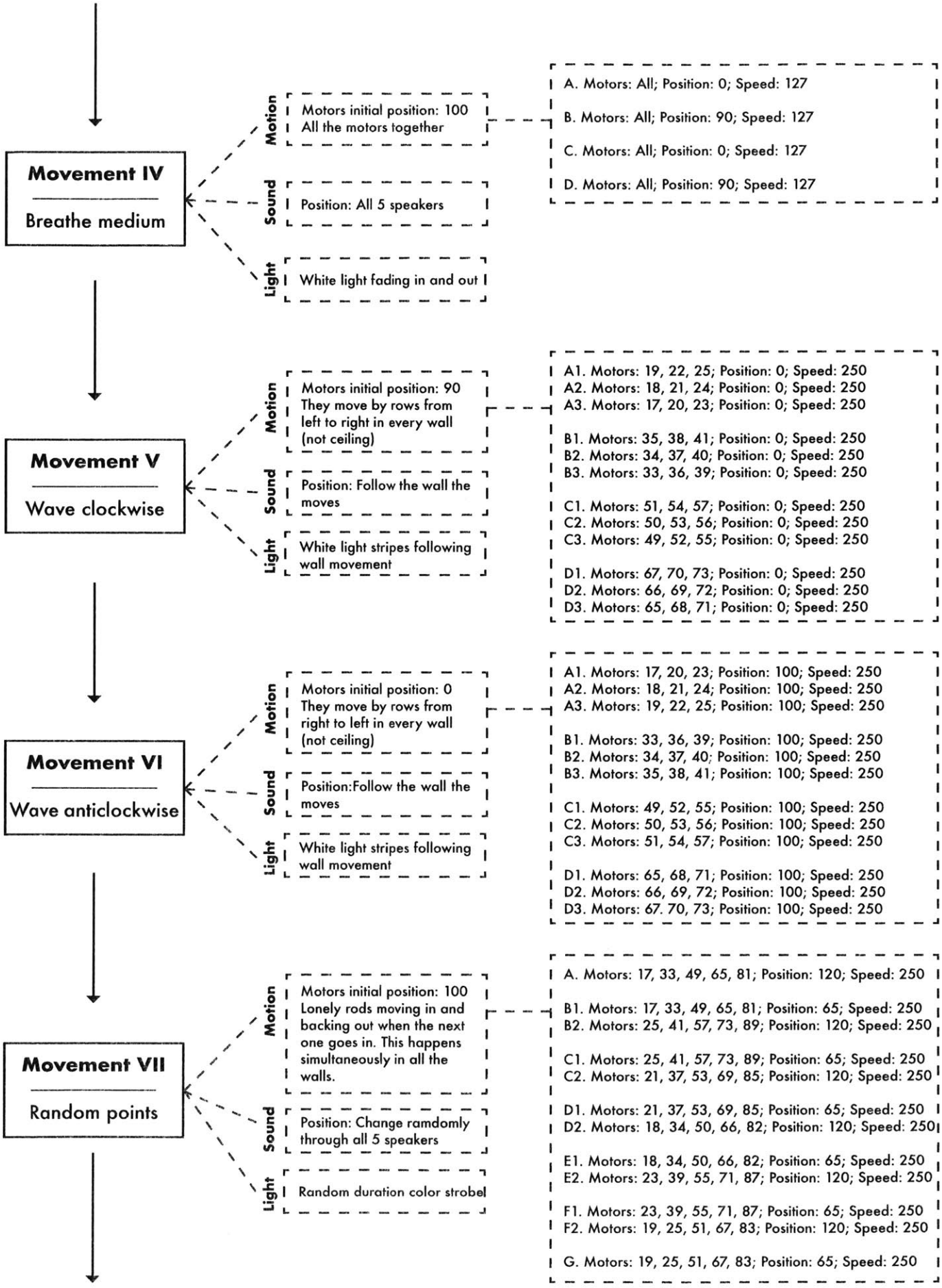
Composition / Movements

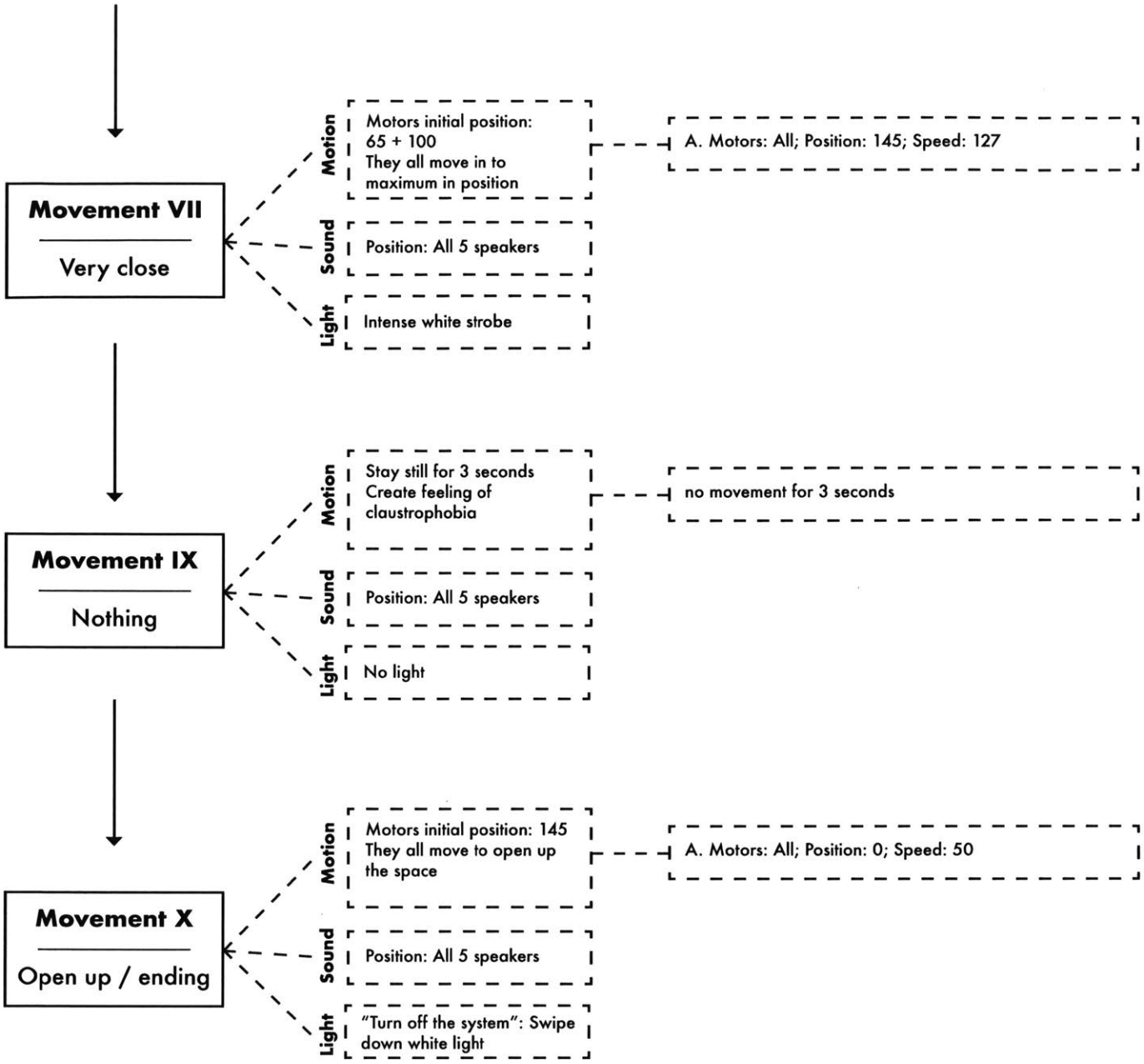
The first composition is composed by ten movements. The idea is to be able to create a gradual progression of situations. Trying to guide to user at all times through the different walls and sensory aspects of the cube.

The system starts breathing slowly, it wakes up and breathes in and out. Then it randomizes movement, sound and light to give a first strike of life to the user; to do so, different rods move in and out in every wall. In the next movement every wall moves independently closer to the user, reminding the user about the existence of five inner sides. After that, the cube breathes in and out. Then it guides the user through a clockwise wave, once it goes from one point of the cube to the other one, it come back the other way round. Randomized action comes back to feed energy to the system. The cube comes as close as it can from the user, it almost touches him/her. Light and sound are very overwhelming and saturated. This movement is reserved for the end because it is the most compelling one; it is accentuated by staying still a few seconds. This creates the sensation of vulnerability and claustrophobia. It deploys the biggest and most intimate action from the cube to the user. To finish, the space opens up slowly while light and sound slowly fades away to complete darkness and silence.

