

MUSIC AND ARCHITECTURE: NOTES ON EXPERIENCING
THE CONVERGENCE OF MUSIC AND THE BUILT ENVIRONMENT

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ABSTRACT




This project is an investigation into the present and possible convergence that occurs between architecture and music. Music moves us, brings us to an ethereal world that is captured in our memories. It construes a space that is embedded in people's consciousness and becomes a haven from the troubles outside of it. Its form is the expression of an idea, born through the manipulations of its composer. This phenomenon of constructed space is a connecting aspect between music and architecture. While architecture and music are different in materiality, they both define a type of space and are organized and structured accordingly. The focus of this project is to use music as a catalyst for architectural design by proposing a framework for the implementation of musical principles in the process of design.

This is explored in three sequential levels of investigation: historical and musical research, proposition of compositional tools, and a building representation illustrating the proposed synthesis. The first level of research delves into musical and spatial theory, existing architectural discourse on the topic, and case studies of architectural works. These are documented with the purpose of deconstructing music and deriving elements of composition to apply into architecture. The second level of investigation develops a design methodology proposal that includes the elements of composition; it proposes additional compositional tools for the transposition of music into design. The third level of investigation is to use these composition tools to design a residential building that is generated through a specific music composition.

The project emulates musical structure and composition through spatial manipulation and geometric form. It illustrates a representation of musical movement in order to extract some of the affect that occurs in the realm of sound. This investigation aspires not to be a purely mathematical translation from a musical piece into architecture, but an implementation of an underlying structure that guides the constructs of music. It explores the ethereal and evanescent value of music through composition strategies. The act of applying music into architecture provides opportunities to craft fuller and more exuberant spaces.

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CHAPTER 1

INTRODUCTION

"All art constantly aspires towards the condition of music."¹
-Walter Pater

PRELUDE

How does architecture and music converge? And further, how can the experience of architectural form and its subsequent spaces be infused with music? Music often embodies an ephemeral world that is embedded in people's memories and becomes a haven from the troubles outside of it. Brandon LaBelle quotes Bruce Smith in the book *Acoustic Territories* as saying, "Sound provides the most forceful stimulus that human beings experience, and the most evanescent."² Despite its physical immateriality, music defines an intangible space that is undeniably affecting. It is perhaps for these reasons, among others, that over the years architecture theorists and practitioners have been intrigued by the notion of connecting music and architecture; reaching from the physical to the emotional aspects of the two disciplines. This project delves into an exploration into this connection and the possible overlap that can be found between architecture and music.

The goal is to use techniques found in music composition and to implement them into architectural composition. This is done by deconstructing the two disciplines into basic elements and mapping their respective parts to each other. It will be done in three sequential levels of investigation: historical and musical research, to discover the basic elements and their compositional arrangement; development of a methodology, which will connect the two disciplines; and building representation on a specific site. The impetus of this project is to both examine and enhance the convergence that occurs between music in architecture as an investigation into the merging and furthering the parallel found in the arts.

1 Walter Pater, *The Renaissance* (Toronto: Random House, Inc., 1919) 114.

2 LaBelle, Brandon, *Acoustic Territories: Sound Culture and Everyday Life* (New York: Continuum, 2010)

THEME

The overarching theme of this project is to use musical principles as a reference to extract compositional tools with which we will implement in architectural design. To preface the investigation, it is useful to define music in this project as being an intentional series of audible sounds. The intentionality indicates some type of logic or organization that we inherently attribute to music; even though the organization within a type of music is hidden, it always has some type of cohesion that drives its composer. This project will predominantly focus on Western Classical Music because of its highly structured and often clearly heard organization, while maintaining a complexity and nuance.

In an article for the *Musical Times*, L.N. Higgins compares music and architecture, saying that while the two are radically different art forms, they both are evidence of man's ability to "create form."³ This form he is referring to is the space we enter that is defined by elements; the elements of architecture are the physical materials and spaces that we create, and the elements of music are the aurally heard sounds, and rhythms that we compose. These elements define a particular type of 'space', whether it is a physically felt, three-dimensional space; or whether it is an intangible auditory space. In both music and architecture, this space may be expanded upon, to create a symphonic gesture, larger or smaller according to need or desire. Through the research investigation, three layers of composition have emerged and defined. These layers of composition become the methodology by which architecture and music can be connected: Composition Variables, Thematic Modules, and Orchestration.

The Composition Variables are often discussed in texts discussing musical form. Within the western music sphere, there are several basic components that are important in the process of this project. In the book *The Musical Experience*, John Gillespie outlines the most basic components of music, listed as being pitch, rhythm, volume, and texture.⁴ These variables are the building blocks that create patterns that may be arranged to construct the "form" that coincides with and supports an idea that is the basis of each composition.

3 L.N. Higgins "Music and Architecture", *The Musical Times*, 66 (1925):509-510. Accessed March 28, 2015. <http://www.jstor.org/stable/912830>

4 John Gillespie. *The Musical Experience*. (California: Wadsworth Publishing Company, Inc., 1968)

While this concept encompasses many building blocks, and not one specific concept, they are the phenomena Walter Pater mentions in his book *The Renaissance* as being the reason which “all art aspires toward the condition of music.”⁵

The second compositional layer is the thematic module. In music, there are several smaller groupings of elements such as motives, phrases, etc. These are groupings that arrange the four variables into patterns. The thematic modules are often arranged amongst each other and organized by a larger form.

The final composition layer is what we will call orchestration. This includes the larger form that arranges thematic modules, known as musical form. The orchestration of a piece will direct movement, length, musical form, and any transformations that might happen within the composition. The orchestration of a piece is the way in which everything comes together and how the multiple elements are arranged amongst each other.

PROJECT GOALS

This project seeks to explore the ways elements in both fields can be interchangeable based on these parallels. The ultimate goal of this project is to outline and implement a methodology that specifically connects these composition layers of music with the composition of architectural elements.

These music composition building blocks are often referred to in literary terms, indicating an inherent organization. Composition variables, such as pitch, rhythm, etc. function as musical ‘building blocks’, and can be built up and organized. This organization, or orchestration, of Composition Variables is the process of music composition. By themselves, these variables are static and random sounds. The composition variables, pitch, rhythm, etc. are stitched together to form Thematic Modules, which are then combined and organized into an overall form. Further, it can be postulated that these compositional elements can be related to architectural ones, where the musical idea is the architectural concept,

5 Pater, *The Renaissance*, 114.

the variables are the structural and spatial manipulations, and the musical form is the architectural form. Of note, musical composition is a complex and vast subject which can be studied and compared at length even further, but will be kept simple in this project for the purposes of its transposition into architectural principles.

BACKGROUND CONTEXT

For many years, architects, musicians, philosophers and the like have explored the interrelations and connections between architecture and music. Vitruvius, in his classic text *The Ten Books on Architecture*, explains the necessity of an interdisciplinary education for architects, making special note of the importance an inclusion of music in the architect's education.⁶ There have since been theories and experiments in the realm of architecture that make connections to music in both the rational and phenomenological realms.

From preliminary research, there are two major strains of thought in the study on the relationship between architecture and music. The first is a mathematical and rational approach. This was perhaps most often referenced by renaissance architects in regards to "musical harmonies" and in the realm of proportion and geometry. Said renaissance architects drew comparisons between the inherent structure and ratios found in music harmonics to what they deemed were "beautiful" proportions. These proportions were related to a universal aesthetic.

More contemporarily, a different and also more rational approach is illustrated by Iannis Xenakis' ideas and implementation of mathematical principles and graphical exploration in both music and architectural design.⁷ However, rather than a purely mathematical viewpoint, he implemented the process of composition into his design.

6 Vitruvius, *The Ten Books on Architecture*, trans. Morris Hicky Morgan (New York: Dover Publications, Inc., 1960) 8.

7 Iannis Xenakis, *Formalized Music: Thought and Mathematics in Music* (New York: Pendragon Press, 1992)

He approached architectural composition in the same way that he composed his music, as seen in graphical exercises with his seminal symphonic composition *Metastasis* as well as his architectural work, such as the Philips Pavilion. By this process, he states in his book *Formalized Music*, that he had found a close connection between architecture and music.⁸

To briefly mention the second strain of thought in regards to architecture and music: is the attention to its atmospheric and emotive power. Music is not an entirely mathematically and logically formulated entity. It is an entity that has inherent structure, and can thus be explained logically. However, the power of music isn't found and crafted by purely mechanized sequences, but is often shaped through an expression or response. There are many examples of a central musical idea which shapes this expression, and is manifest in the execution of a composition. One architect who utilized this was Daniel Libeskind, when he alluded to this in his poetic Jewish Museum in Berlin. Inspired by Schoenberg's opera, *Moses and Aaron*, he crafted "voids" through inspiration by the hollow despondency created by the silences in the opera.

SCOPE OF PROJECT

The scope of this project is in gathering musical principles and theory, and implementing them into architecture at a schematic level. It is inspired by the latter strain of thought, but more closely follows the processes of the former strain of exploration. By studying the tenants of musical structure, architectural elements can exemplify some of the effect that music implies. Studying a specific musical form is an ideal starting point to explore the structural principles that are inherent in music. In his book *Understanding Music*, William Newman describes the concept of musical form at a very basic level, saying that: "Musical form is architecture in sound; it is the end product when the elements and the intangibles of the musical experience are coordinated in a particular fashion and within perceivable limits."⁹ It can be a proposition for utilization as a framework in architectural design.

8 Iannis Xenakis, *Formalized Music: Thought and Mathematics in Music* (New York: Pendragon Press, 1992) 10

9 William Newman, *Understanding Music: An Introduction to Music's Elements, Styles, and Forms--for both the Layman and the Practitioner*. New York: Harper & Row, Publishers, 1961.

This project will propose an implementation of an underlying structure that guides the constructs of music. Specific compositions from western classical music will be used to illustrate the concepts found through the literature exploration.

For this purpose, the research portion of this project will delve into the following areas of investigation. The next, second chapter is a documentation of the past and current thought and practice in regards to the topic of music and architecture. It is an elaboration of the background context that is discussed in this introduction and attempts to knead out previous theory and precepts found in music and how they were applied in architecture. The third chapter documents research related to music and our perception of space, to provide more information and justification in formulating a methodology for a music to architecture transposition. The fourth chapter encompasses the basis for the methodology, in interchanging the base elements of architecture and music and their relation to each other. The fifth chapter is the operational methodology, which elucidates the orchestration of these pieces. The sixth chapter is the final project, which illustrates all of the principles and methodology set forth in this thesis.

In summary, studying compositional principles of a specific musical form sets up a framework by which to create strategies to fuse musical principles with physical form. This framework is a tool to “compose” architecture. Whether it is apparent or not, music and architecture are both composed, and are shaped through rules that lend each a sense of structure and organization. While there are many material differences between architecture and music, both are intentionally formed, and have a structure. In an article for the *Musical Times*, L.N. Higgins writes on the discussion regarding music and architecture, saying that: “Both the building and the music are only different manifestations of the same principle--the principle of man’s supreme gift of creating form.”¹⁰ Music itself is formed by a type of liquid architecture that unites each composition to form a cohesive whole.

10 L.N. Higgins, “Music and Architecture” *The Musical Times* 66 (1925) 509-510.

CHAPTER 2

INSPIRATIONS: MUSIC IN ARCHITECTURE

PAST AND CURRENT DISCOURSE

Early Practice

Renaissance architects theorized correlations in proportion and harmony, believing aesthetic beauty to have underlying laws present in all the arts. One commonly cited belief was the use of harmonic ratios in renaissance thinking and building. The harmonic series in music held a close correlation to the golden ratio, where particular ratios in musical harmonies were, and still are, widely accepted as being consonant--or pleasing harmonies. While there is no evidence that musicians intentionally used the golden ratio in their composition, the phenomena of the harmonic equivalent led architects and thinkers of this period to believe that there was an inherent, cosmic proportion that existed in the world. Thus, aligning architectural measurements to these proportions rendered a building 'beautiful'. Peter Vergo, in his book *That Divine Order: Music and the Visual Arts from Antiquity to the Eighteenth Century*, refers to these proportions as 'divine harmonies' as he documented Alberti's references to music in relation to mathematics and the Golden Ratio. Vergo notes that: "Thus, buildings designed according to these principles would embody 'musical' proportions, thereby creating 'harmonies for the eye'".¹¹

This was supported by dialogue and theory produced by mathematicians and philosophers of the day. The belief was that particular music and intervals could produce particular moods or feelings. Music consists of intervals that are either consonant or dissonant. Consonant intervals are pleasing to the ear, while dissonant intervals produce 'harsh' or 'grating' sounds. Vergo quotes philosopher Marin Mersenne as saying that major imperfect consonances as 'very suitable for joy and for expressing virile and courageous actions'.¹²

11 Peter Vergo, *That Divine Order: Music and the Visual Arts from Antiquity to the Eighteenth Century*, (London: Phaidon Press Limited, 2005) 142

12 Peter Vergo, *That Divine Order*. 191

Vergo also cites Descartes, saying that Major third and major 7th produce more pleasing effects of music on feelings.¹³ This is reflected in many subsequent classical compositions, with the perhaps happenstance that many joyous songs are in a particular major key signature, and many other 'sad' or 'gloomy' songs being composed in minor keys.