The following diagram shows the mapping of every parameter to build the different Movements of the composition


Movement I
Breathing slow
Motion
Motors initial position: 0
Central rods of all the walls
Motors: 21, 37, 53, 69, 85
A. Position: 85; Speed: 50
B. Position: 0; Speed: 50
C. All motors; Position: 65; Speed: 50
Sound
Position: 4 wall speakers
Light
"Turn on the system":
Swipe up white light
Sensory
All sensors are mapped to change the color of the light on their wall, and trigger sound texture that fits with the composition
*this is repeated throughtout all the movements.
Movement II
Random points
Motion
Motors initial position: 65
Lonely rods moving in and backing out when the next one goes in. This happens simultaneously in all the walls.
A. Motors: 17, 33, 49, 65, 81; Position: 90; Speed: 250
B1. Motors: 17, 33, 49, 65, 81; Position: 65; Speed: 250
B2. Motors: 25, 41, 57, 73, 89; Position: 90; Speed: 250
C1. Motors: 25, 41, 57, 73, 89; Position: 65; Speed: 250
C2. Motors: 21, 37, 53, 69, 85; Position: 90; Speed: 250
D1. Motors: 21, 37, 53, 69, 85; Position: 65; Speed: 250
D2. Motors: 18, 34, 50, 66, 82; Position: 90; Speed: 250
E1. Motors: 18, 34, 50, 66, 82; Position: 65; Speed: 250
E2. Motors: 23, 39, 55, 71, 87; Position: 90; Speed: 250
F1. Motors: 23, 39, 55, 71, 87; Position: 65; Speed: 250
F2. Motors: 19, 25, 51, 67, 83; Position: 90; Speed: 250
G. Motors: 19, 25, 51, 67, 83; Position: 65; Speed: 250
Sound
Position: Change ramdomly through all 5 speakers
Light
Random duration white strobe
Movement III
Wall in
Motion
Motors initial position: 65
Every wall moves at different times, all the motors on the wall move together
A. Motors: 17, 18, 19, 20, 21, 22, 23, 24, 25
Position: 100; Speed: 250
B. Motors: 33, 34, 35, 36, 37, 38, 39, 40, 41
Position: 100; Speed: 250
C. Motors: 49, 50, 41, 52, 53, 54, 55, 56, 57
Position: 100; Speed: 250
D. Motors: 65, 66, 67, 68, 69, 70, 71, 72, 73
Position: 100; Speed: 250
Sound
Position: Follow the wall the moves
Light
Color (blue) on wall that moves


Movement IV
Breathe medium
Motion
Motors initial position: 100
All the motors together
A. Motors: All; Position: 0; Speed: 127
B. Motors: All; Position: 90; Speed: 127
C. Motors: All; Position: 0; Speed: 127
D. Motors: All; Position: 90; Speed: 127
Sound
Position: All 5 speakers
Light
White light fading in and out
Movement V
Wave clockwise
Motion
Motors initial position: 90
They move by rows from left to right in every wall (not ceiling)
A1. Motors: 19, 22, 25; Position: 0; Speed: 250
A2. Motors: 18, 21, 24; Position: 0; Speed: 250
A3. Motors: 17, 20, 23; Position: 0; Speed: 250
B1. Motors: 35, 38, 41; Position: 0; Speed: 250
B2. Motors: 34, 37, 40; Position: 0; Speed: 250
B3. Motors: 33, 36, 39; Position: 0; Speed: 250
C1. Motors: 51, 54, 57; Position: 0; Speed: 250
C2. Motors: 50, 53, 56; Position: 0; Speed: 250
C3. Motors: 49, 52, 55; Position: 0; Speed: 250
D1. Motors: 67, 70, 73; Position: 0; Speed: 250
D2. Motors: 66, 69, 72; Position: 0; Speed: 250
D3. Motors: 65, 68, 71; Position: 0; Speed: 250
Sound
Position: Follow the wall the moves
Light
White light stripes following wall movement
Movement VI
Wave anticlockwise
Motion
Motors initial position: 0
They move by rows from right to left in every wall (not ceiling)
A1. Motors: 17, 20, 23; Position: 100; Speed: 250
A2. Motors: 18, 21, 24; Position: 100; Speed: 250
A3. Motors: 19, 22, 25; Position: 100; Speed: 250
B1. Motors: 33, 36, 39; Position: 100; Speed: 250
B2. Motors: 34, 37, 40; Position: 100; Speed: 250
B3. Motors: 35, 38, 41; Position: 100; Speed: 250
C1. Motors: 49, 52, 55; Position: 100; Speed: 250
C2. Motors: 50, 53, 56; Position: 100; Speed: 250
C3. Motors: 51, 54, 57; Position: 100; Speed: 250
D1. Motors: 65, 68, 71; Position: 100; Speed: 250
D2. Motors: 66, 69, 72; Position: 100; Speed: 250
D3. Motors: 67. 70, 73; Position: 100; Speed: 250
Sound
Position:Follow the wall the moves
Light
White light stripes following wall movement
Movement VII
Random points
Motion
Motors initial position: 100
Lonely rods moving in and backing out when the next one goes in. This happens simultaneously in all the walls.
A. Motors: 17, 33, 49, 65, 81; Position: 120; Speed: 250
B1. Motors: 17, 33, 49, 65, 81; Position: 65; Speed: 250
B2. Motors: 25, 41, 57, 73, 89; Position: 120; Speed: 250
C1. Motors: 25, 41, 57, 73, 89; Position: 65; Speed: 250
C2. Motors: 21, 37, 53, 69, 85; Position: 120; Speed: 250
D1. Motors: 21, 37, 53, 69, 85; Position: 65; Speed: 250
D2. Motors: 18, 34, 50, 66, 82; Position: 120; Speed: 250
E1. Motors: 18, 34, 50, 66, 82; Position: 65; Speed: 250
E2. Motors: 23, 39, 55, 71, 87; Position: 120; Speed: 250
F1. Motors: 23, 39, 55, 71, 87; Position: 65; Speed: 250
F2. Motors: 19, 25, 51, 67, 83; Position: 120; Speed: 250
G. Motors: 19, 25, 51, 67, 83; Position: 65; Speed: 250
Sound
Position: Change ramdomly through all 5 speakers
Light
Random duration color strobe



Movements diagram

"So we can formulate this law: *perception is master of space in the exact measure in which action is master of time.*"[32]

IV.II PERFORMANCE | The cube is experienced through its performance in time. The performance brings the cube to life and deploys its personality and relational abilities. An experimental and experiential performance has been installed at the MIT Media Lab in the Opera of the Future group as the first experimental scenario to test how this platform can change how we think about sound and its relationship to space.

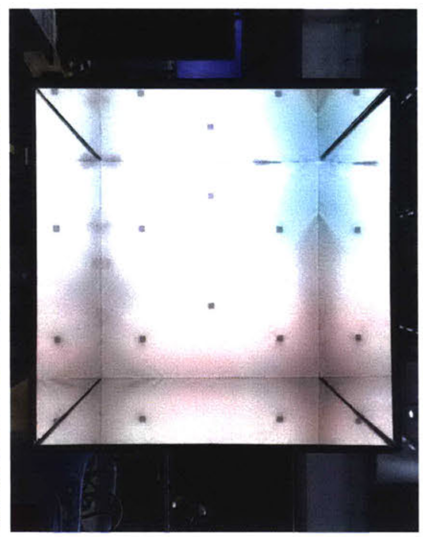
Many prototypes were made, however they were smaller than the final cube (e.g. a small 1'x2' cube for head only or a 4'x4' wall). The final design included the feedback from over 50 people who tried the immersive experience. Participants tended to report a sense of movement and transportation, for example, "although I haven't gone anywhere, I feel transported" and "the space makes music feel extremely tangible".

Now that the cube is fully constructed, a more intensive study will be conducted. The objective of this study will be to evaluate the impact of the design in participants from different backgrounds, for example architects and composers. The evaluation will consist in having people experience the multi-sensory composition and then answer a questionnaire. This experimental design will yield a systematic approach to study if the performance conveys the desired meaning and effect. The objective of experiencing the multi-stimuli choreography performance is based on the hypothesis that it will increase the quality or quantity of affective associations. If so, it will yield new cognitive connections and will be able to be reproduced in later aesthetic spatial experiences.

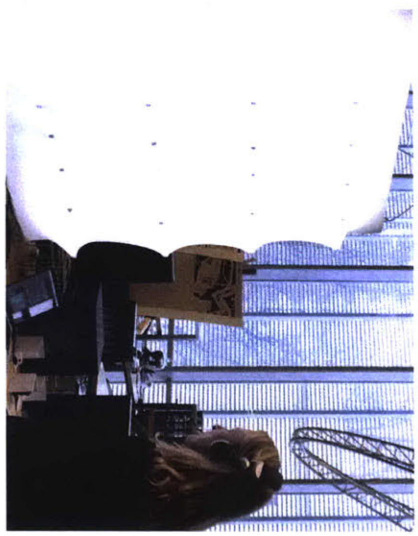
relationship

54. Small cube, experimental prototype 1, cube for head only, dimension: 1'x2', Oct 2016
55. Fragmented cube, experimental prototype 2, suspended wall, dimension: 4'x4', Apr 2017
56. Suspended cube, dimension: 6'x6' + variable projection dependent on motion, Aug 2017

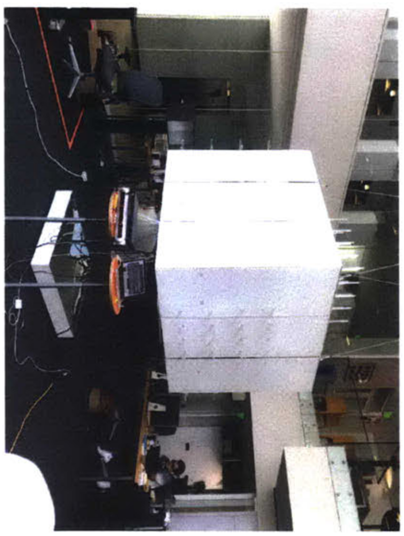
relationship



54



55



56

relationship

The cube is intended to be an instrument that allows a composer to create a piece of art with all its sensory stimuli combined. The best way to take advantage of its multi-sensory features is to think of each one as part of a whole. The perfect balance of the different elements is what will deliver a compelling performance. The polymorphism of the cube is given not only by its flexible fabric walls, but also by the sounds, the lights, the colors, and the vibrations. All these elements combined can build a compelling experience. The objective is to achieve an organized whole, where the sum of its parts reveals the expressiveness of a system where no isolated element is predominant and all the parts exist in a fluent dialogue between each other. One way to approach making a composition for the cube is to create a series of situations that guide the user seamlessly through diverse scenarios. This fluent arrangement of sensory elements will construct a sensory mass, an amalgamated atmosphere that envelops the user and transports him/her to a physical world of sound.

relationship

relationship

Cube's Mechanical Limitations:

The first experimental performance identified the limits of the expressiveness and malleability of the cube. Although the first composition gave insight to many issues that the cube had, the most important lesson was to understand that by combining elements, through time, the composer can create different behavioral patterns of the cube. The individual inside the cube identifies these serial patterns and is joyfully conditioned to simultaneously create behavioral expectations towards the cube's actions. For example, if a type of sound is accompanied by the combination of floor vibrations with the walls being in a specific position, every time this sound appears the individual will be waiting for all these other elements to come together.

There is much to be explored through composition by playing with the listener's behavioral expectations. Not only can these patterns be created and repeated to reinforce the expected result, but also there is much to be studied about what happens to the listener that is immersed into these patterns when they are broken. By breaking these logic associations, an inflection point is created and attention is driven towards the environment. This can intensify the creation of surprise and interest of the individual inside the cube.

A different limitation on the cube's gradient ability in performance was also identified through its first composition. Unfortunately the motion of the actuated walls has limitations and they do not present as many degrees of freedom as expected. This affects the delivery of a compelling experience, because the current design's movements seem somewhat repetitive and predictable. In future iterations, the design must allow for more variables on the movement of the walls by augmenting the maximum speed of the motors. If the motors move faster, the walls will host richer and more expressive movements allowing for a more dynamic language and a more organic character.

Another important element to re-design in later models of the cube will be the mechanical system. Even if the current system fulfills its objective, it is very noisy and not very expressive. A smoother system would create a more compelling and soothing experience; one option would be to use linear motors. Many aspects of the sensory composition imply observation and flow. Both are currently disrupted by the sound and linearity of the mechanical system. To dampen these disruptions, the sound of the mechanical system is embraced and included as part of the composition. This provides consistency between the body and the composition, however, reducing the mechanical

relationship

noise will help to achieve better results towards the desired effect and affect.

The final electronic feature that requires improvement is the cube's Sensory/Reactive System. It needs to be more robust. It is important to use the finished cube to explore how to make it a sentient being. The concept of life used to refer to the cube right now is still in a metaphorical and perceptual realm. The incorporation of other sensors, as well as a more intelligent brain would provide an incredible experimental composition platform and a sublime relational kinetic system. Further research and work need to be done in this direction. Even though the interaction is now at its first stage of exploration, and it is still basic and superficial, it does set the scenario to open discussions and debate around the idea of intelligent spaces and the emotional relationship between humans and nonhuman agents.

relationship

Compositional lessons:

In the cube, the sound can be moved around the four speakers that are installed on each wall. In order to get the best out of this feature, the movement of the sound needs to be well calibrated to expose its directional dynamics. For example, if the same sound is being projected from all speakers, the directional effect on the listener is lost because they will simply hear the sound from everywhere. However if the sound is programmed to move from one speaker to another, constantly changing the source of the projected sound, the directional effect of the sound can have a much sharper effect on the listener. For example, if you program the sound to come from all the speakers, then to just one, and then again to all, and then to just two, and the again to all, and then to just one, the contrasts will deliver a more lively and unanticipated interaction.

The dynamic range of the speakers is augmented by the addition of a fifth speaker that silently transmits all the sub-bass through the platform where the listener is positioned. The vibrations of the platform enable the composition to increase in sensory/compositional options. The vibrations are very effective on the listener in that they evoke a very clear response. It is an important part of the cube, however it can be almost too present, obfuscating the other sensory stimuli. Additionally, once the listener feels the vibrations, it becomes reportedly disappointing for the listener to remove them, since this creates a sensation of void and a less interesting situation. An effective way to use the vibrations is to use a wider dynamic and expressive range in the sounds sent to the platform channel. If the the composition considers having vibrations all throughout, they will make the environment a lot more physical and the interaction will be extremely embodied. To avoid making them static or overused, it is important to vary the intensity, pitch and rhythm of the vibrations throughout the performance, creating a progression of vibrations rather that an on & off composition.

The lights are one of the most powerful compositional features of the cube, however they present a similar problem as the previously mentioned vibrations. Once the lights are on, it is very hard to turn them off without causing a negative effect on the listener's experience. The light is reportedly an important trigger to create a sense of immersion. Because the lights allow the listener to visually perceive the new atmosphere as soon as he or she steps into the cube, it is important to start the performance with the lights on. Additionally a fade-in at the beginning of the experience is recommended because it seems to signal to the person that the system is turning on. In the first composition, the lights were shut down at specific moments to create contrasts and show the shadows on the walls.

relationship

As mentioned before, this is not very effective since it just takes the individual out of the experience and creates a break on the flow of the performance. An alternative is to find contrasts with colors and color intensities. Also, it is important to remember that different colors can come from different LEDs at different dynamic intensities, which can add a strong tool for communication. Additionally, the light should only turn off when the performance is over, using it as a tool to determine the end of the composition.

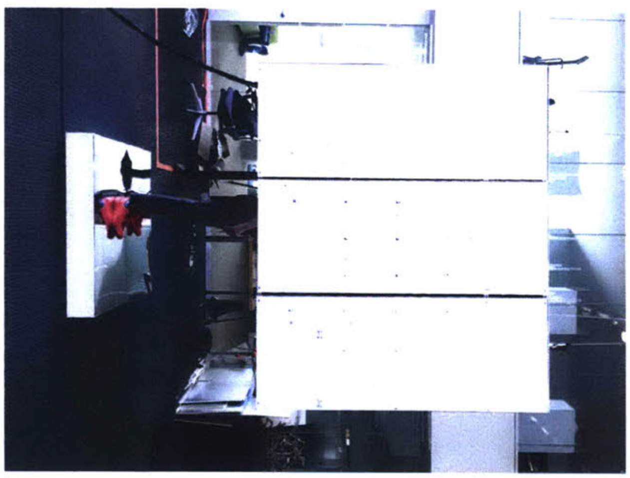
The most interesting part of this composition is to play with the user's expectation and guide him/her through a cube's natural performance in such a way that it keeps the listener's attention fully focused throughout the composition. A composition that keeps the individual completely busy and attentive to the environment at every moment is going to yield a more immersive performance.