Contemporary Practice

This use of mood and musical idea can perhaps be translated back into architecture, as seen in several architectural works such as the previously mentioned Jewish Museum by Daniel Libeskind, where his crafted voids in the museum sequence echoed the hollow despondency found in Schoenberg's unfinished Moses and Aaron opera.¹⁴ The opera was one of the foundational concepts of the museum, linking the architectural design with not only the desolate feeling of the Jewish persecution, but also giving cultural significance to his design.

Regarding this usage of music in sensual and emotional environments, Charles Jencks elaborates on this in an article for the Architectural Review. He states that there are qualities that unite architecture and music, which can be seen in "structures that heighten the senses and make one perceive more sharply and emotionally."¹⁵ Jencks continues to make the argument that architecture and music are linked in their ability to evoke emotion and expression.

13 Peter Vergo, *That Divine Order*. 191

14 "The Jewish Museum, Berlin" *The Guardian*, October 11, 2007. <http://www.theguardian.com/artanddesign/2007/oct/11/architecture.museums>

15 Jencks, Charles. "Architecture Becomes Music". *Architectural Review* 233, no. 1395 (2013): 91-108

Others have also visualized a conceptual approach to music in architecture. In their book *The Geometry of Environment*, Lionel March and Philip Steadman quote Frank Lloyd Wright's comments on 'integral ornament' in architecture, when he says: "That amazing revolution in tumult and splendor built on four tones based upon a rhythm a child could play on the piano with one finger. Supreme imagination reared the four repeated tones, simple rhythms, into a great symphonic poem that is probably the noblest thought-built edifice in the world. And architecture is like music in this capacity for the symphony."¹⁶

However, architects also envision a more structured integration of music into architecture. Iannis Xenakis is a succinct example of utilizing compositional methods in design. His projects, to be discussed later in this paper, is in part a result of his experimentation with contemporary music composition. He implemented specific musical principles into visual aesthetic, such as the flying glissando that appears in the Philips Pavilion he designed with Le Corbusier. Or the polyphonic architectural facade he crafted on the Monastery at La Tourette. His are precedents of the visual implications of musical terminology.

One of the preeminent architects who has made an intentional effort to incorporate music into design is Steven Holl. "Music, like architecture, is an immersive experience--it surrounds you. One can turn away from a painting or a work of sculpture, while music and architecture engulf the body in space."--Steven Holl.¹⁷ The statement above is indicative of Holl's approach to the design, regarding his intent to tap into the emotive aspect of architecture. Modern architects draw from the psychological traits and effects of music to formulate more sensational architectural spaces. They have also taken individual musical techniques and translated it into architectural gesture.

16 Lionel March and Philip Steadman. *The Geometry of Environment: An Introduction to Spatial Organization in Design*. (Cambridge: MIT Press, 1974) 62

17 Steven Holl, "Architectonics of Music," *32BNY*, Accessed April 1, 2015, <http://architectonicsofmusic.com/am>

Inspired Music Composition

As an interlude between the dialogue of inspired architecture in the past and contemporarily, should be a discussion of the inverse occurrence. While much of the discourse documented in this project has focused on music's influence on architecture, it is also of interest and important to note that music has long since been inspired by physical and spatial events. The translation of visual phenomena into music, whether it is drawn from nature or architecture, has been a theme in many compositions. The composer of a famous series of pieces, Vivaldi penned the Four Seasons, which depicts mood and circumstance in each of the four seasons. The depiction of a violent storm is evident in "Winter", through the sudden forte, and unique sounds and tempo, as well as being written in a minor key.

As impressionism made its way through art and music, composers were inspired by the imagery created. Claude Debussy wrote his Nocturnes after being inspired by several paintings, also called Nocturnes, by artist James McNeill Whistler.¹⁸ Both artist and composer were intent on representing light and color in their respective art forms, representing the musical idea through an impressionist's lens.

Nature plays a large role in the inspiration of music. Only a few pieces among many: Debussy also wrote "La Mer", which depicts the crashing waves of the sea. Felix Mendelssohn also was inspired by the movement of the ocean, when he composed Fingal's Cave during a boat trip around Scotland. He was inspired by the crashing waves around the cave.¹⁹ This movement is evident and can be heard through the rhythm and movement depicted in the piece.

18 "Nocturnes: Claude Debussy". LA PHIL. Accessed November 8, 2015. <http://www.laphil.com/philpedia/music/nocturnes-claude-debussy>

19 Schwarm, Betsy. "The Hebrides, Op. 26: Overture by Mendelssohn". Encyclopedia Britannica. Accessed November 8, 2015. <http://www.britannica.com/topic/The-Hebrides-Op-26>

Another poignant and expressive example of imagery that inspired music was Arnold Boecklin's painting "Isle of the Dead", which can only be described as "haunting" with its dark undertones depicting an island in the middle of an ocean. This painting is what inspired Sergei Rachmaninoff's "Isle of the Dead". It is this sentiment of darkness that Sergei Rachmaninoff was inspired by when composing his musical piece of the same name. Listening to Rachmaninoff's piece, there are clear musical depictions of the painting.²⁰ Its somber tune, expresses a darker nature. The rhythm of the 5/8 time signature is reminiscent of the rowing boat that crosses the island in the painting.

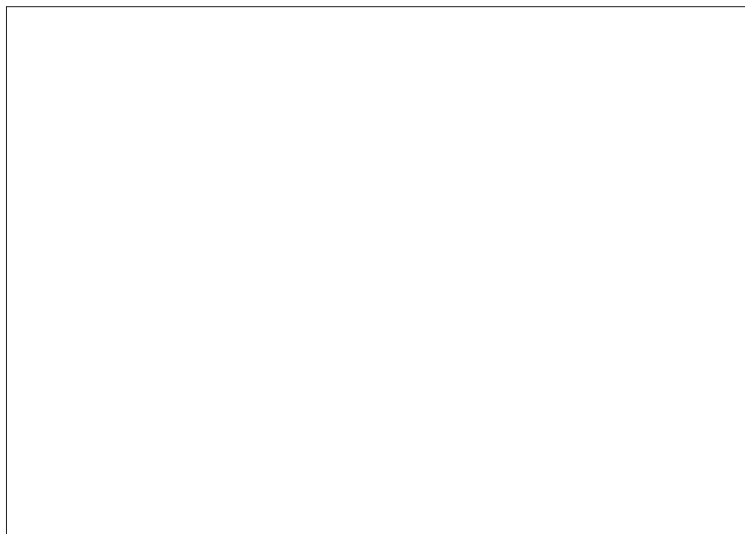


Figure 1: Isle of the Dead

Source: Boecklin, Arnold. "Isle of the Dead". 1880. Artchive. Accessed November 8, 2015. http://www.artchive.com/artchive/B/boecklin/isle_of_the_dead.jpg.html.

²⁰ Matthew Gurewitsch. "Music; a Visual Requiem That Inspired Rachmaninoff" The New York Times, January 6, 2002. Accessed November 8, 2015. <http://www.nytimes.com/2002/01/06/arts/music-a-visual-requiem-that-inspired-rachmaninoff.html?pagewanted=all>

CASE STUDIES

Stretto House

Steven Holl has designed several built projects that derive their inspiration from music. His ideas are more in line with the experiential aspect of both music and architecture, believing that architecture can have a profound effect on people. He expresses this in a video interview posted on his website, saying that "It's exciting to me that architecture can change the way you feel. Like music, you know, when you're playing a piece of music if you're sad, it can bring you into another world."²¹ The Stretto House shown in figure 2, is one of Holl's projects that is an example of his desire to bring music into architecture.



Figure 2: Images of the Stretto House
Source: Steven Holl Architects, *Stretto House*, New York: The Monacelli Press, Inc. 1996.

21 Rosenfield, Karissa. "Video: A Conversation with Steven Holl inside the Daeyang Gallery & House" 10 Jul 2012. ArchDaily. Accessed 07 May 2015. <<http://www.archdaily.com/?p=253378>>

Situated on a parcel in Texas, the Stretto House was designed by Steven Holl Architects, and completed in 1991.²² The 6,000sq ft. house is located on a site with a stream running in the middle. The stream flows through the parcel, forming three dams. Steven Holl was inspired by the constant sound of water flowing and overlapping into the dams, which was reminiscent of how *stretto* occurs in music.²³ The house was designed around Hungarian composer Bela Bartok's piece *Music for Strings, Percussion and Celeste*, and incorporates several themes from the piece--the most emphasized in the project is the *stretto* that occurs throughout the composition.

The overlapping qualities in Bartok's *Music for Strings, Percussion and Celeste* becomes a prominent device in the composition, even from its introduction in the very first movement. The recurring subject is introduced in the first measure, and also heard in various forms throughout the composition's four movements. Shown below is the first page of the score where the theme is introduced, followed by a repeat of the voice, shown in a different color. The recurrent theme begins in the fifth measure, the subject overlapping in counterpoint to the first. The subject enters repeatedly, becoming the overlapping quality that inspired Steven Holl.

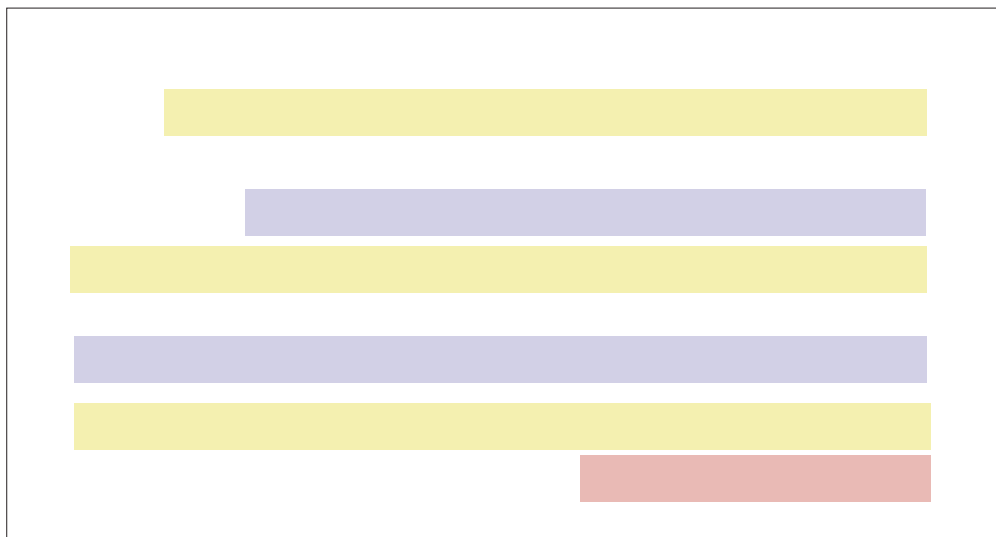


Figure 3: Bela Bartok, *Music for Strings, Percussion and Celesta*.
Source: Public Domain. New York: Boosey & Hawkes, 1939.

22 Oscar Riera Ojeda, ed., *The New American House: Innovations in Residential Design and Construction* (New York: Whitney Library Design, an Imprint of Watson-Guptill Publications, 1995) 96-101.

23 Steven Holl Architects, *Stretto House*, (New York: The Monacelli Press, Inc., 1996) 7.

Merriam-Webster's Dictionary defines stretto as "the overlapping of answer with subject in a musical fugue."²⁴ One voice will begin the theme, and another voice with the same subject will begin before the first voice concludes. Stretto occurs in a fugue at the point where the voices overlap. Figure 4 is taken from an excerpt from Bach's Well Tempered Clavier Fugue no. 1. It shows in blue the fugue subject, and where it enters a second time on the base clef. The second subject comes in before the first subject ends. The rectangle superimposed over the score indicates the moment the two voices overlap, thus delineating the stretto.



Figure 4: Bach's Well Tempered Clavier Fugue no. 1

Source: http://upload.wikimedia.org/wikipedia/commons/8/86/Stretto_-_Bach's_Well_Tempered_Clavier_Fugue_no._1_mm._21-23.png

While the concept is closely related, it is worth noting that the house is more a model of the *fugue*, which features a contrapuntal overlap of voices throughout a piece in music. In Steven Holl Architects' book on the *Stretto House*, Holl explains his ideas on the dialogue between the musical concept *stretto* and architecture, saying, "This dovetailing musical concept could, I imagined, be an idea for a fluid connection of architectural spaces."²⁵

In his description of the project, Holl makes a comparison between music and architecture, saying that "Bartok's Music for Strings, Percussion and Celeste has a materiality in instrumentation which the architecture approaches in light and space."²⁶ He applies this in the project by creating what he calls "aqueous" spaces, or spaces that not only overlap, but lead into one another in the interior of the house.

²⁴ Merriam-Webster's Collegiate Dictionary. 11th ed. Springfield, MA: Merriam-Webster, 2003. Also available at <http://www.merriam-webster.com/>.