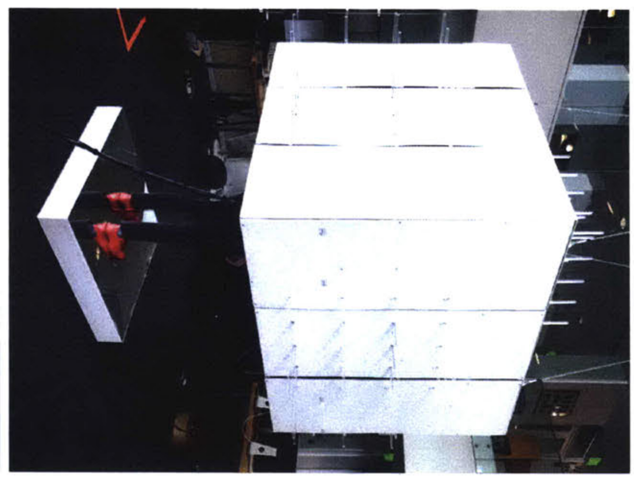
The first composition created was less drastic and the individuals were less engaged. This was verbally reported by listeners who began thinking about other things while being in the cube. The second composition was written with a more drastic combination of scenarios; scenarios that had bigger contrasts between one situation and the next. Listener feedback to the second composition reported that the most interesting parts were the ones when the cube deployed extreme physical contrasting changes, for example, when the walls were closer to them and then yielded to create a bigger space. Initially, the composition created spatial contrasts only at its end with the intention of creating a more dramatic action at the end of the performance. However, the second composition's feedback indicates that more dynamic accents throughout the performance create a more immersive result.

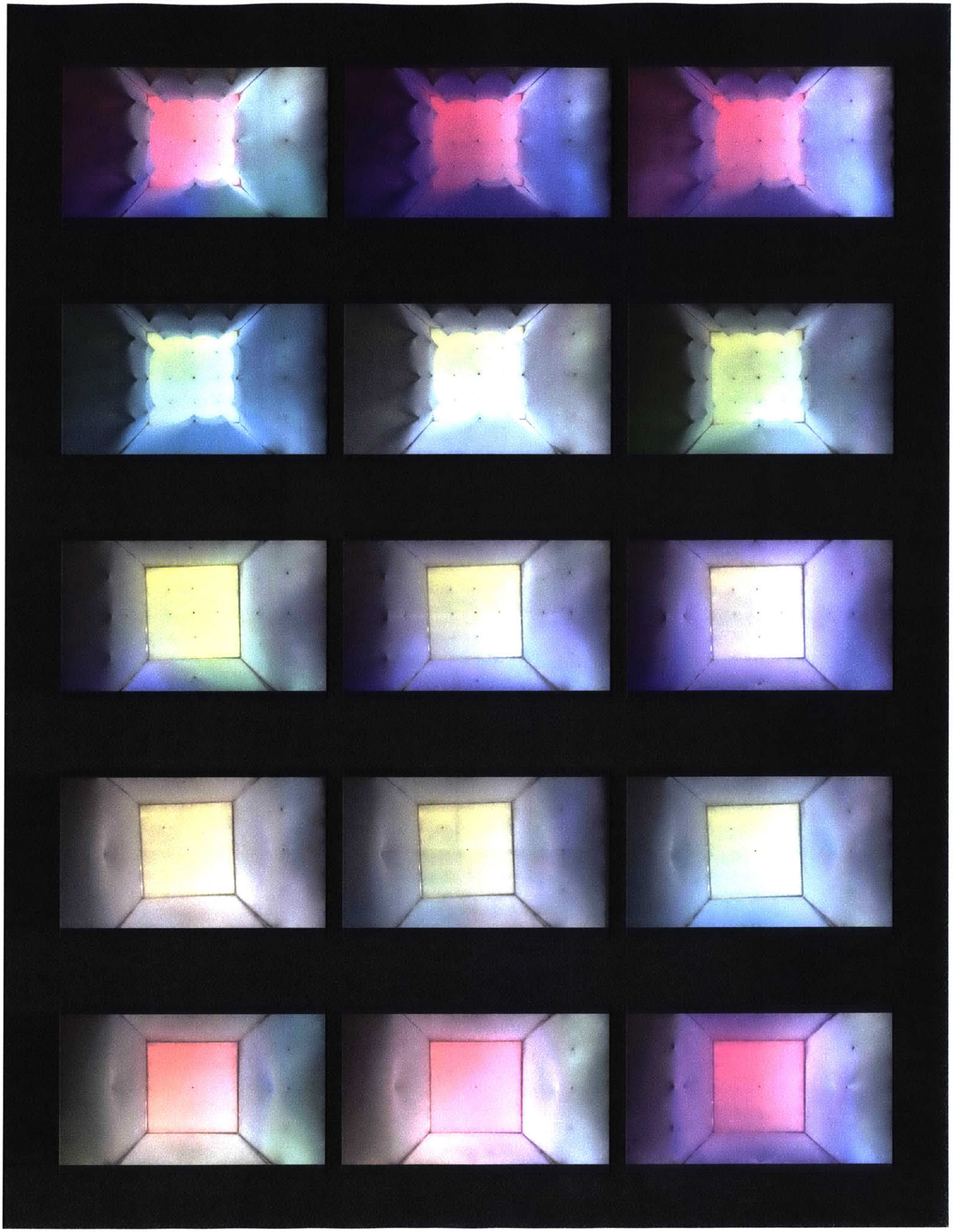
relationship

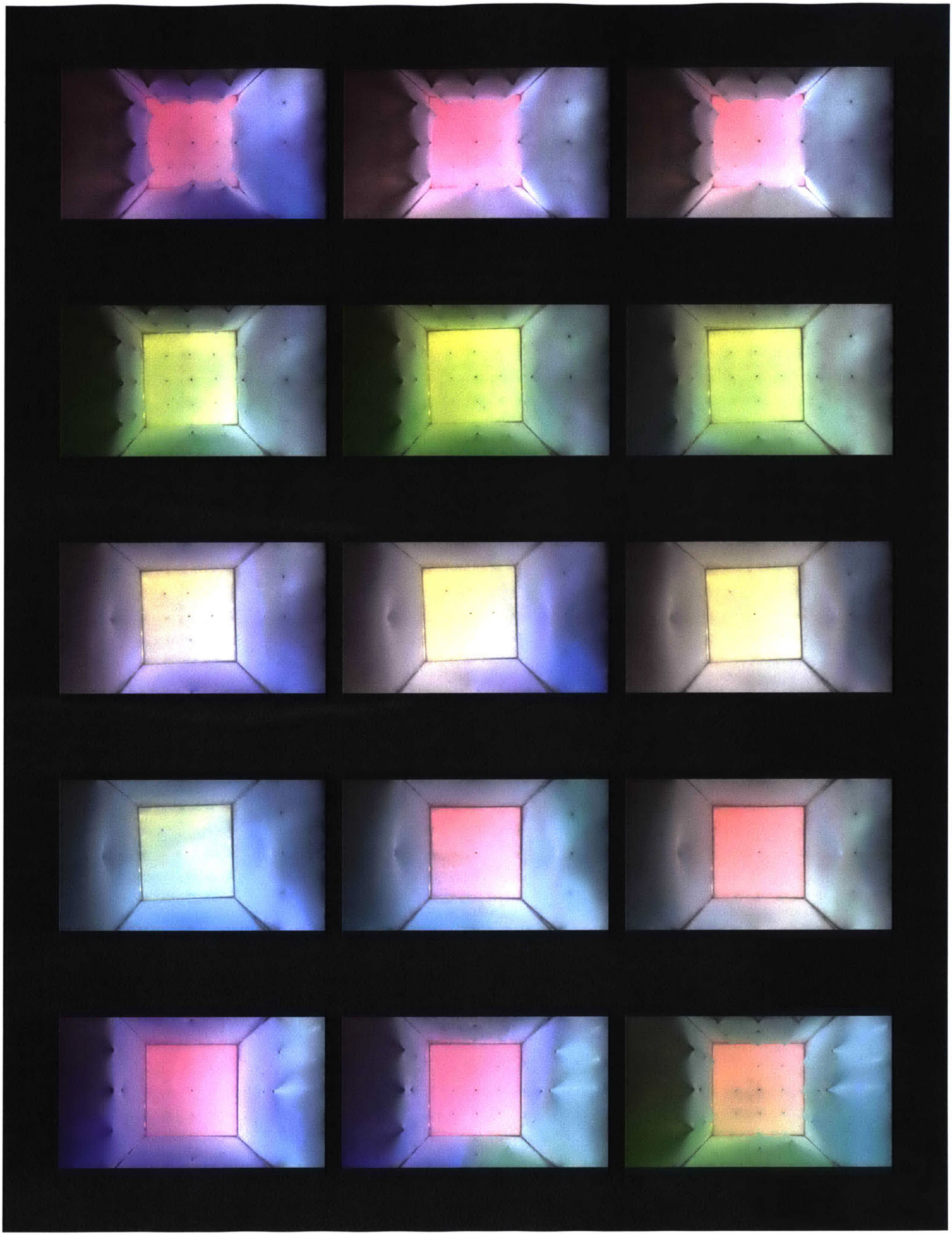
57. Human being inside of the cube during performance