²⁵ Steven Holl Architects, *Stretto House*, 7

²⁶ "Stretto House". Steven Holl Architects, accessed March 3, 2015, <http://www.stevenholl.com/project-detail.php?id=26>

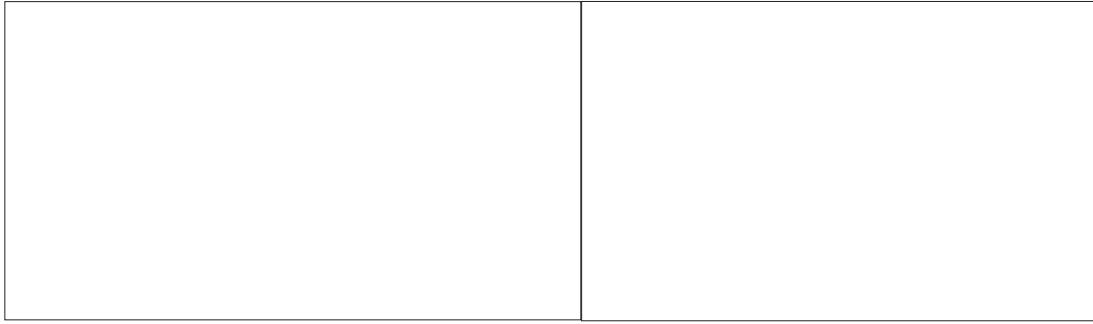


Figure 5: Stretto House watercolor

Figure 6: Stretto House Floor Plan.

Source: Steven Holl Architects, *Stretto House*, 7

Figures 5 and 6 show the concept in the floor plan as the rooms overlap through orientation and floor level changes. Early watercolor drawings show his intent that spaces would flow into and over one another naturally. Holl also intended that the roof mirrored this concept, layering them over one another. The openings formed were intended to “pull” light into the house.

There are several other ways Bartok’s piece was incorporated into the design of the house. One has to do with organization. The Stretto House’s four sections is reflective of the four movements that constitute the piece. The placement of four masonry walls was placed based on the beat of the second cello in the reintroduction of the main theme near the end of the piece.²⁷ The house’s plan is generally linear, with the stretto represented through floor level changes and overlapping rooms.

Holl also makes a comparison between instrumentation in Bartok’s piece and building materiality. Instrumentation has a particular tone and texture, and Holl represented each major grouping of instruments through materials. The string instruments, which have a lighter sound, is offset by the lower, heavier sound of percussion. He represents the string instruments with the metal roofs over a glass enclosure, and the percussion with masonry walls. The light and heavy materials alternate through the house.

²⁷ Alessandra Capanna. “Music and Architecture: A Cross Between Inspiration and Method”. *Nexus Network Journal* 11 (2009): 257-272



Figure 7: Stretto House Elevation
Source: Steven Holl Architects, *Stretto House*, 7

In summary, Holl approached the inclusion of music in several different ways. The most prominent and recurrent theme is use of *stretto*. This is evident in the layout of the house by sequence of spaces, and the formation of the roof. The second item is through organization. The house's four sections, shown in figure 7, mirror the four movements that compose Bartok's piece. Another way he drew parallels is through the materiality. When representing the two different tones found in Music for Strings, heavy masonry mirrored percussion, and light, curving metal for the stringed instruments. Holl also describes the music having an influence on light and space. In terms of space, the overlapping nature of Bartok's piece comes into play, with Holl designing the house as "aqueous space". He says the floor planes cause the spaces in the house to overlap and lead into one another. Light comes through skylights that are formed by the overlapping nature of the roof and walls. "Floor planes pull one space to the next, roof planes pull space over walls and an arched wall pulls light from a skylight."²⁸

Facade of the Monastery at La Tourette

The famous monastery was built in Eveux-sur-Arbresle, France in 1960. Iannis Xenakis was an architect, engineer who began working with Le Corbusier in 1947 as an engineer before designing projects himself. He worked for Le Corbusier for a number of years before going on his own.

28 "Stretto House". Steven Holl Architects, accessed March 3, 2015, <http://www.stevenholl.com/project-detail.php?id=26>

He was also a 12-tone composer, possibly best known for his composition *Metastasis*, which later became an inspiration for architectural projects.²⁹

In the design for the Monastery at La Tourette, Xenakis worked with Le Corbusier, and designed the “undulating glass panes” found in the facade of the building.

There were several factors that had an influence on the design. Xenakis was charged with designing a facade that was light, and still transparent, much in confirmation with Le Corbusier’s ideas of pilotis. However, the interior spaces needed to be shaded. The glass panes function, thus was letting in lighting and ventilation, while maintaining a transparency. Xenakis’ solution to this was to transpose musical rhythm to the facade through means of glass panes, or as Le Corbusier first enthused, “musical glass panes”.³⁰

The project is an example of including “musical” rhythm in architectural space, as well as producing a type of visual counterpoint. In his writings on La Tourette, Iannis Xenakis describes this project in regard to his process and experimentation in fusing music and architecture.³¹ His intent in these “undulating glass panes” as he ended up terming them, is an example of how he transposed musical rhythm into architecture. Movements in music, such as *adagio*, *largo*, *presto*, etc. is related to density in the sense that density is the “number of events per unit of length”. He drew parallels from the density in sound, pitch, and tempo to correspond to the physical density of the undulating facade of the window.

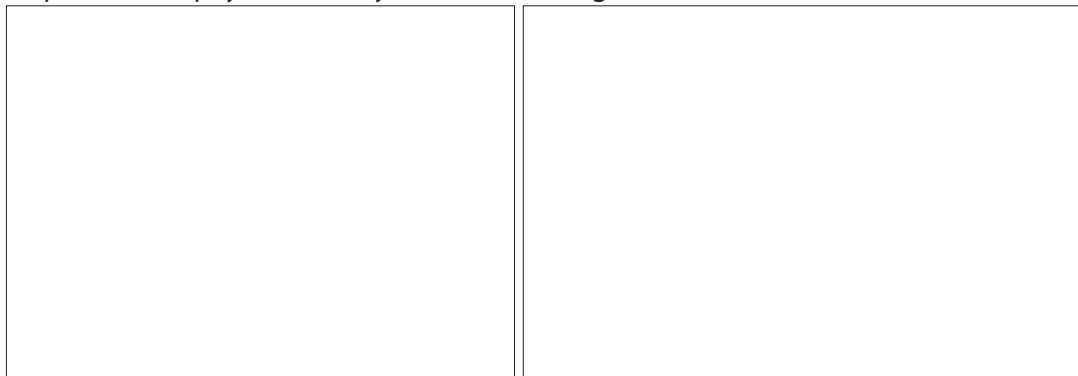


Figure 8: La Tourette

source: “Couvent Sainte-Marie de la Tourette,” Accessed 05/08/15. http://www.fondationlecorbusier.fr/CorbuCache/900x720_2049_289.jpg

29 Iannis Xenakis, *Music and Architecture: Architectural Projects, Texts and Realizations*. (New York: Pendragon Press, 2001), 72

30 Iannis Xenakis, *Music and Architecture: Architectural Projects, Texts and Realizations*. (New York: Pendragon Press, 2001), 72

31 Xenakis, *Music and Architecture: Architectural Projects, Texts and Realizations*, 72

The second musical principle Xenakis refers to in this project is the idea of counterpoint. The vertical composition of the undulating panes was designed in counterpoint, a musical principle of overlapping themes as independent voices, yet overlapping each other to create a unified whole. In his writings, Xenakis alluded to the visual polyphony he had composed in the facade of La Tourette. The three levels of the west facade formed the three lines of rhythm, and he juxtaposed the three layers amongst each other to create a unified facade. Therefore, the composition became both functional and aesthetic.

As a composer, Xenakis' musical sensibilities led him to design a building similarly to how he would compose a piece. In the process of designing the facade, Xenakis writes in the book *Music and Architecture* that he chose four elements a, b, c, and d, of the golden section, "and their twenty-four permutations, which I arranged on the unfolding of the facades, like a variation on a single theme, in time."³² Xenakis then used the same process in composing his music, with dimensions and length of pitch according to the modulator and golden ratio. The same technique of graphical analysis shown in the graph for his composition, was used when designing the fenestration of La Tourette.

In summary, Xenakis relates music and architecture in terms of density of sound and pitch to correspond to the density of undulating glass panes. This was also done in a practical way, where Xenakis sketched the undulation density of the windows based on where along the monastery needed more shade. He also designed each floor level both separately and as a whole, so vertically all the levels appeared as a unified facade.

32 Iannis Xenakis, *Music and Architecture: Architectural Projects, Texts and Realizations*. (New York: Pendragon Press, 2001), 72

Xenakis' Composition

Metastasis is Xenakis' first major musical work, consisting of a 60 instrument orchestra. In it, he experimented with glissandi, which denotes a movement on an instrument that slides through a pitch. This, for example, can be done on a violin

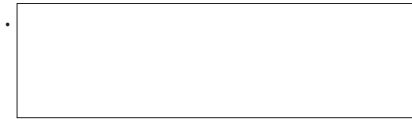


Figure 9: Glissando

source: <http://www.molevalleymusic.co.uk/TheoryGradeOrnaments.html>

The glissandi is most prominent in the beginning and end of the piece. There is also influences from Le Corbusier's *Modulor*, which "created a close structural link between time and sound".³³ as Xenakis had also been experimenting in music and the golden section.

He also used 2D depictions of movement of pitches. In his graphs for the *Metastasis*, each instrument occupies a pitch in time. The graphs shown in figure 10 depicts parts of the composition, and the instrumentation is shown through the solid lines. The undrawn y axis denotes pitch, while the x axis is time. Here the movement of the orchestra as a whole is visualized. Each orchestral piece occupies a different pitch, and they move as a whole, intersecting and expanding through time.

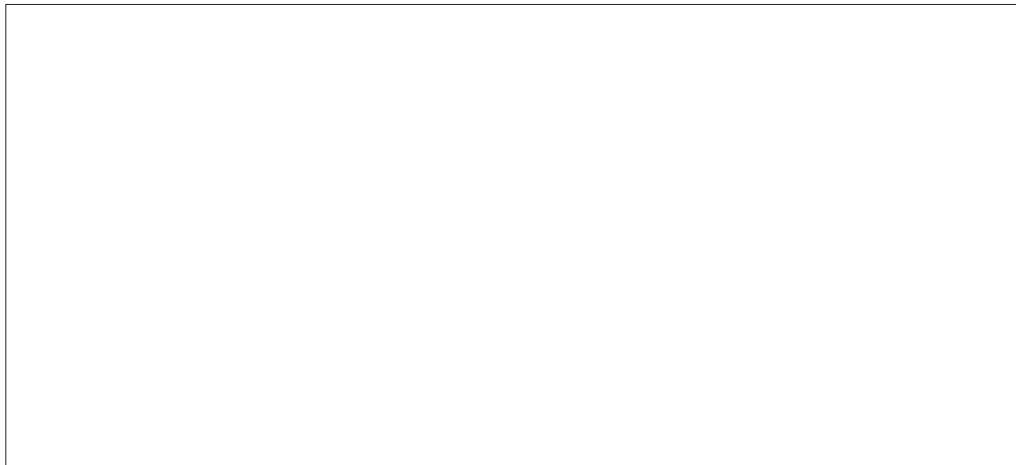


Figure 10: Graph of metastasis

source: Xenakis, Iannis. *Formalized Music: Thought and Mathematics in Music*. New York: Pendragon Press, 1992

33 Iannis Xenakis, *Music and Architecture*.

Philips Pavilion

In preparation for the World's Fair in 1958, Xenakis designed the Philips Pavilion in collaboration with Le Corbusier. Le Corbusier formulated the plan for the pavilion through a series of design sketches. The plan is described as "stomach shaped" and was meant to accommodate the circulation for the pavilion. Xenakis used this as the baseline for the design of the form for the Philips Pavilion.

Xenakis' experimentations and composition exercises in *Metastasis* had influences when designing this project. Similarly to the composition, Xenakis imagined the pavilion through ruled lines that he drew from the edges of the floor plan to peaks in the pavilion. The graphic explorations shown in relation to *Metastasis* are similar to the ones he created in the process of designing the Philips Pavilion.³⁴

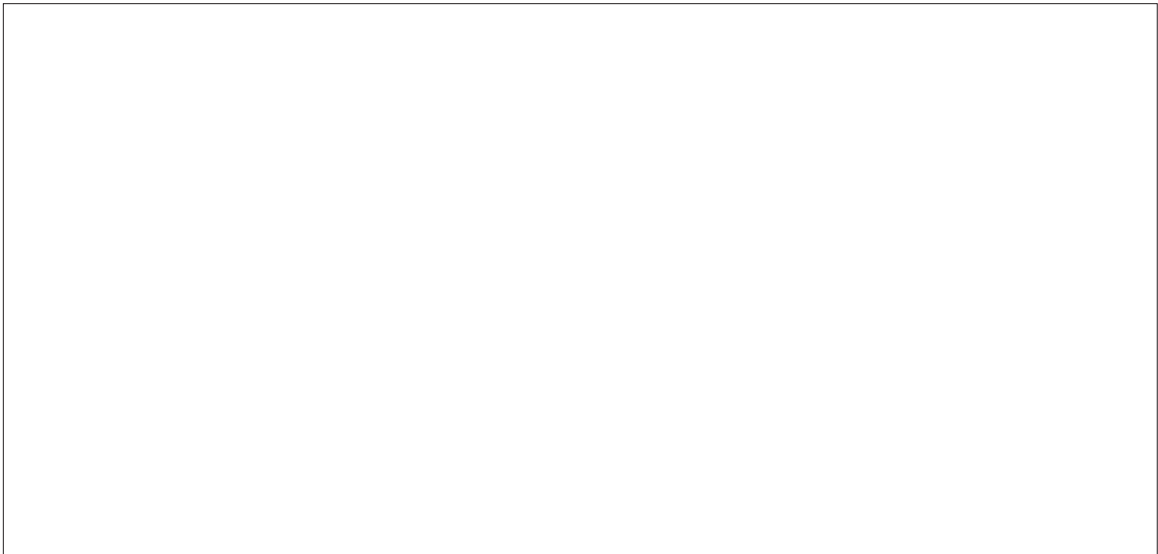


Figure 11: Philips pavilion
source: Carnegie Mellon University School of Art, "Hybrid Instrument Building".
Accessed 5/8/15. <http://teach.alimomeni.net/2014fall2/?p=4274>

34 Iannis Xenakis, *Music and Architecture*.

While Xenakis' project has obvious and explicitly stated references to music, it is not a literal translation of a given composition, as Steven Holl did in the previously mentioned projects. Rather, Xenakis found an avenue to architecture through the way he composed and structured *Metastasis*. In his book *Formalized Music*, Xenakis explicitly states the influence his experience in composing *Metastasis* had on his design for the pavilion. He offers that "on this occasion music and architecture found an intimate connection."³⁵ And the process he is referring to is illustrated by drawings of the ruled lines of glissandi that occur in the piece, as depicted on his graphical experimentations with it in the Philips Pavilion.

35 Iannis Xenakis *Formalized Music: Thought and Mathematics in Music*, (New York: Pendragon Press, 1992): 10.

CHAPTER 3

OBSERVATIONS: MUSIC AND SPACE

The previous chapter was an overview of past conclusions and discussion that were specifically centered around the topic of architecture and its connection to music. To further this research, it will also be useful to collect information regarding the basic constructs of music, and the characteristics that relate it to physical space in order to provide a more complete background knowledge required to decompose the basic musical elements in order to transpose music and architecture. This chapter will document the research done on music theory and composition, music's relationship to physical space, and music composition in relation to spatial perception.

A BRIEF STUDY IN MUSIC THEORY

As a prelude to the discussion of spatial and musical concepts, this section will define subjects in musical theory that were discovered during the research portion of this project. These concepts will eventually be framed within the composition layers: Musical Variables, Thematic Module, and the overall Compositional Form. Each of these paradigms operate at different scales that are to be implemented into architecture. Musical Variables are the building blocks that are composed to form patterns. These groupings of patterns become Thematic Modules, and finally, Compositional Form is the organizational element that ties everything together into a larger story. The musical idea is also a concept of note; it is the theme or main idea of the composition, similar to the architectural concept, and as it is the background and driver for the three subsequent composition layers. This chapter will focus on the several smaller musical elements that were commonly encountered in this portion of the research, in order to lay a clear groundwork for further discussion of the larger musical concepts and forms further defined in the following pages.

Musical Variables

In discussing architecture and music, there are a number of musical terms that are recurrently referred to in regards to how music has been implemented in architecture. These terms are generally musical in nature, and have little original application in architecture. To contrast, there are also terms between music and architecture that are often, but not always interchangeable and generally used in both disciplines, such as “rhythm”, or “texture”. The following exploration deals with the terms, or concepts, that are specifically used in music and have been utilized as tools or frequently referenced in architectural projects. These concepts have been listed as they have been discovered through the literature review. Some of them have already been briefly mentioned in relation to documented projects.

At a basic level, musical sound can be outlined as having four components that shape and organize sounds into music. Both Christ et al in the book *Materials and Structure of Music*, and Gillespie in *The Musical Experience* cites four properties that define organization in musical sound^{36,37}: pitch, duration, intensity, and timbre.

Pitch is often described as “high” or “low”. This is determined by the frequency of vibration in sound waves. When the vibrations increase, the pitch becomes higher. Duration is the amount of time a particular frequency lasts for, and is often referred to in terms of rhythm. The third element is intensity. Intensity refers to the volume of sound. Gillespie explains intensity in relationship to pitch, saying that “intensity...depends on the extent or *amplitude* of vibration.”³⁸ Timbre is otherwise known as the tone quality. Tone quality is a varied sound dependent on the instrument, or object from which the sound comes. It indicates different members contributing to a sound. These four components are basic structural units that appear as patterns and varied throughout each composition. They are the basic building blocks of music and will be further discussed in the following chapter.

36 John Gillespie. *The Musical Experience*. California: Wadsworth Publishing Company, Inc., 1968

37 William Christ, Richard DeLone, Vernon Kliewer, Lewis Rowell and William Thompson. *Materials and Structure of Music, Volume 1*. New Jersey: Prentice Hall, Inc., 1972.

38 John Gillespie. *The Musical Experience*. California: Wadsworth Publishing Company, Inc., 1968

Harmonic Series

One of the oldest and most frequently cited musical concepts that architecture pulls from are the ratios found in the harmonic series. This often refers to the Renaissance ideas of a universal harmony that is present in both architecture and music. What was theorized as “Harmonic ratios” corresponds to the harmonic series in music. The harmonic series, or overtone series, relates to frequencies in sound over the musical scale. Ratios correspond to pitches along the scale.

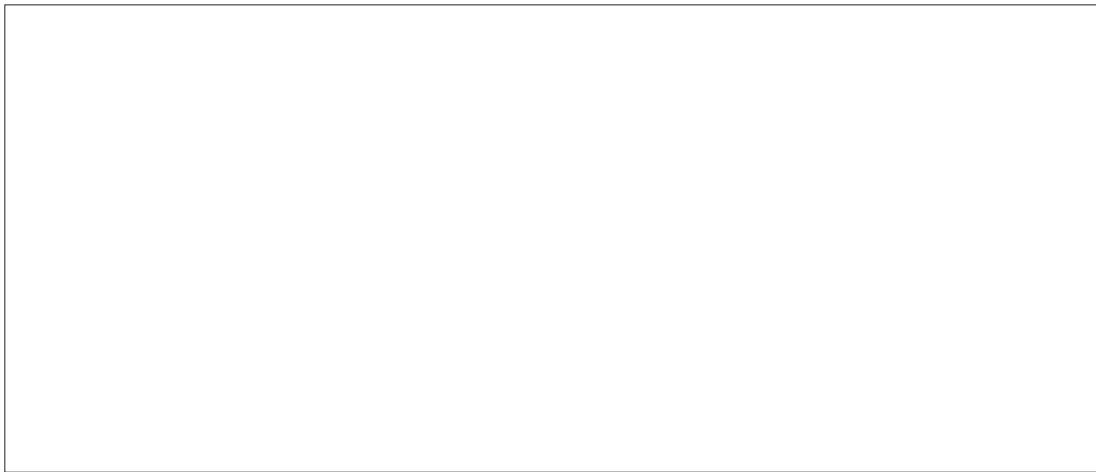


Figure 12: Harmonic Series

source: http://upload.wikimedia.org/wikipedia/commons/e/e8/Harmonic_series_intervals.png

Otto Von Simson made the assertion in his classic text *The Gothic Cathedral*, that he was in agreement with Augustine’s definition of music as a science.³⁹ He narrates the belief that there is a natural and universal occurrence of proportion and beauty. And this universal beauty is found in music.

It is of note that this thesis will not attempt to mathematically rationalize musical frequency and its proportions in architecture. However, this is a key concept because it sets a precedent for the idea that a musical composition will translate well into a built form in the physical environment.

39 Otto Von Simson, *The Gothic Cathedral*, (New York: Bollingen Foundation Inc, 1956)

Tonality

Tonality is the gravitational force that draws a composition back to a tonal center, where the composition begins in one key, and then eventually returns to the key. In the text *Materials and Structure of music vol. 1*, William Christ et. al defines tonality as a framework for pitch within a composition.⁴⁰

Tonality is important in this investigation because it is part of the structural backbone of musical space. It creates a basis for transformation and variation as well as the foundational piece for every pitch in the composition. This is true whether a composer adheres to it throughout the piece or not. In discussing musical space, Robert Morgan writes in an article entitled "Musical time/Musical Space" that people who listen to music have the impression of the different phrases and voices that occur in music because of tonal space.⁴¹ Tonal space defines a structure by grouping sounds together relative to one another. In this way, Morgan argues that a musical composition "defines its own space."⁴²

Within the realm of tonality is a musical form that sprung up in the contemporary music period. The 12-Tone Method is a compositional method that was first developed by Arnold Schoenberg. Schoenberg intended it to be a step in moving away from traditional tonality. Schoenberg developed this technique anticipating that it signified the next movement in music. In the 12-tone method, there are no tonal centers, and each of the notes within the chromatic scale are utilized and played with equal emphasis. A composer is to use a sequence of all twelve tones before returning to the original tone. Each subsequent "set" within the composition must follow the same order of intervals, but may vary between pitch, inversion, etc. The 12-tone method came up multiple times in the literature review, in any reference to Iannis Xenakis, who was a 12-tone composer.

40 William Christ, Richard DeLone, Vernon Kliewer, Lewis Rowell and William Thompson, *Materials and structure of Music, Volume 1*. New Jersey: Prentice-Hall, Inc., 1972

41 Robert Morgan, "Musical Time/Musical Space". *Critical Inquiry*, 6 no. 3 (1980): 529. Accessed March 11, 2015. <http://www.jstor.org/stable/1343107>.

42 Robert Morgan, "Musical Time/Musical Space", 529.

Polyphony and Counterpoint

Polyphony indicates the presence of multiple parts, or voices, present in a composition. The multiple voices are arranged amongst each other, in counterpoint. In contrast to having one melody and accompaniment, counterpoint presents a scenario where all parts are equal, and there is no single prominent melody. These independent parts are then arranged, overlapping and layering over each other. In his book *Musical Structure and Design*, Cedric Thorpe Davie quotes Tovey in defining counterpoint as 'the conveying of a mass of harmony by means of a combination of melodies'.⁴³ Multiple voices are present in the composition to form their own melodies, but are layered amongst one another to form a harmonic complementary whole.

A popular example of counterpoint is the children's song "Row Row Row your boat". The song is begun by one singer, and halfway through the song, another singer enters with the same beginning lines, overlapping the song with the same melody before the end of the song's first line. Among many classical pieces and composers, a more complex example is any of Bach's Fugues or Inventions. A master of counterpoint, Bach provides many succinct examples of this technique.

Figure 13 below depicts a few of the lines from Bach's BWV 780 Invention. The red and blue notes represent two voices, each with an independent, recurring theme, and they both exist and harmonize with one another to complete the piece.

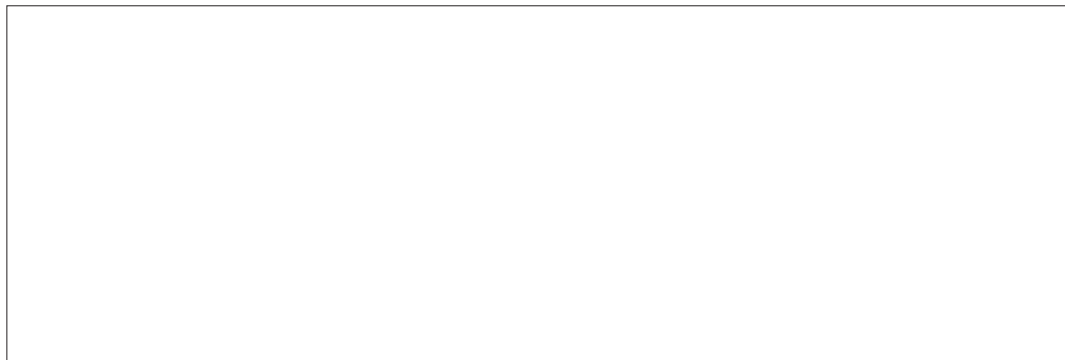


Figure 13: Bach BWV 780 Invention

source: <https://www.teoria.com/res/images/reference/inventio01.gif>

43 Cedric Thorpe Davie, *Musical Structure and Design*, (Dover Publications, 1966)

Historically, architects and musicians have drawn parallels between their respective professions in the use of interchangeable concepts. Counterpoint and polyphony are essentially musical terms that have been on occasion used to describe architectural elements. An example of this is in the Gothic cathedral, whose interior reflects the stacking of elements and rhythm.⁴⁴ In an article for *Architectural Review*, Charles Jencks writes that:

The parallels between architecture and music are extraordinary. Perotin and his musicians were working out the harmonies of three and four melodies stacked above each other...Architects were also stacking three or four levels (arcade, triforium, gallery, clerestory)...The architectural melodies did not run in as strong opposition as the music. They were smoothed along and ran parallel in horizontal chunks; but there are decorative elements that give the architecture a subtle counterpoint.

An example of an architect referring to counterpoint in an architectural design is perhaps the most clearly articulated and intentionally illustrated by Iannis Xenakis, a composer and architect-engineer who worked with Le Corbusier for a number of years.

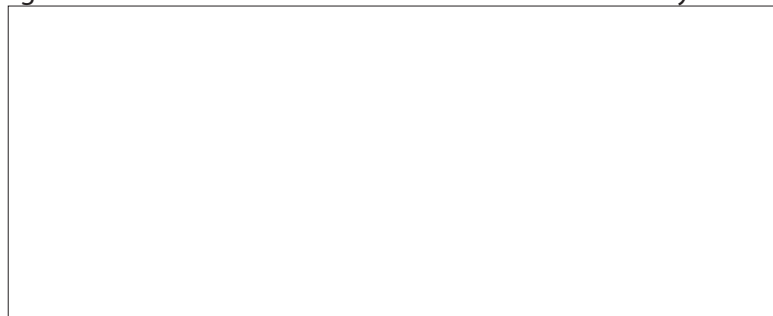


Figure 14: La tourette elevation

From 1953-1960, Iannis Xenakis' designed the "undulating glass panes" that composed the facade for the Monastery at La Tourette. These glass panes visually reflect the rhythmic density that occurs in music through a horizontal arrangement over the facade of the building.