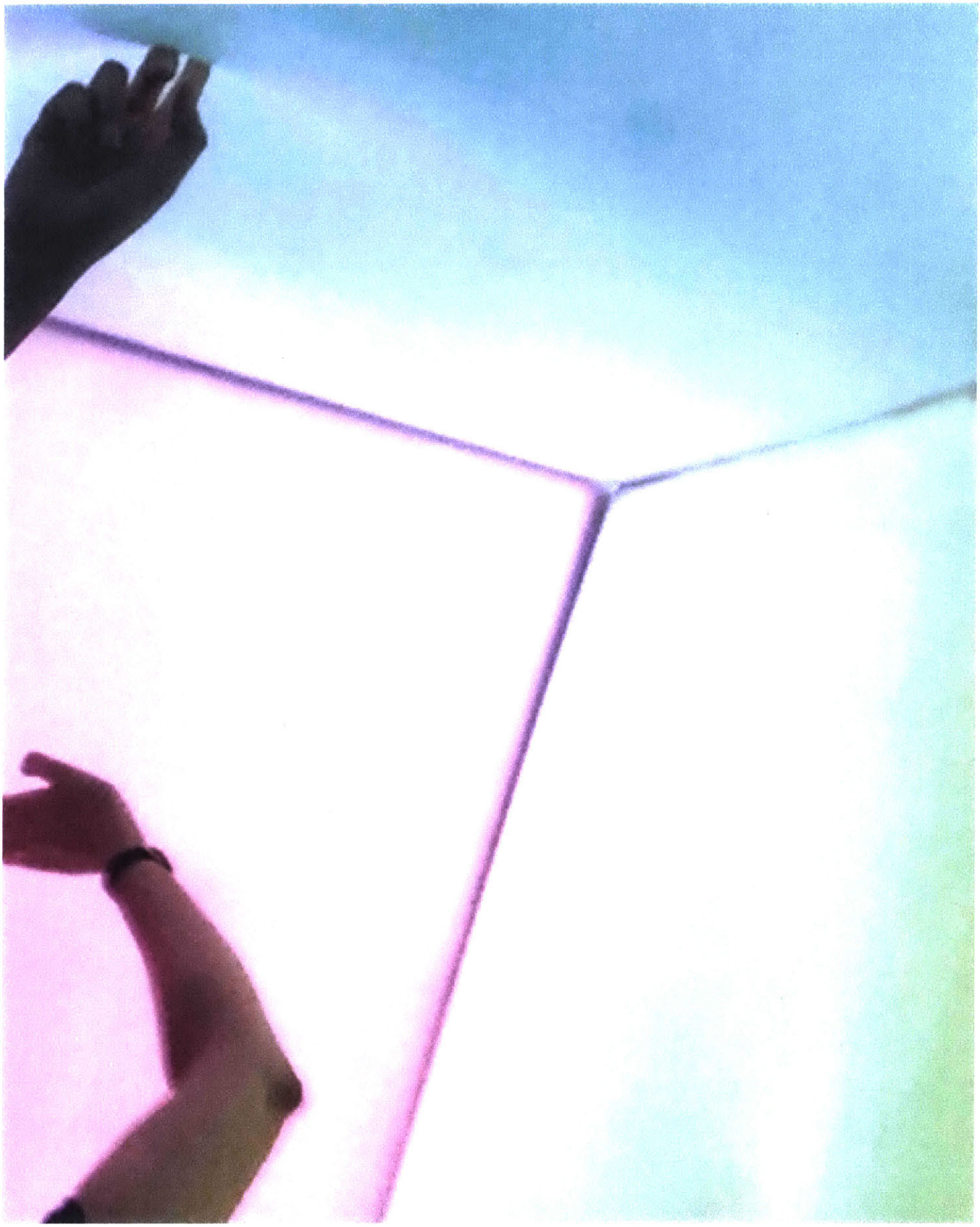
relationship

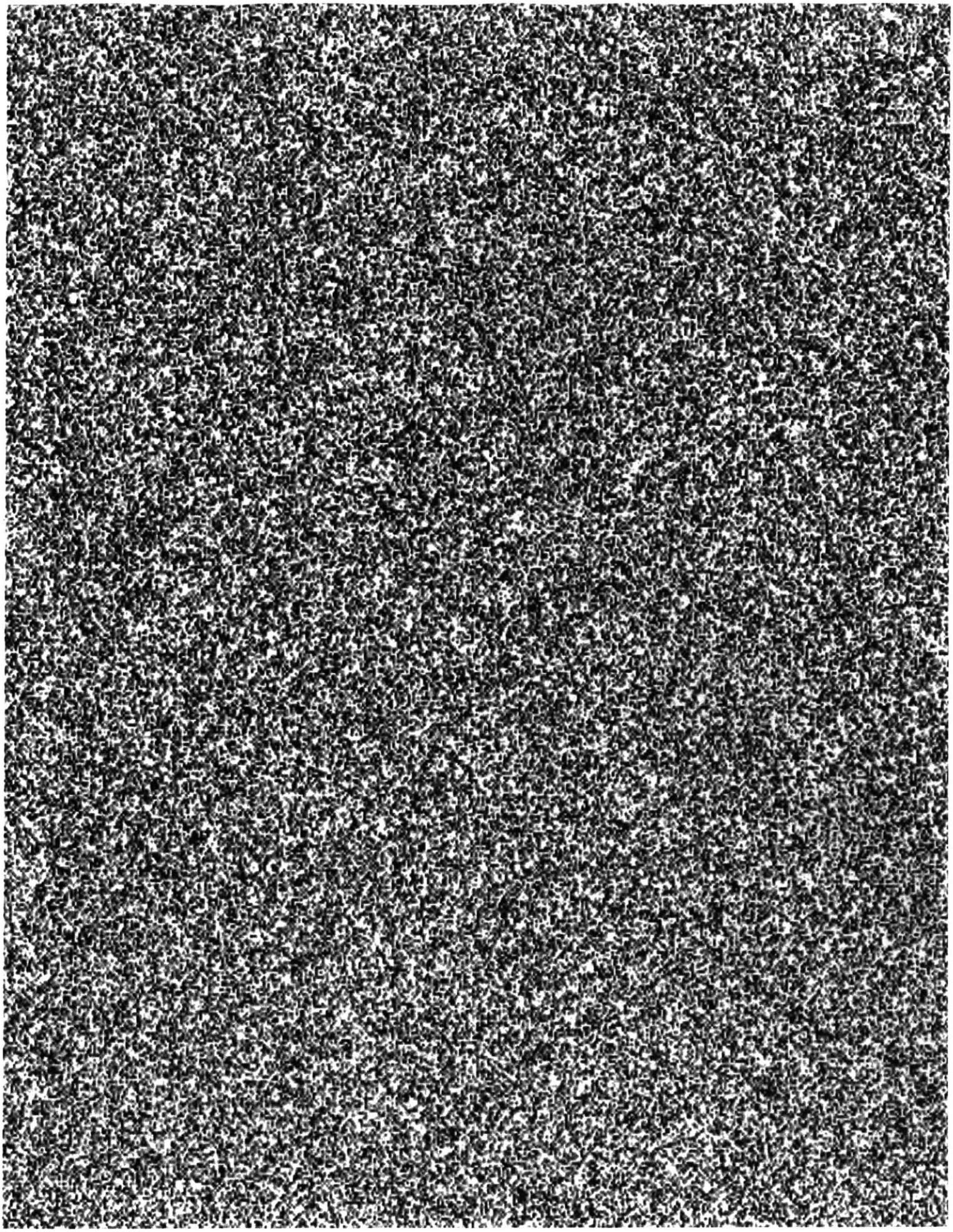












Spaces That Perform Themselves provides a creative tool to explore cross-modal sensing in the context of sound perception augmented by manipulating sound, movement, light, color, and vibrations; essentially creating an inclusive and diversified language of music. It proposes a new auditory experience and explores alternative modes of listening.

The kinetic multi-sensory environment that was built differs from other existing tools by presenting an original scenario to experiment with cross-modal composition. The addition of a kinetic architecture system that morphs according to musical situations and that can be combined with other sensory stimuli brings to life an innovative way of thinking about the composition of an aesthetic experience.

This thesis is the beginning of a cross-disciplinary research effort with the objective of creating a series of spatial compositions for the senses. Although the exploration was challenging, its outcome is very enriching and stimulating. I intend to further develop these ideas and continue researching about a unified sensory composition and spatial performance and apply them to diverse experimental applications in performance, storytelling and design.

During the process I learned a great deal about cross-modal perception and spatial sensory composition. The model created allowed me to study related ideas and see how effective they are in real life. Although the cube has many limitations, it is a great tool to have in our laboratory as a programmable space for diverse perceptual studies and sensory mapping. Throughout the development of this project I also gathered many technical skills and furthered my understanding of electronics, mechanics, computational mapping, design and interaction. However, the most important lesson was the relational aspects of the project.

conclusions

It required me to research body and space interaction and the elements that construct emotional relationships via material memory. The outcome allowed this project to present a model that proposes architecture as a medium not only for a purpose, but also for an effect.

After observing the behavior and capabilities of this system, it is possible to identify areas that need improvement and further development. After this thesis, I will continue augmenting the expressive capacities of the cube so that it can reach the envisioned interactions. I will also reflect about what would be the best next step in terms of scalability potentials of this system. The refined prototype will further the research and understanding of individual experiences within a multi-sensory kinetic environment, as well as design aspects imperative to the project. Analysis gained from this phase will provide insight to later editions of the project, elevating the scale to a size capable of hosting larger groups of people. Even though the cube works for an individual experimental scenario, many explorations are yet to be done with bigger rooms that can host more than one person at the same time. This will surely trigger new interactions and emotional connections between the people within the room, as well as between the room and the people.

Technically the mechanical system can be improved to achieve a more organic expression and compelling performance. Once achieved, the cube will span the reach and possibilities of its envisioned composition and performance abilities. This will deliver a more engaging and interesting system. It will also be beneficial to find a way to create a better sense of immersion by excluding the exterior world from the experience. As the current version allows an open space between the walls and the platform, this immersion is not completely achieved. At the moment,

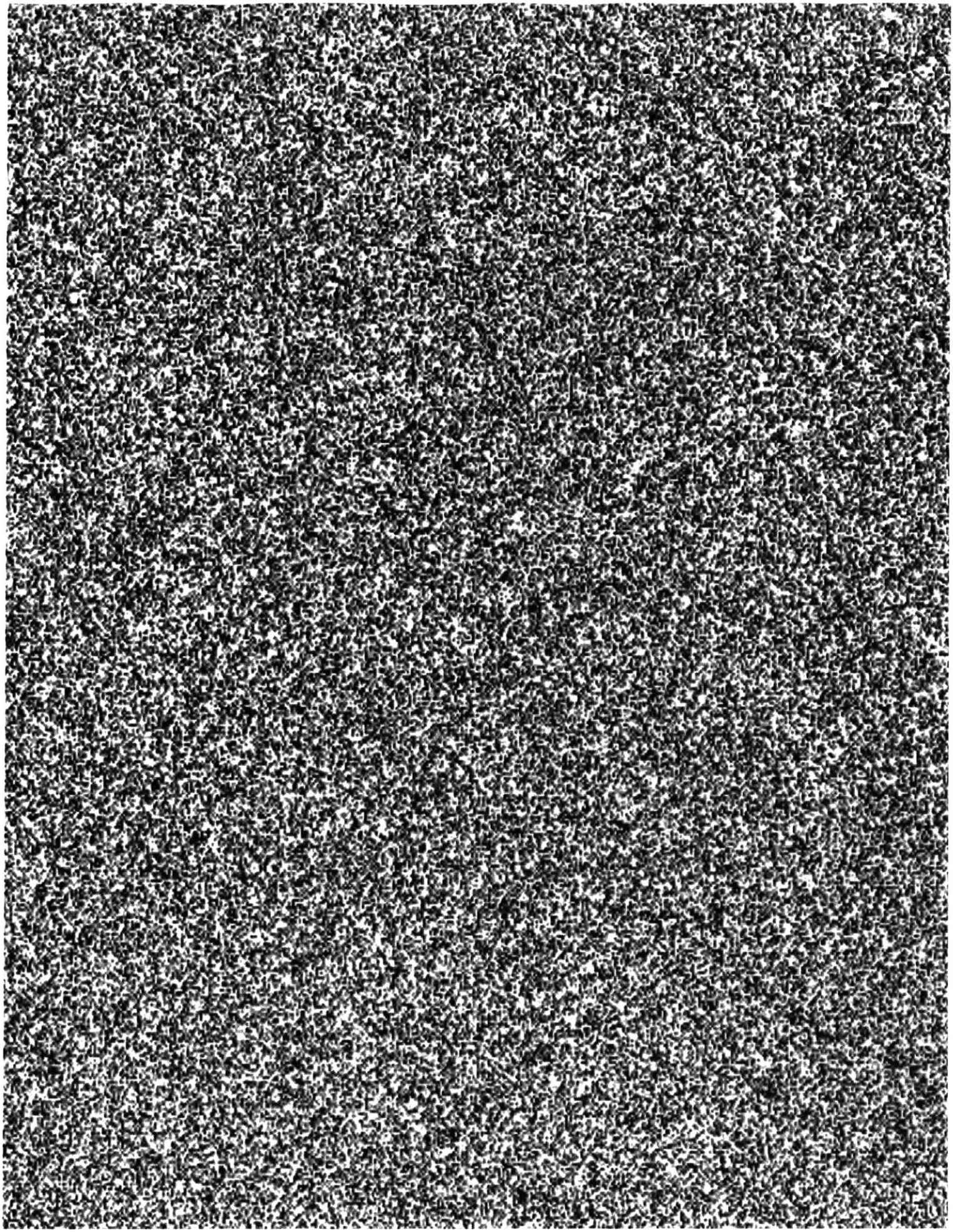
conclusions

the cube has not been set up in a space specially designed for it, so there are exterior elements such as ambient sound, and/or people talking and moving, that create a big distraction from the experience. These distractive factors affect the experience of the performance, but can be partially reduced by creating a very intriguing composition. It would be good to explore a way to really envelope the body completely and have a barrier that isolates the listener from the outside world.

One of the most important personal conclusions I can draw from building and experimenting with the cube is to understand that machine is finite, however the person who interacts with it is not. This project exposes the encounter between an artificial object and an organic creature. This project bridges the interaction between finite and infinite, it frames the setup for a poetic relationship between things and beings.

Technological advancement has always had an effect on the creation of emerging and experimental aesthetic models. Robotic architecture and computational mapping are presenting tools to constantly change our environments as well as creating more meaningful ways to relate with it. In the case of the cube, they instate the foundation of an experimental compositional model that expands aesthetic expression in the field of music and architecture. This level of sensory unification changes how we think about sound and its relationship to space. Also, unusual aesthetic forms emerge, as well as the production of knowledge towards the enlargement of the fields of music or sound studies and architecture or spatial studies.

conclusions



INTRODUCTION

---

[1] *"...from the time these means of moving sound have been available, I have been speaking of and composing and finding notation for space melodies, to indicate movement up or down in space, or describe a particular configuration in a given space, at a certain speed."* (Maconie, *Stockhausen on Music, Lectures & Interviews*, 103).

[2] *"...concurrently sounding sine waves of different frequencies will provide an environment in which the loudness of each frequency will vary audibly at different points in the room, given sufficient amplification. This phenomenon can rarely be appreciated in most musical situations and makes the listener's position and movement in the space an integral part of the sound composition."* (Young & Zazeela, *Selected Writings La Monte Young & Marian Zazeela*, 10-16).

[3] *"Creating spaces with the vocabulary of sound introduces new forms of expression - the potential for a fundamentally new experience. It is above all the intensity, the rhythm, the speed of the moving sound and their interrelated variations that determine the shape of a space. As an event in time, a sound-shaped space has such psycho-physiological dimensions as pulling, stretching, guiding, bouncing, etc., depending on how sound is organized between the loudspeakers."* (Leitner, *Ton : Raum, Sound : Space*, 15).

[4] The Philips Pavilion was designed for the Brussels World Expo 1958 by Le Corbusier's studio. It was designed primarily by the architect and composer Iannis Xenakis that was working there at the time. The Philips Pavilion was designed to showcase Philip's latest speaker technologies, spatializing music through the building. The audience was immersed in a sonic and light installation: Le Poème Electronique composed by Edgar Varèse, and the projection of a composition of selected videos and moving images by Le Corbusier.

[5] After the Phillips Pavilion in 1958, Iannis Xenakis explored a new typology: *"The Polytope"*, that literally means *"many spaces"*. The objective was to create a place using different *"spaces"* (light, color, sound and architecture) overlapping to construct an immersive experience.

[6] The Fun Palace was designed in 1964 by British Architect Cedric Price in collaboration with avant-garde theater producer Joan Littlewood. This building was projected under the concept of being an interactive, performative and adaptable building. In order to achieve this, Price and Littlewood created a unique synthesis of

cybernetics, information technology, game theory, Situationism, and theater. The Fun Palace proposes an ever changing building, in order to fulfill the needs of the inhabitants, inviting them to experience an alternative to fixed routines and free them from serial existence. It was never build, it represents a utopian dream of the cultural shifting landscape of the postwar years.