44 Charles Jencks. "Architecture Becomes Music." *Architectural Review* 233, no. 1395 (2013)

In addition to rhythm and density, Xenakis designed these lines in counterpoint across the floor levels of the monastery.⁴⁵ As seen on the West elevation, each floor level contains the rhythmic line that layers above or below the next to form one coherent facade. Of course, this is an example of 2-dimensional application, but can also be utilized in a 3-dimensional space.

Musical Form

Musical form is an important concept that is the overall unifying element of a piece of music. It dictates the overall arrangement of the composition, and how we hear this arrangement. At a basic level, musical form determines the sequence of the musical composition. We can set up a comparison that occurs in the use of form, in that architectural experiences are also experienced in a sequence; whether it is in a long and one directional circulation such as a museum, or whether it is a small and arbitrary plan, such as a small house. We always experience adjacent spaces in tangent to one another. The following discussion is based on a couple of musical forms, whose structure and concepts can be emulated in architecture.

There are many other musical forms yet to be documented in this project, ranging in time periods and styles. The particular musical forms in this following discussion have been chosen for the straightforward clarity found in their highly structured and intentional nature. They also stand as classic examples of musical form, and a good starting point for subsequent explorations in the realm of the music-architecture connection. There were specific musical forms focused on in this project. The initial formal studies were in theme and variation, followed by the Chaconne and Passacaglia and ending with the Fugue. The Theme and Variation is a basic form utilized frequently by western classical musicians. It features a thematic element in the melody and a number of variation movements following. The second form is the Chaconne and Passacaglia, a precursor to the Theme and Variation.

45 Iannis Xenakis, *Music and Architecture: Architectural Projects, Texts and Realizations*. (New York: Pendragon Press, 2001) 65

It was originally a dance form that has been used by many composers to structure their pieces, and is basically composed around a central “theme”, which is a bass line that is constantly repeated throughout the piece. The third form for future research is the Fugue, a highly structured, baroque form. Individual classical and modern works that are indicative of these forms will be analyzed as to their structure and contributing musical techniques and devices in order to propose a type of implementation into architecture.

Theme and Variation

Theme and variation is a musical form that begins with a simple theme, and accompaniment. It is a series of shorter songs that have the same melody, or theme. Each time it repeats, the theme or accompaniment is transformed. The theme is often in the form of a simple melody that is introduced and then recurs through the entire series of variations. After the initial introduction of the theme, the subsequent composition is based entirely off repetitions and interpretations of the theme, with variations to harmony, rhythm, and tempo, among others. For example, composers might begin with a 1:1 rhythm, and modify or change the rhythm while building up the theme throughout the piece. Often, a theme and variation will have at least one variation where one theme is in a minor key if it was originally played in a major key, and vice versa. Composers will also place a coda near the completion of the piece to signify the end.

In terms of the basic types of variations, Paul Fontaine lists a number of ways variations may occur.⁴⁶ Not all are listed here, but the following variations that overlap with several other sources on music theory are taken from his list:

1. Embellishing the melodic line, or Ornamentation
2. Changing the harmony
2. Change theme’s register
3. Texture, counterpoint
4. Switching from the Major to Minor key, or vice versa
5. Augmentation / Rhythm / tempo change

46 Fontaine, Paul. *Basic Formal Structures in Music*. New York: Meredith Publishing Company, 1967.

Mozart's "Ah Vous Dirai-je Maman" contains a familiar theme that most people would recognize as "Twinkle Twinkle Little Star". The following page will elaborate on this composition as a preface to further discussion in the following chapter. This theme begins from the first measure, with a simple accompaniment playing a harmony at the same tempo. Both the melody and accompaniment are written at a simple 1:1 tempo. The theme is then repeated throughout the piece with various accompaniment, tempo, and other changes.

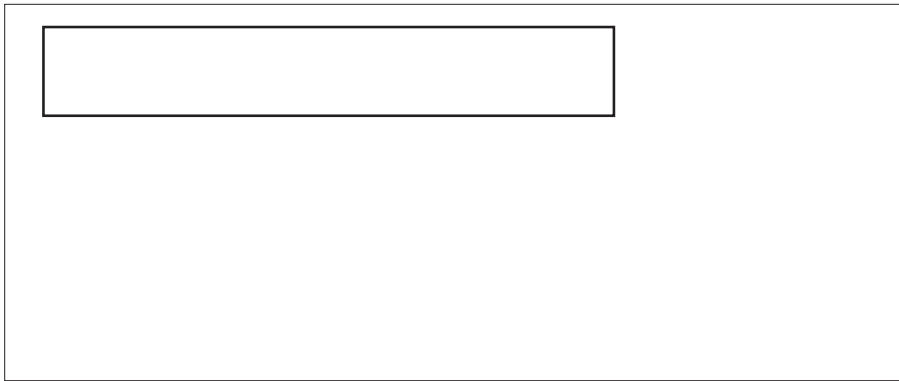


Figure 15: Theme of Mozart's Ah, Vous Dirai-Je Maman
Public Domain. Theme, mm 1-24

The first variation builds upon the theme with the sixteenth notes mixed among the theme's voice, and the accompaniment more or less maintaining the same form as the original theme, at the same tempo. The second variation is similar, with the exception that the quicker sixteenth note runs are in the left hand accompaniment section of the score. This is an example of a variation that has changes in the tempo of the accompaniment.

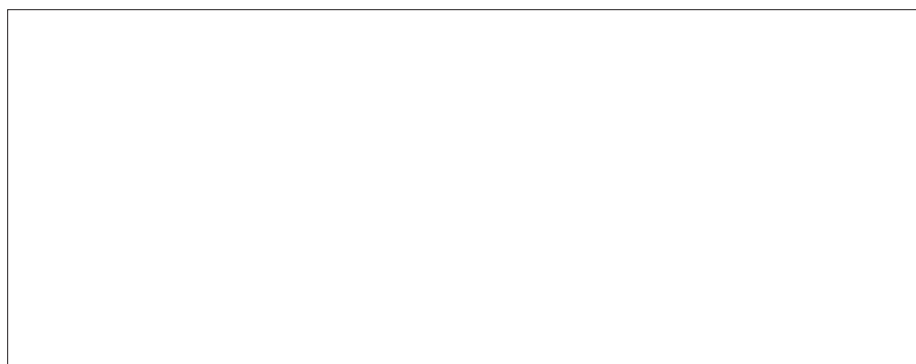


Figure 16: The First Variation of Mozart's Ah, Vous Dirai-Je Maman
Public Domain. Var. 1 mm 1-11.

Another variation from Mozart's theme is found in the eighth variation in the piece. As mentioned earlier, a technique often used in theme and variation is one variation showcasing a change from a major key to a minor one, or is changed to a major key if the composition is overall minor. In this case, the original theme was in C major, with the variation showcasing a switch to C minor.

Because the piece can have indefinite amounts of iterations, composers will often insert a coda near the end of the piece, followed by an ending sequence. In this case, the coda terminates the final variation and ends in an ascending sequence to the final C major chord.

Chaconne and Passacaglia

To briefly mention a few other composition forms, one might begin with the Chaconne, or Passacaglia. A Chaconne, also called Passacaglia or Ground, is structured by the bass line that repeats throughout the piece with most of the variations in the higher voices. Having origins in dance, the terms Chaconne and Passacaglia have subtle differences, but are often used interchangeably⁴⁷. Similar to a theme and variation, which features a melodic theme that is continuously transformed, the Chaconne or Passacaglia instead use a recurrent bass line that is continuously repeated with variation and transformation of other aspects of the composition. While there are many close similarities to the preceding Theme and Variation, the Chaconne and Passacaglia is differentiated by the complete consistency of its respective "theme", which does not change or transform at all throughout the piece.

47 Percy Goetschius, *The Larger Forms of Music Composition: An Exhaustive Explanation of the Variations, Rondos and Sonata Designs, for the General Student of Music Analysis, and for the Special Student of Structural Composition*, New York: G. Schirmer, Inc., 1915

Fugue

Fugues are useful in this study because they are a good illustration of the use of counterpoint in music composition. It is a highly structured, baroque form that is often inserted in other musical forms. Fugues begin with a subject, or a melodic line that becomes a repeated thematic element throughout the piece. One voice will begin, and another voice with the same subject will enter before the first voice concludes. The 'theme' in a fugue is often called the Subject, and the subject will have a subsequent reoccurrence at a different interval. The most distinctive component of a fugue is that the subject is imitated numerous times throughout the composition.⁴⁸ The form then seems to grow cumulatively from the initial subject. Figure 17 depicts Fugue no. 21 in B flat major from Bach's Well-Tempered Clavier book 1. The subject is introduced by itself in the first measure, and then reoccurs in the fifth measure.

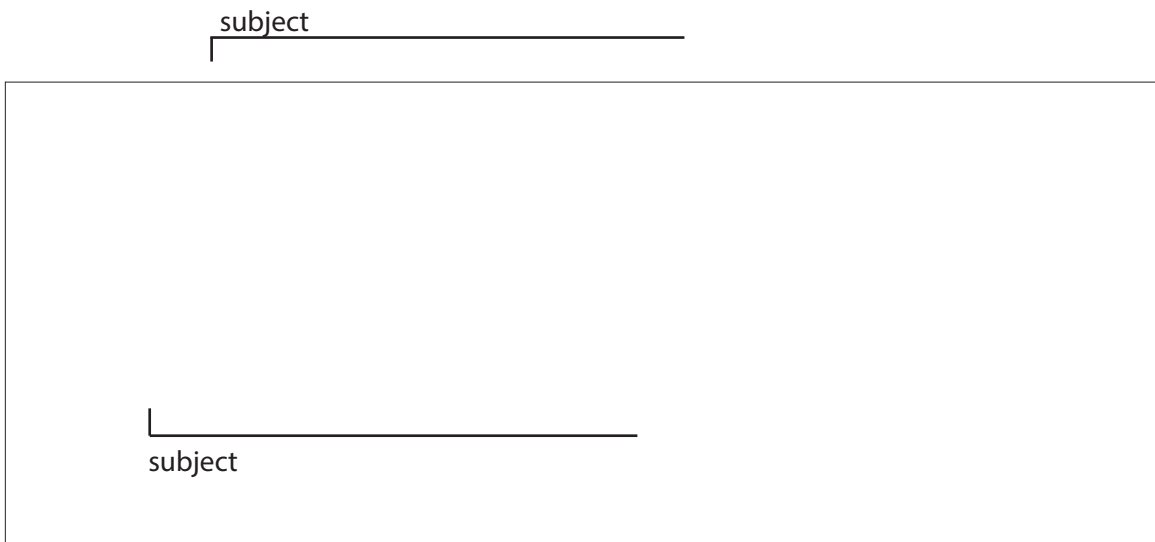


Figure 17: Introduction to Bach's Fugue No. 21
the well tempered clavier book 1. mm 1-8. Public Domain.

48 William Christ, Richard DeLone, Vernon Kliewer, Lewis Rowell and William Thompson. *Materials and Structure of Music, Volume 2*. (New Jersey: Prentice Hall, Inc., 1972) 237

COMPOSITION STRATEGIES

Through the years, composers have used music as a way of imparting an idea or evoking a feeling. The basic variables of music were listed as the building blocks of music, and they can vary and be arranged in interesting ways. These variables can be combined and transformed in order to form several musical composition strategies that support music's influence as an experiential art. Simply, the musical manipulations and the form and composition itself is what conveys the overall idea of the piece. It is this phenomenon, which Walter Pater pursues in the book *The Renaissance*, that makes music one of the few art forms where form and meaning truly coincide⁴⁹

Once applying these variables, we can see how music both adds to, and is also inspired by spatial values. This is evident through music by itself, but it is also important and illustrated in the way music is written for film. In cinema, music makes the scenes viewers watch more three-dimensional, and add a greater experiential effect. Composers pull from real-life sounds, images and ideas and compose them into musical impressions. The following composition strategies were written about by various composers who specialize in film music. They are strategies that add spatial value to the music that is composed for cinema. In regards to its relationship to architecture, the result of the following strategies have similar experiential values. These strategies were birthed from experiences in physical space, and could logically be transposed back into physical space.

49 Pater, *The Renaissance*, 114.

Tension and Release

This strategy came up several times during the literature review. The purpose is often to create a more impactful moment or arrival. Composer Joel Doueck wrote in the article "Music and Emotion--A Composer's Perspective" an example of tension and release could involve building increasing discord, immediately before resolving to a gentle harmony. He describes it as "an accelerating rhythm giving way to a sustained statement of arrival."⁵⁰

This is the first strategy because it is already referenced in architecture. Frank Lloyd Wright is a seminal example of using the term "compression and release" in the houses he designed, particularly to emphasize the dominant spaces in his designs.⁵¹ He did this for example, by creating narrow hallways or low ceilings that led into a larger and more open living room.

Building Tension

Above, Joel Doueck cited an accelerating rhythm as a way of building tension in music.⁵² In addition to accelerating rhythm, there are several other ways of building tension. In the same article, he writes that the use of tremolo in sustained string lines reflects tension. "Perhaps because human perceptions are geared toward recognizing change—and tremolo is continuously instability, continuous change. So it gives us a sense of instability and suspense."⁵³ Author Zohar Eitan notes that regarding musical tension, the use of crescendo is a key element in creating tension in music. "Regardless of the values of other musical parameters manipulated (pitch direction, pitch register, and tempo change), listeners perceived musical segments increasing in loudness as increasing tension."⁵⁴ Additional ways composers create tension is through: pedal point, ostinato, and gradual tempo and pitch change.

50 Joel Doueck, "Music and Emotion – A Composer's Perspective" *Frontiers in Systems Neuroscience* 7 (2013): 1, July 14, 2016, doi: 10.3389/fnsys.2013.00082 Elgar, Edward. "Variations on an Original Theme 'Enigma', Op. 36." From Public Domain. Mineola: Dover Publications, 1992.

51 Grant Hildebrand, *The Wright Space Pattern and Meaning in Frank Lloyd Wright's Houses* (Seattle: University of Washington Press, 1991)

52 Doueck, "Music and Emotion – A Composer's Perspective", 1992.

53 Doueck, "Music and Emotion – A Composer's Perspective", 1992.

54 Zohar Eitan, "How Pitch and Loudness Shape Musical Space and Motion" in *The Psychology of Music in Multimedia*. United Kingdom: Oxford University Press, 2013.

Highlighting

Doueck also writes how rhythm and loudness communicates urgency and importance. He uses the example of the movie *Jaws*' soundtrack, which works like the Doppler effect—shark grows nearer, faster and louder.⁵⁵ This creates a type of tension and urgency. Additional highlighting in musics might occur as quick moments of accents, or clusters. Also an effective accent, particularly in music for film, is the use of silence.

Silence could be perceived as the lack of form or movement, and is also effective in architecture. Daniel Libeskind designed the Jewish Museum, intentionally inserting “moments of silence” into the circulation.⁵⁶ The Salk Institute also, while not intentionally designed musically, gives the impression of architectural silence at its famous point of entrance.

Creating a Feeling of Movement

Rhythm always plays an important role in the perception of movement in music, whether it is a slow and calm rhythm, to a faster and accelerating one. Everyday occurrences, such as the rhythmical sound our footsteps make on the ground as we rush to a meeting, or as we calmly stroll down the street, allude and inspire the rhythmic strategies of composition. The rhythmical sounds created by our own movements denotes a particular tempo of movement.

Joel Doueck also noted that shifting the musical key up in intervals of a third implies forward motion. “The musical underpinning is that this modulation ‘destroys the root’. For some reason the brain jumps to this new place and no longer searches for the resolution back to the original key.”⁵⁷ He also writes that using an unexpected musical shift, lack of resolution to surprise and enliven. “It could be a breach in musical form or timing, or both together.”⁵⁸

55 Joel Doueck, “Music and Emotion – A Composer’s Perspective” *Frontiers in Systems Neuroscience* 7 (2013): 1, July 14, 2016, doi: 10.3389/fnsys.2013.00082 Elgar, Edward. “Variations on an Original Theme ‘Enigma’, Op. 36.” From Public Domain. Mineola: Dover Publications, 1992.

56 “The Jewish Museum, Berlin” *The Guardian*, October 11, 2007. <http://www.theguardian.com/artanddesign/2007/oct/11/architecture.museums>

57 Doueck, “Music and Emotion – A Composer’s Perspective”, 1992.

58 Doueck, “Music and Emotion – A Composer’s Perspective”, 1992.

Orchestration

It is of note to mention the use of instrumentation and orchestration in composition. Joel Doueck writes about timbre in an orchestra or individual instrument. "The melancholia of the cello, the innocent sadness of the oboe, the mystery of the flute, the boldness of the trumpet, or the transparent beauty of the harp" that each instrument implies its own emotion.⁵⁹ Authors Rayburn Wright and Fred Karlin write in *On the Track* an observation that emotional responses in film composition come through unaccompanied melodies, and are also effective when the single melody emerges from an orchestral passage.⁶⁰ This change in instrumentation or orchestration could be an important component in conveying an emotion or experience.

In terms of its relation to architecture, specific instrumentation in music has a more vast and aural effect that is difficult to generally apply to form without being specific. It is therefore not directly covered in the four variables, but may in future study, such as lighting, color, materiality, among others. Immediately, in regards to the arrangement of musical sounds the use of orchestral arrangement could reflect a more dense space.

59 Doueck, "Music and Emotion – A Composer's Perspective", 1992. 59

60 Fred Karlin and Rayburn Wright. *On the Track: a Guide to Contemporary Film Scoring*. New York: Routledge, 2004.

MUSIC AND PHYSICAL SPACE PERCEPTIONS AND COMMONALITIES

There are several conclusions on the connections between "musical space" and physical space. There has been a discernible link between musical space and physical space by the terminology and description used when referring to both musical and architectural elements. Robert Morgan notes this phenomenon in an article entitled "Musical Time/Musical Space", saying that "Indeed, it would seem impossible to talk about music at all without invoking spatial notions of one kind or another."⁶¹ Musical space has a strong relationship to tonality, because music creates its own space and its components are structured relative to one another. Further, Morgan continues on his idea of musical space as "a space of relationships." Although their space and materiality is not tangible, Musicians create structure through composition, and musical form. Morgan writes that "a musical composition not only defines its own space, but does so by moving through this space in its own unique manner."⁶²

The concept lends itself to comparisons between this so-termed "musical space" and physical space, and through that, a possible correlation found between physical and musical space. This begins with the very basic constructs of musical sound. As a first example of this, pitch is described as "high" or "low". This is generally relative to the key signature given the piece, and notated higher on the musical staff. Also, a sound or combination of sounds have parallels to physical objects as they "fill up" a space, otherwise referred to as density. Duration and rhythm suggests movement, as a piece with a faster beat suggests faster movement, and likewise, a slower beat suggests slower movement.

This is illustrated in a section of the *Enigma Variations*. In the book *Music and Mathematics*, Wilfrid Hodges writes of music's existence in space through dimensions and geometry. In the chapter titled "The Geometry of Music", Hodges emphasizes that Edward Elgar wrote part of the *Enigma Variations* based on a walk he went on with his good friend G.R. Sinclair, the namesake of the eleventh variation entitled "G.R.S."

61 Robert Morgan, "Musical Time/Musical Space". *Critical Inquiry*, 6 no. 3 (1980): 527-538. Accessed March 11, 2015. <http://www.jstor.org/stable/1343107>.

62 Robert Morgan, "Musical Time/Musical Space".

The point in the score shown in figure 18 is when Sinclair's dog fell down into a river. Hodges quotes Sinclair, who told Elgar, "Set that to music".⁶³ The descending runs depicting the tumbling dog can be read just by the score alone through the "descending" sixteenth notes. This story illustrates the intuitive connection that exists between musical movement and physical space.

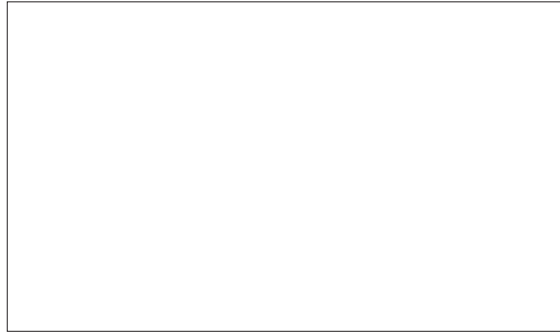


Figure 18: Descending musical movement
Elgar, Edward. "Variations on an Original Theme 'Enigma', Op. 36." From Public Domain. Mineola: Dover Publications, 1992.

There are examples discovered through the previous case studies. The first was the *Stretto House*. Steven Holl represents the overlapping gesture characteristic of a fugue in his *Stretto House* by overlapping spaces and materials. Iannis Xenakis, at the forefront of connecting music and architecture, translated specific musical moments into his design in several of his projects. Rhythm in musical movements became synonymous with the rhythm and density of the facade of La Tourette. *Glissando* became the image of the Philips Pavilion's sweeping gestures. This concept of translating musical gestures into physical space is seen clearly in his interpretation of *glissando* through his sketches and graphical analysis. In explaining the musical term *glissando*, Merriam-Webster's Dictionary defines it as "a rapid sliding up or down the musical scale"⁶⁴ This evokes imagery of movement up or down.

Xenakis is recorded as using graphical means when composing the portion of his piece for

⁶³ Hodges, Wilfrid. "The Geometry of Music," in *Music and Mathematics: From Pythagoras to Fractals*. ed. John Fauvel, Raymond Flood and Robin Wilson, 91-112. (New York: Oxford University Press, Inc., 2003), 91.

⁶⁴ Merriam-Webster's Collegiate Dictionary. 11th ed. Springfield, MA: Merriam-Webster, 2003. Also available at <http://www.merriam-webster.com/>

Metastasis⁶⁵. and his graphical analysis of the music shows much of the same movement described in the physical space, where time is shown as the x-axis, and pitch is the y-axis. Not exclusively depicted as such in this case, pitch is often described in terms of “high” and “low”, inferring their position in space. This may be attributed to the notation system, which places pitch on paper, but nevertheless is indicative of an inherent existence in a type of soundspace. Intentionally or not, these comparisons give a physical impression of the gestures that musical sounds make in their immaterial space.

The case studies reveal the designer’s translation of a musical technique is aligned with common perceptions of musical movement in space. Perceiving and attributing spatial characteristics of musical movement is a common occurrence, and is often grounded according to our physical experiences. According to several studies an increasing sound or tone in music, or increasing volume, is reminiscent of an object coming closer and larger.⁶⁶

Eitan notes that the results of this study mirrors the natural occurrence of a person or object getting louder in physical space as they approach the listener. This is explained by the Doppler Effect, which illustrates why objects become louder as they get closer and the sound recedes as the object gets farther away from us. Eitan also notes that the use of crescendo is a key element in creating a feeling of tension.⁶⁷

The basic musical element that is not directly related to physical space is pitch. High frequency tones are often called “high pitched”, and the same for lower frequency tones. Wilfrid Hodges postulates in the book *Music and Mathematics* that this assumption has grown from the birth of notation and the placement of frequencies along the vertical axis of the musical staff.⁶⁸ However, most people tend to associate “higher pitch” with “higher height” for all groups of people tested in Eitan's studies, even 6 month old infants were shown to associate higher frequency tones with higher physical height. Studies have also shown that

65 Xenakis, Iannis. *Music and Architecture: Architectural Projects, Texts, and Realizations*. New York: Pendragon Press, 2001

66 Zohar Eitan, “How Pitch and Loudness Shape Musical Space and Motion” in *The Psychology of Music in Multimedia*. United Kingdom: Oxford University Press, 2013.

67 Eitan, “How Pitch and Loudness Shape Musical Space and Motion”, 2013.

68 Hodges, Wilfrid. “The Geometry of Music,” in *Music and Mathematics: From Pythagoras to Fractals*. ed. John Fauvel, Raymond Flood and Robin Wilson, 91-112. (New York: Oxford University Press, Inc., 2003), 91.

when the pitch is constantly ascending, it is associated with an increase in size⁶⁹

The connections of music to placement in physical space leads back to the conclusion that architecture and music are related in the sense that they both inhabit a type of space. And because they are both created from elements that are otherwise random and useless, they are both constructs that inhabit and work within the confines of their respective spaces. This can be the starting point and foundational idea for translation of musical concepts into architecture. It sets up a precedent of making connections between musical concepts and architectural elements through the idea of “space” and how they occupy their respective spaces. The clearest, and foundational way that this occurs, particularly in intangible space, is through form. Thus, the translation of form between disciplines can be used as a means to discover and create parallels between architecture and music.

Music can be translated into architecture on several different levels--two of which will be focused on at their most basic moments: “building blocks” and the form which ties them together. These two “levels” are separate, but should be unified and designed in conjunction with each other. Both Berry⁷⁰ and Thorpe Davie⁷¹ when writing about music theory, emphasized the smaller components of music that grow to become a whole. They both drew parallels between the composition of music and the structure of a novel, or a play. Berry writes in the introductory chapters in *Form in Music* that:

The small units which are the building stones of music are, ideally, bound together into a logical succession by (1) the common rhythmic, harmonic, and melodic features which they share; (2) the techniques by which they are joined; and (3) their use in the development of accumulative points of climax (and repose) in the musical work.⁷²

69 Eitan, "How Pitch and Loudness Shape Musical Space and Motion", 2013.

70 Berry, Wallace. *Form in Music: An Examination of Traditional Techniques of Musical Form and their Applications in Historical and Contemporary Styles*. New Jersey: Prentice-Hall, Inc., 1986.

71 Thorpe Davie, Cedric. *Musical Structure and Design*. London: Dennis Dobson, 1953.

72 Berry, Wallace. *Form in Music: An Examination of Traditional Techniques of Musical Form and their Applications in Historical and Contemporary Styles*.

As previously noted, there has been a discernible link between music and architecture by the terms used to describe them. The correlations are strong enough that an intangible concept can be used and implemented in a tangible space. While one can't visualize rhythm when listening to music, the concept can be construed in physical space, and can be visualized through formal structure or on a facade. In music, each of these elements are joined together to form a composition. Musical form can serve as the concept of said joining element that ties the architectural elements together to create unified whole, and serve as part of the composition framework and structure.