[7] *"The architect no longer designs the final form but rather creates an initial state, introduces a set of controlled constraints and then allows the structure to be activated to find its form in real time."* (Farahi Bouzanjani, Learch, Huang, Fox, "Alloplastic Architecture: The design of an interactive tensegrity structure". *In ACADIA 2013 Adaptive Architecture: Proceedings of the 33rd Annual Conference of the Association for Computer Aided Design in Architecture. In Interactive.* 129-136.)

[8] Ruairi Glynn is Director of the Interactive Architecture Lab at the Bartlett School of Architecture, UCL.
"So as the worlds of architecture and robotics collide, offering new motive and spatial forms of interaction, the cerebral processes of human social relationships are irresistibly stimulated." (Glynn, *Interactive Architecture, Adaptive World*, 7).

[9] Skylar Tibbits is a co-director and founder of the Self-Assembly Lab housed at MIT's International Design Center. The Self-Assembly Lab focuses on self-assembly and programmable material technologies for novel manufacturing, products and construction processes.

[10] Michael Fox is the President of ACADIA (Association for Computer Aided Design in Architecture) and founder of the late Kinetic Design Group at MIT.
"If an environment could adapt to our desires, it would have the ability to shape our experience." (Fox, *Interactive Architecture, Adaptive World*, 16).

[11] Spaces are never truly static, any space can be dynamic depending on the interactions that emerge on it, the constant reconfiguration of quotidian situations, the lifespan of materials and the timescope perspective in which we observe them. Though in this specific case I talk about static spaces to make a point about the objective of this thesis. Considering as *static*, any architectural space that is perceived as passive and immutable, one that does not have a programmable body, organic components or computer aided structures with the capacity of changing physically over a short period of time. Whereas dynamic spaces are considered to be kinetic architectural systems that can reconfigure the organization, geometry, dimensions and shapes of a room or a building.

[12] Maurice Merleau-Ponty's book *"Phenomenology of Perception"* focuses on the embodiment of human actions in order to understand the body's existence as "being-toward-the-world". This concept illustrates how lived experience is expressed through its spatiality. The book's focus on problems of perception and embodiment is to clarify the relation between the mind and the body, the objective world and the experienced world.

[13] "...whatever be the nature of perception, we can affirm that its amplitude gives the exact measure of the indetermination of the act which is to follow. So that we can formulate this law: *perception is master of space in the exact measure in which action is master of time."* (Bergson, *Matter and Memory*, 32).

[14] *"Acoustemology conjoints "acoustics" and "epistemology" to theorize sound as a way of knowing. In doing so it inquires into what is knowable, and how it becomes known, through sounding and listening. Acoustemology begins with acoustics to ask how the dynamism of sound's physical energy indexes its social immediacy. It asks how the physicality of sound is so instantly and forcefully present to experience and experiencers, to interpreters and interpretations. Answers to such questions do not necessarily engage acoustics on the formal scientific plane that investigates the physical components of sound's materiality (Kinsler et al. 1999). Rather, acoustemology engages acoustics at the plane of the audible - akoustos - to inquire into sounding as simultaneously social and material, an experiential nexus of sonic sensations.*
Acoustemology joins acoustics to epistemology to investigate sounding and listening as a knowing-in-action: a knowing-with and knowing-through the audible." (Feld, "Acoustemology". In *Keywords in Sound*, 12-21).

[15] *"The authenticity of architectural experience is grounded in the tectonic language of building and the comprehensibility of the act of construction to the senses. We behold, touch, listen, and measure the world with our entire bodily existence and the experiential world is organized and articulated around the center of the body. Our domicile is the refuge of our body, memory and identity. We are in constant dialogue and interaction with the environment, to the degree that it is impossible to detach the image of the Self from its spatial and situational existence. "I am the space, where I am," as the poet Noel Arnaud established."* (Pallasmaa, "An Architecture of the Seven Senses", In *a+u Architecture and Urbanism: Questions of Perception*, 33).

[16] *"ACTOR, ACTANT: Actant is a term from semiotics covering both humans and nonhumans; an actor is any entity that modifies another entity in a trial; of actors it can only be said that they act; their competence is deduced from their performances; the*

notes

action, in turn, is always recorded in the course of a trial and by an experimental protocol, elementary or not." (Latour, *Politics of Nature, How to Bring the Sciences into Democracy*, 237).

[17] "We are vital materiality and we are surrounded by it..." Bennett, *Vibrant Matter, A political ecology of things*, 14)

II BODY

---

[18] Mark Wigley, *Buckminster Fuller Inc., Architecture in the Age of Radio*, 16.

III EXPRESSION

---

[19] Donna Haraway, *A Cyborg Manifesto: Science, Technology, and Social-Feminism in the Late Twentieth Century*, in Simians, Cyborgs and Women: The Reinvention of Nature,153.

[20] Henri Bergson, *Matter and Memory*, 34.

[21] Vittorio Gallese, *Bodily Framing*, in *Experience, Culture, Cognition, and the Common Sense*, edited by Carlonie Jones, David Mather and Rebecca Uchill, 240.

[22] Marvin Minsky, *The Society of Mind*, 29.

[23] Francesco Spampinato, *Les Métamorphoses du son, Matérialité imaginative de l'écoute musicale*, 174. Translation by the author.

> "Le sens le plus important de notre corp, c'est le toucher... L'ouïe se lie au toucher d'un point de vue phylogénetique (dans les organes de la ligne latérale du poisson, consacrés ä- la fois ä- la réception de stimuli pressifs et d'ultrasons, puis évolués en organes auditifs chez les amphibiens, jusqu'ä- nos oreilles) et d'un point de vue ontogénétique (les vibrations sonores sont saisies par le foetus ä- travers le captage de pressions du liquide amniotique sur l'épiderme; au cours de la phase prénatale on peut parler d'une "oreille globalle", ä- savoir de toute la peau "ä- l'écoute"). Ainsi, se dessine une vision "haptocentrique" de la sensibilité humaine, oü- le contact tactile est la source des associations synesthésiques et des associations affectives de l'homme."

notes

[24] Brandon LaBelle, *Background Noise, Perspectives on sound art*, Introduction xi.

[25] Maria Villela-Petit, *La Phénoménalité Spatio-Temporelle de la Musique*, in *L'espace: Musique/Philosophie*, edited by Jean-Marc Chouvel et Makis Solomos, 39. Translation by the author.

> "... la musique révèle la profondeur dynamique de l'espace, non dans l'éloignement, come le fait la vision, mais au sein même de la plus intime proximité, come profondeur vivante." 39

[26] Bevil R. Conway, *Processing*, in *Experience, Culture, Cognition, and the Common Sense*, edited by Carlonie Jones, David Mather and Rebecca Uchill, 89.

[27] Bevil R. Conway, *Processing*, in *Experience, Culture, Cognition, and the Common Sense*, edited by Carlonie Jones, David Mather and Rebecca Uchill, 92.

[28] Emmanuel Alloa, *Getting in Touch: Aristotelian Diagnostics*, in *Carnal Hermeneutics, Perspectives in Continental Philosophy*, edited by Richard Kearney and Brian Treanor, 205.

notes

III EXPRESSION

---

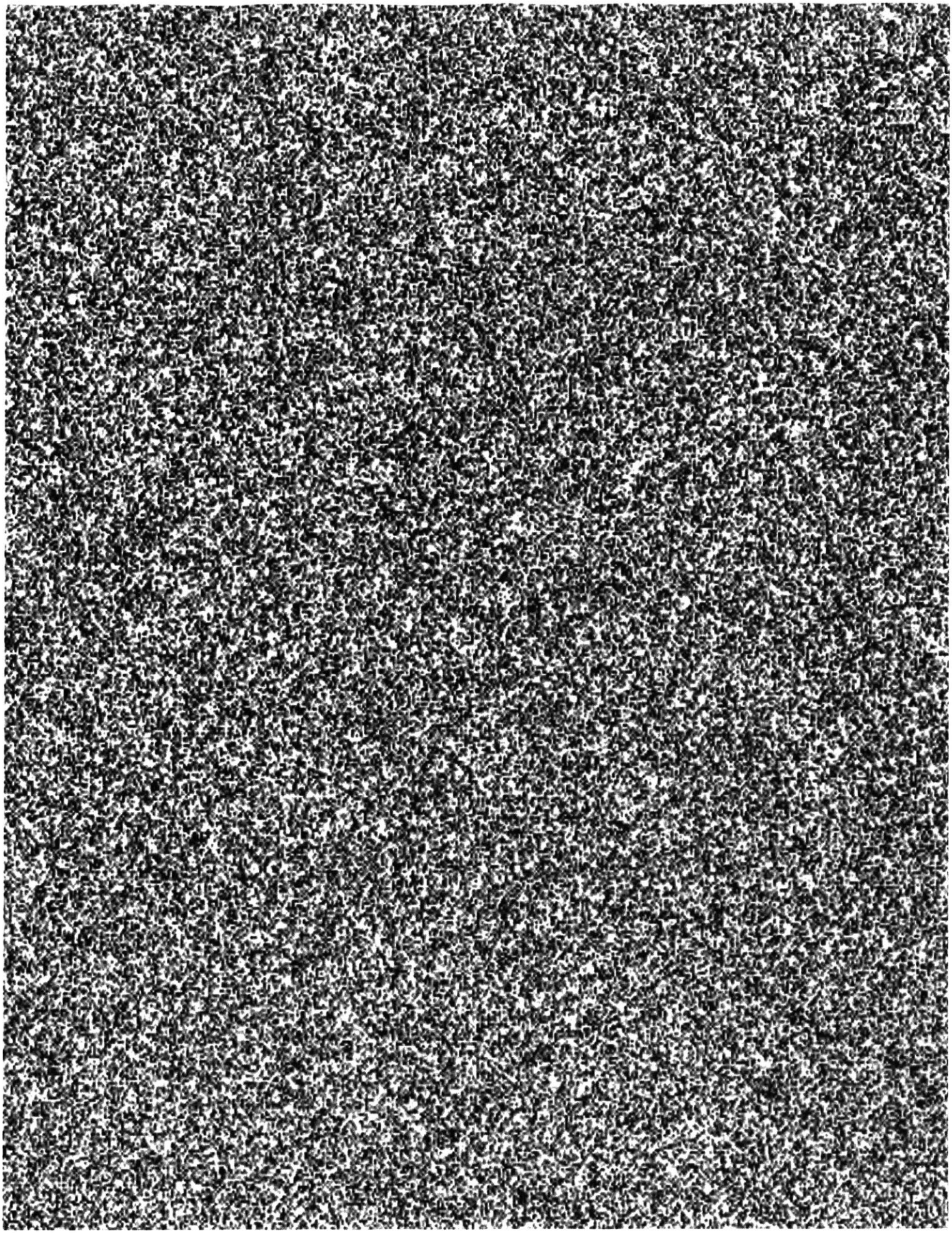
[29] Gilles Deleuze and Felix Guattari, *Rhizome*, in *A Thousand Plateaus, Capitalism and Schizophrenia*, 10.

[30] Alva Noë, *Strange Tools, Art and Human Nature*, 15.

[31] Francesco Spampinato, *Les Métamorphoses du son, Matérialité imaginative de l'écoute musicale*, 142. Translation by the author.

> "Le corps devient lectuer de l'expérience parce que l'écoute s'accompagne d'une micro-reproductionempathique des configurations tensives de la musique, à travers l'adoption de certains *patterns de tonus musculaire*: une "micro-danse imitative".

[32] Henri Bergson, *Matter and Memory*, 32.



Bennett, Jane. 2010. *Vibrant Matter, A political ecology of things*. Durham and London: Duke University Press.

Bergson, Henri, translated by N.M. Paul and W.S. Palmer. 1996. *Matter and Memory*. 5th ed. New York. Zone Books.

Blesser, Barry, Salter, Linda-Ruth. 2009. *Spaces Speak, Are you listening? Experiencing aural architecture*. Cambirdge: MIT Press.

Born, Georgina. 2017. *Music, Sound and Space, Transformations of Public and Private Experience*. Cambridge, UK: Cambridge University Press.

Chouvel, Jean-Marc, Solomos, Makis. 1998. *L'espace: Musique/ Philosophie*. Paris: L'Harmattan.

Cox, Trevor. 2015. *The Sound Book, The Sciences of the Sonic Wonders of the World*. New York: Norton.

Deleuze, Gilles, Guattari, Felix. 2016 (16th edition). *A Thousand Plateaus, Capitalism and Schizophrenia*. Translation by: Brian Massumi. Minneapolis: University of Minnesota Press.

Farahi Bouzanjani, Behnaz, Learch, Neil, Huang, Alvin, Fox, Michael, "Alloplastic Architecture: The design of an interactive tensegrity structure". *In ACADIA 2013 Adaptive Architecture: Proceedings of the 33rd Annual Conference of the Association for Computer Aided Design in Architecture. In Interactive*. Toronto: Riverside Architectural Press. 129-136.

Feld, Steven. 2015. "Acoustemology". In *Keywords in Sound*, edited by David Novak & Matt Sakakeeny. Duke University Press. 12-21.

Fox, Michael. 2016. *Interactive Architecture, Adaptive World*. New York: Princeton Architectural Press.

Glynn, Ruairy. 2014. Animating Architecture: Coupling High-Definition Sensing with High-Definition Actuation. Archit Design, 84: 100–105. doi:10.1002/ad.1707.

Haraway, Donna. 1991. "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in *Simians, Cyborgs and Women: The Reinvention of Nature*. New York: Routledge. 149-181.

Jones, Caroline, Mather, David, Uchill, Rebecca. 2016. *Experience, Culture, Cognition, and the Common Sense*. Cambridge: MIT Press.

yhqarqoilidid

Kearney, Richard, Treanor, Brian. 2015. *Carnal Hermeneutics, Perspectives in Continental Philosophy*. New York: Fordham University Press.

LaBelle, Brandon. 2013. *Background Noise, Perspectives on sound art*. New York: Bloomsbury Academic.

Lakoff, George, Johnson, Mark. 1980. *Metaphors we live by*. Chicago: University of Chicago Press.

Latour, Bruno. 2004. *Politics of Nature, How to Bring the Sciences into Democracy*. Cambridge, MA and London, England: Harvard University Press.

Latour, Bruno, Yaneva, Albena. 2008. "Give me a Gun and I will Make All Buildings Move : An ANT's View of Architecture." *Explorations in Architecture: Teaching, Design, Research*. edited by Reto Geiser. Basel: Birkhäuser. 80-89.

Leitner, Bernhard. 1978. *Ton : Raum, Sound : Space*. New York: New York University Press.

Maconie, Robin. 2010. *Stockhausen on Music, Lectures & Interviews*. London: Marion Boyars Publishers LTD.

Merleau-Ponty, Maurice. 2012. Phenomenology of Perception. Trans. Donald A. Landes. New York: Routledge.

Minsky, Marvin. 1986. *The Society of Mind*. New York: Simon and Schuster.

Negroponte, Nicholas. 1972. *The Architecture Machine, Towards a More Human Environment*. Cambridge: MIT Press.

Negroponte, Nicholas. 1975. *Soft Architecture Machines*. Cambridge: MIT Press.

Noë, Alva. 2016. *Strange Tools, Art and Human Nature*. New York: Hill and Wang.

Obrist, Hans Ulrich. 2013. *A Brief History of New Music*. Zurich: JRP | Ringier.

Pallasmaa, Juhani. 1994. "*An Architecture of the Seven Senses*". In *a+u Architecture and Urbanism: Questions of Perception*, ed/ Steven Holl, Juhani Pallasmaa, and Alberto Pérez-Gómez (Tokyo: a+u Publishing Co., Ltd., 1994), 33.

Pallasmaa, Juhani. 2012. The eyes of the skin, Architecture and

bibliography

the senses. John Willey & Sons Ltd.

Schafer, R. Murray. 1994. *The soundscape: Our Sonic Environment an the Tuning of the World*. Rochester: Destiny Books.

Spampinato, Francesco. 2008. *Les Métamorphoses du son, Matérialité imaginative de l'écoute musicale*. Paris: L'Harmattan.

Sterken, Sven. 2009. "Immersive Strategies in Iannis Xenakis's Polytope". OASE Journal 78. 116-125.

Tibbits, Skylar. 2016. Self-Assembly Lab: Experiments in programming matter. Routledge.

Torpey, Peter A. 2009. *Disembodied Performance: Abstraction of Representation in Live Theater*. S.M. Thesis: Massachusetts Institute of Technology, Media Arts and Sciences.

Varela, Francisco, Thompson, Evan, Rosch, Eleanor. 1991. *The Embodied Mind: Cognitive Science and Human Experience*. Cambridge: MIT Press.

Wever, Peter. 2015. *Inside Le Corbusier's Philips Pavilion: A Multimedial Space at the 1958 Brussels World's Fair*. Rotterdam, Netherlands: NAi Boekverkopes / Booksellers.

Wigley, Mark. 2015. *Buckminster Fuller Inc., Architecture in the Age of Radio*, Zurich: Lars Müller Publishers.

Yaneva, Albena. 2008. "How Buildings 'Surprise': The Renovation of the Alte Aula in Vienna," in *Science Studies: An Interdisciplinary Journal of Science and Technology Studies, special issue "Understanding Architecture, Accounting Society"*.21(1).

Young, La Monte, Zazeela, Marian. 2004. "Dream House". In *Selected Writings La Monte Young & Marian Zazeela*, edited by M. H. Tencer. Ubuclassics. 10-16.

yhqarbgoildid