This project will draw from the building blocks mentioned, by drawing parallels between architecture and musical devices. The second is the joining of these devices through the larger, encompassing area of form. The following discussion is a tentative exploration in these two aspects. It is a study in making connections between musical elements and architectural ones, beginning with the smaller elements that form a unified whole. The smaller elements are the specific variables that will correspond to architectural elements that are unified under a formal structure that resonates with a specific musical form. The chosen musical form is the element that ties together and organizes the elements.

Thus far, we have based this project upon the statement that Music and Architecture both denote a type of space, or form, that we experience. There have been two established assumptions that connect music and architecture:

1. Both are created from elements that are organized through form
2. Both have the ability to create spatial expectations or interest through transformation of form

These assumptions are the basis for a methodology to outline the connecting points and patterns between architecture and music.

CHAPTER 4

METHODOLOGY: CONNECTING VARIABLES

MUSICAL FRAMEWORK

The proposed transposition between music and architecture is a methodology that will be developed in the course of the next two chapters. This chapter will discuss the most basic connecting elements between architecture and music, the 'rules' that exist between them and the most basic way they are mapped to each other. This discussion will be the basis for all future design and arrangement. The connecting elements are outlined by the basic Composition Variables that were derived from the previous chapters. The next chapter will discuss the strategies in beginning to actually generate form based on musical theory. It will document the compositional operations on the variables.

There are many material differences between architecture and music, both are intentionally formed, and have a structure. They are both created from natural elements that are arranged and composed by man. Whether it is apparent or not, they are also both shaped through rules that lend each a sense of structure and organization. While musical ideas generally appear to be artistic impressions of a particular phenomena, there is always a type of structural logic behind the expression.

Whereas music is often perceived as an expressive art built to the discretion of the composer, there still exists sets of rules and structures that are indicative of an inherent order existing in each piece. Through an analysis of musical construction, there are three sequential principles through which musical phenomena can be filtered and explained. These key elements and corresponding variables denote a strong correlation that can occur between both musical and architectural composition. When seeing music as noises that are intentionally put together and organized, there are several layers that are perceptible. At an overall scale, Musical form is an integral element of the composition process in the overall sequence of a composition. When deconstructing the components within each form, there are

many smaller modules within the overall form. For example, the theme and variation denotes a form of multiple separate themes. In other words, the form is made of many separate modules. These Thematic Modules are all composed of separate elements, which we will call Composition Variables. All elements are joined and dependent upon one another to convey a particular meaning or idea. To summarize, Composition Variables are the musical building blocks that are linked together into patterns, or Thematic Modules, that are repeated and varied and joined by a particular Overall Form. Together, these convey the idea, or whole of the piece.

It is of note that the architectural spaces that are created and defined by these variables are simply spatial placeholders. They are meant to reflect the enclosure, organization, and general experience of musical moments. They denote the enclosure indicators such as size, the height, amount of surrounding elements among other boundaries of spatial experience. It is similar to massing in an architectural design; the actual materials and color is dependent on other factors such as site, client, and the designer's creativity. These issues may be further elucidated upon in a future study, but is not discussed in this thesis.

MUSICAL VARIABLES

These building blocks can be used as preliminary variables for the composition of musical architectural form. As discussed previously, these variables were derived from the study on musical theory. They are the most basic elements of music that exist in every composition. Also based on the research, we will postulate that these elements may also be spatial definers in relation to architecture. A space can be manipulated according to these elements. These variables were common and found in the various texts studied throughout this project. They have been succinctly described in Gillespie's book *The Musical Experience*, where he outlines what he calls the basic "dimensions" of music⁷³. Christ et al also outlines the same four elements, describing them as the tenants of musical sound that impact structure

73 John Gillespie. *The Musical Experience*. (California: Wadsworth Publishing Company, Inc., 1968) .

of music⁷⁴. These four elements can be transposed into architecture as spatial definers, and act as the building blocks of transformable elements within a larger form. We therefore make the following assumptions in the process of transposing these most basic musical elements to spatial ones, and vice versa.

1. Pitch is the frequency of sound as notated on the score. For this project it will denote any movement or marking along the vertical axis of the score. Pitch will be related to physical height.

2. Rhythm, also meter and tempo. It is movement along the horizontal axis of the score that involves time. Spatially, it directs the spacing or density of an element.

3. Dynamics encompasses sense of loudness or touch. This is related to scale or size of a space. Dynamic markings also notate hierarchy.

4. Texture is the way additional components insert themselves to support a theme or melody. Could be any manner of accompaniment, including contrapuntal. Spatially, this could be any surrounding element or secondary space that reinforces the predominant space.

These can be illustrated visually by musical notation. Musical notation is essentially a 2-dimensional record of musical sound, and music's expression in musical space is thus visualized 2-dimensionally through the score. With this in mind, all four basic musical variables can be illustrated through the musical score. As a reference image, Figure 32 depicts a blank musical staff. The main 'axes' dictate how and which notes are played, and there are two main 'axes' on the staff. Horizontally, duration of notes is indicated through the beat played through each measure by the constraints of the time signature. Vertically, the pitch is indicated by their position on the staff, within the indicated key signature.

74 Christ, William, Richard DeLone, Vernon Kliewer, Lewis Rowell and William Thompson. *Materials and Structure of Music, Volume 1*. New Jersey: Prentice Hall, Inc., 1972.

Pitch and physical height

As noted earlier, sound waves with shorter wavelengths are “high pitched” tones, which are placed higher on the staff. The sound waves with longer wavelengths are “low pitched” tones, and are lower on the staff. Listeners often perceive a high pitched sound as being high in physical space, and low pitched sounds as being low in physical space. Composers often reflect this intuitive assumption when representing spatial activity with pitch. For example, Wilfrid Hodges in *Music and Mathematics*, writes of one of Edward Elgar’s pieces in which the musical descent from high-pitched sounds to low-pitched ones was inspired by a friend’s dog who fell down a ravine.⁷⁵

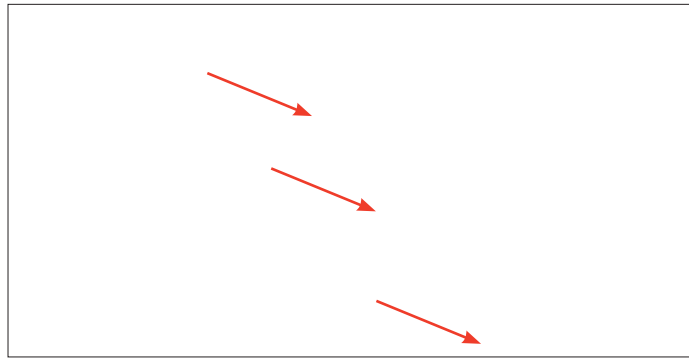


Figure 19: Elgar's descending pitch
Elgar, Edward. “Variations on an Original Theme ‘Enigma’, Op. 36.” From Public Domain. Mineola: Dover Publications, 1992.

The descending line is apparent from the score, and almost looks like a descent down a physical hill. The common perception of high pitch as being high in physical space, and low pitch as being low in space is sometimes attributed to the notation system developed in western music, which places the shorter frequencies on any instrument on a higher position on the clef⁷⁶, thus bringing about the notion that the shorter frequency sound is a “higher” pitch. Based on the “high” and “low” pitch in musical space, physical height can correspond to pitch. However, this has been debated in experiments on participants who universally

75 Hodges, Wilfrid. “The Geometry of Music,” in *Music and Mathematics: From Pythagoras to Fractals*. ed. John Fauvel, Raymond Flood and Robin Wilson, 91-112. (New York: Oxford University Press, Inc., 2003), 91.

76 Hodges, Wilfrid. “The Geometry of Music,” in *Music and Mathematics: From Pythagoras to Fractals*. 93.

associated higher pitch with heigher spatial height, including six month old toddlers.⁷⁷

In terms of transformation, a higher pitch can be applied to individual notes, but it can also be applied to general sections or phrases. Figure 22 is a reprise of the score from the earlier-discussed Bach's Chaconne from his Partitia in D Minor for Violin.

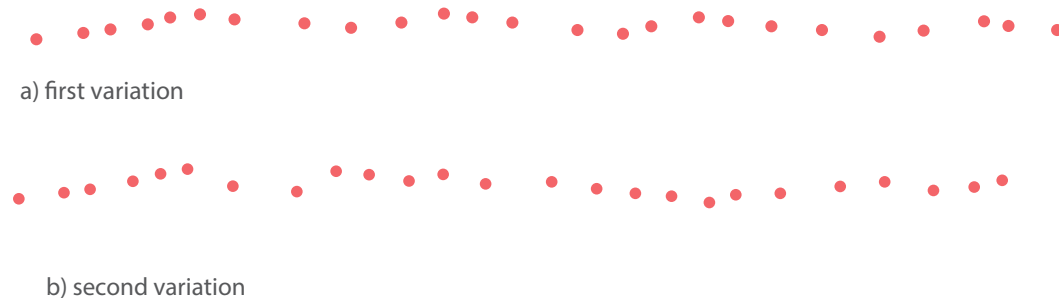


Figure 20: Exerpts from Bach's Chaconne
Source: J.S. Bach, Partitia in D Minor for Violin, Public Domain

The score in figure 20 shows the same melody being repeated in the second variation of the Chaconne. The major change in the latter variation was that the same melody was played an octave higher than the first. Spatially, this would indicate a space that is an octave, or floor level, higher than the previous one.

It seems intuitive to assume that "higher pitch" relates to higher spatial height, and the corresponding height for lower pitch. Zohar Eitan writes the chapter "How Pitch and Loudness Shape Musical Space and Motion" in the book *The Psychology of Music and Media*. He records groups of experiments in which people tend to associate "higher pitch" with "higher height" for all groups of people tested, even 6 month old infants.⁷⁸ A transformation of pitch height should therefore correspond to spatial height, when assuming that these proposed variables reflect our perception of a space. For this project, any transformation involving pitch, register, or other concepts that deals with specific sound waves will be grouped with this variable.

77 Zohar Eitan, "How Pitch and Loudness Shape Musical Space and Motion" in *The Psychology of Music in Multimedia*. United Kingdom: Oxford University Press, 2013.

78 Zohar Eitan, "How Pitch and Loudness Shape Musical Space and Motion" in *The Psychology of Music in Multimedia*. United Kingdom: Oxford University Press, 2013.

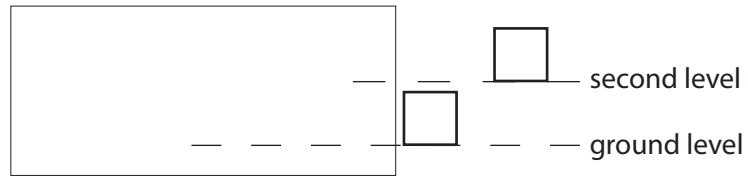


Figure 21: Relative octaves to building stories

Similar to the idea of tonality, any type of musical transformation (to be discussed later) is relative to the original octave, or level, that the theme was conceived in. Thus, if a composition begins in one key as shown in figure 21 above, the ground level of the physical spatial mass will be connected to the octave that the original key began. When the melody or voice reaches one octave higher than the original, the space moves to the second level. This type of relative attachment is the same for all variables--the original theme is the base point for further comparison and transformation.

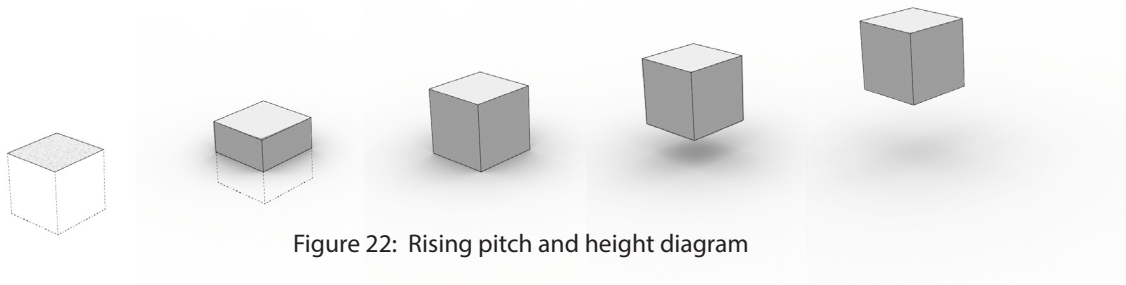


Figure 22: Rising pitch and height diagram

This translation of rising pitch is not limited to individual elements as shown in the diagram above, but if the changing pitch is within a thematic module, as in Elgar's composition, the rising pitch may also be represented through a gradual change.

3/4 Rhythm to spacing and density

Rhythm denotes the arrangement or pattern of a particular piece or section of music. In order to consolidate musical elements for this project, the “rhythm” variable could also be indicative of anything related to timing-- including meter and tempo. Musical rhythm is structured in an easily understandable way. Each note has a value which is indicated on the score. And each note value can be divided or notated according to any rhythm. When placed next to each other on the score, rhythm is even easily seen visually as well as heard. Below are the basic note values and rhythms seen in musical notation.

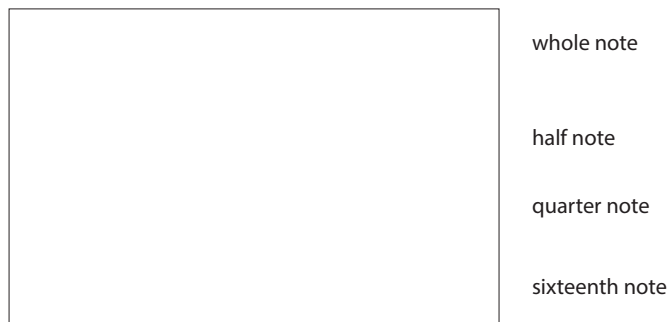


Figure 23: Basic Rhythmic Values

The y-axis on a staff notates the duration of each note along a particular time signature, and can denote variations to the beat. The smaller the duration of note, the more notes there are in a measure. The durations of notes are often combined in a repetitive manner in multiple ways to create different types of beats in music.

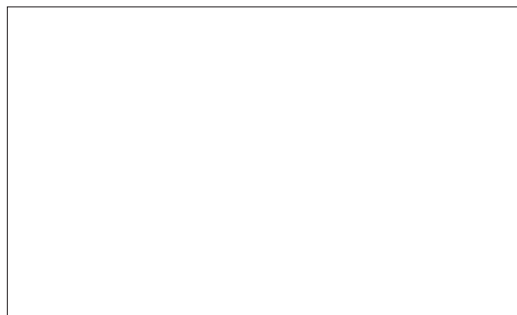


Figure 24: Various Rhythmical Beats

This musical concept and use of rhythm translates into architecture through the idea of transformation via duration. As the duration becomes longer, there are fewer items in the space, and as the duration becomes shorter, there can be more items in the same space. Rhythm is common musical analogy used in architecture, particularly for the spacing of any given element. Practically, we see this in structural bays and other structural elements. Xenakis' use of the brise soleil on the façade of La Tourette demonstrates his sensibility for the use of fluctuating rhythm in architecture and how each level's fluctuations could be arranged in visual counterpoint amongst each other.

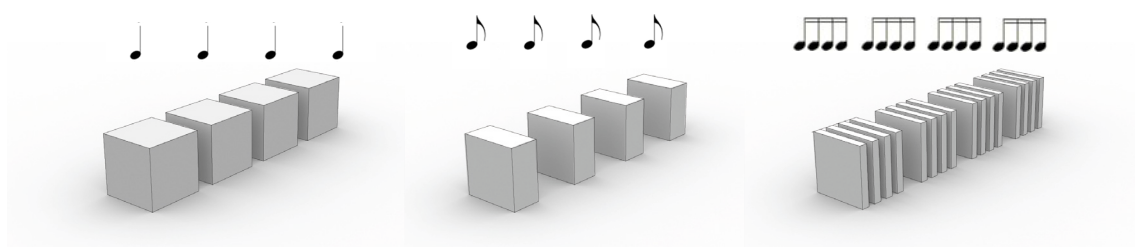


Figure 25: Rhythmic values to spacing and density

Rhythm may change and transform throughout a song. As mentioned in the discussion on pitch, the initial rhythmic mass sets the bassline for subsequent changes. Any following transformation is relative to the originally stated one. For example, below is Mozart's 'Twinkle' variations which were previously discussed. The melodic line in the theme is in quarter notes, while the melodic line in Var 1 is in sixteenth notes. Thus, whatever rhythmic value or measurement we set in the theme will be divided into four, since one quarter note is equal to four sixteenth notes.

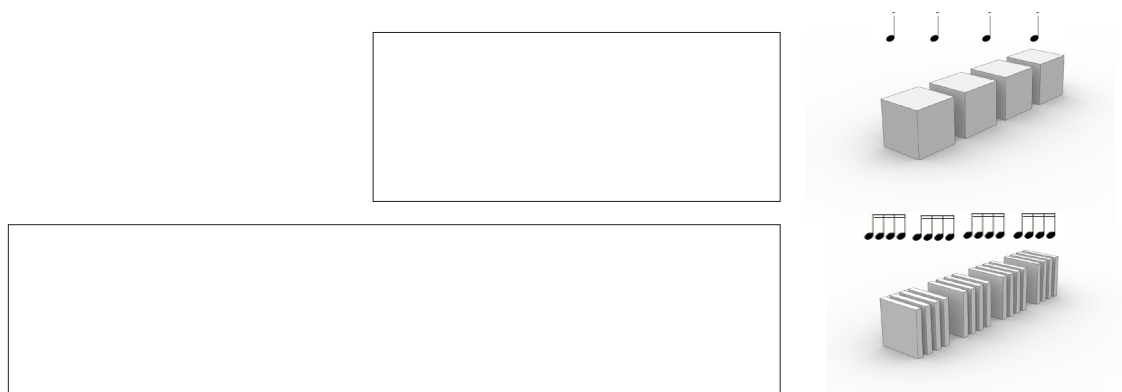


Figure 26: Rhythmic transformations in Mozart's Twinkle Variations

There are many examples of rhythm in architecture. Perhaps the most notable are structural elements which are placed at rhythmical spacing amongst each other, such as columns, and structural beams. While the design of these structural elements are not necessarily done through the lens of musical rhythm, this order and form found in architecture is reflective of the universal order and form found in the arts. Iannis Xenakis, in designing the facade of the Monastery at La Tourette, took advantage of this musical rhythmic value as well as counterpoint, by creating a varying rhythm in the window mullions. Most architectural elements have the capacity for some type of rhythm.

http://www.robandmariel.com/wp-content/uploads/2015/04/La_boiserie_dellAula_Baratto_realizzata_da_Carlo_Scarpa_tra_il_1955_e_il_1956-650x436.jpg	https://chlorinegardening.files.wordpress.com/2010/02/la_tourette.jpg la tourette, iannis xenakis + le corbusier	http://blog.a-cero.com/wp-content/uploads/2010/07/hola.jpg Paul klee museum, Renzo Piano

Figure 27: Rhythmic Examples in Architecture

sfz Dynamics to Scale and Hierarchy

Dynamics in music are markings that indicate loudness within the passage, as well as accents and other forms of sound intensity. Dynamics also indicates how the piece should be articulated. The following are a few of common markings found in musical notation:



<i>p</i>	<i>mp</i>	<i>mf</i>	<i>f</i>		
<i>piano</i>	<i>mezzopiano</i>	<i>mezzoforte</i>	<i>forte</i>	crescendo	diminuendo
soft	moderately soft	moderately loud	loud	gradually louder	gradually softer

Figure 28: Common dynamic markings in music notation

A composer might add markings throughout the score to indicate how he wants the piece to be played. Loudness in music also has relatively intuitive conclusions in regards to its relation to spatial qualities and listener perception. As discussed earlier, in musical experiments, participants were shown to associate loud sounds with larger objects. An increasing sound or tone in music is reminiscent of an object coming closer and larger, as that is what already occurs in the physical world. The sound track for *Jaws* demonstrates this, with the rise in its sequence eliciting tension in anticipation of the unseen, approaching shark.

Larger spaces gives the perception of greater “weight”. Thus, an *ff* marking might correspond to a more expansive space, where *pp* would be smaller. Depending on the composition, dynamic markings can show a hierarchy, or an important passage within the piece. Architectural spaces also contain hierarchy as perceived by the user. A sequence of smaller spaces followed by a large space show the large space as having greater hierarchy. A preminent example of this is seen in religious buildings, in which the largest space is perceived to have a greater importance.

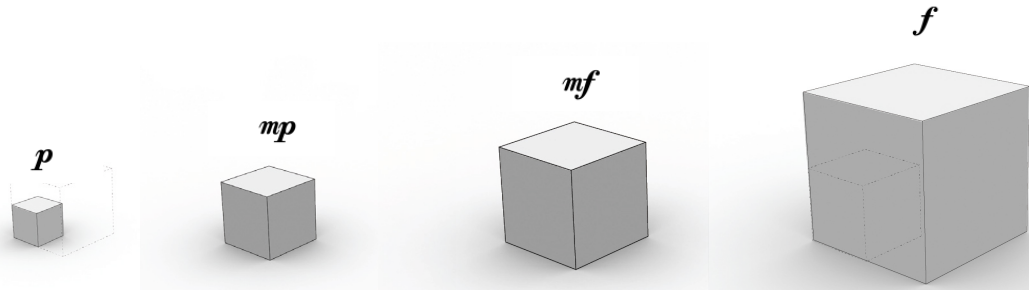


Figure 29: Dynamic markings and spatial boundaries

Dynamic markings can indicate hierarchy. A series of smaller spaces followed by a large space has the same effect a series of softer tones has before a sharp, louder tone. Architectural spaces also contain hierarchy as perceived by the user.

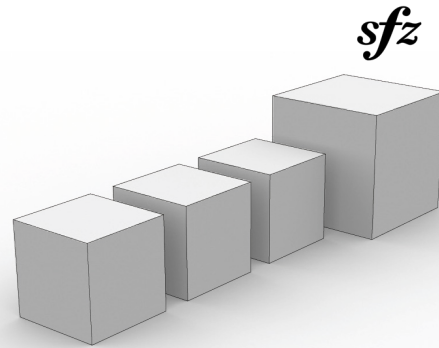


Figure 30: Dynamics showing hierarchy through an accent

An example of this is a sequence of smaller spaces adjacent to a large space. Users have the perception that the larger space is the more important in the series.

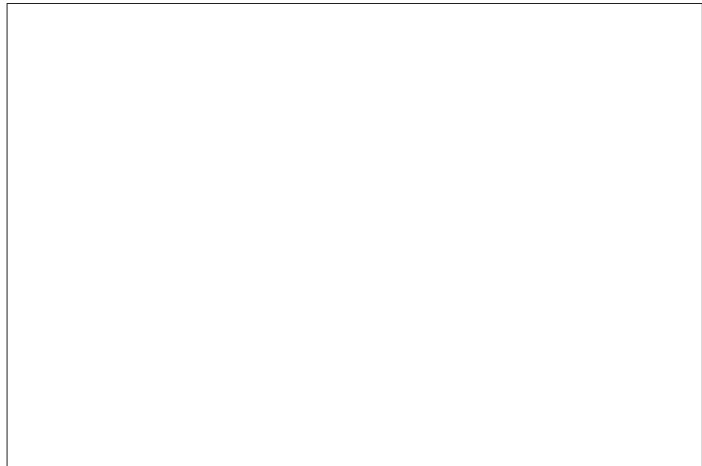


Figure 31: An example of dynamics and hierarchy

Source: <http://etc.usf.edu/>

Texture to Supporting Elements

This project will generally refer to musical texture as the amount of voices and the arrangement of these voices within a composition. It is a sequence of additional notes or chords that are arranged with the melody or predominant theme. This includes polyphony, as which was a term discovered in the literature review. It can be used as a transformative variable, and spatially refers to the number of elements present in a composition. There are various ways to achieve different types of texture, and is dependent upon the musical concept or effect that is desired. Harmony and Counterpoint can be translated into the addition and arrangement of multiple elements to a space or building and its relationship to one another. This concept gives the idea of layering equal elements of the geometry amongst one another. While harmony and counterpoint are uniquely different items, both add a sense of depth and complexity to a simple melody. This is ultimately represented in this project by the addition of spaces or objects that work together to support a main concept or theme. This can be utilizing this idea for harmony as an additive, secondary object or space, or as contrapuntal spaces or objects that are all equally important and unified.

Like musical accompaniment, there are many ways supporting elements can appear in architecture. These elements aid in defining a space, and can basically be seen as planes that outline the theme, and manipulated according to the other base variables. Musical texture often introduces a denser sound and complexity, thus construes the texture of a piece. There are many ways supporting elements can appear in architecture. These elements aid in defining a space, and can basically be seen as planes that outline the theme, and manipulated according to the other base variables.



Figure 32: Diagrammatic representation of various musical textures

Accompaniment can appear in many ways. The following are only a few basic examples found through musical research. One example is Mozart's 'Twinkle' Variations, which demonstrates a simple harmony in the bass clef that follows the shape of the melody in a one-to-one rhythm.

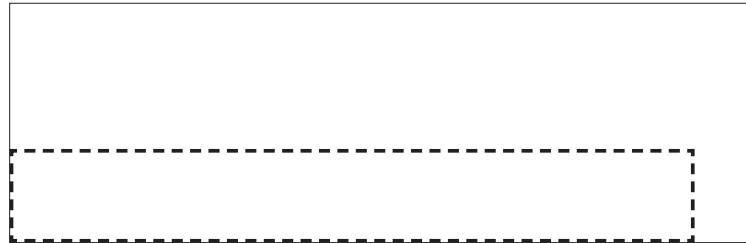


Figure 33: Texture in Mozart's 'Twinkle' Variations

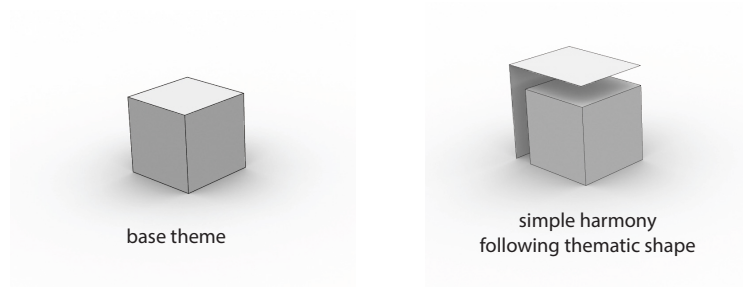


Figure 34: Example of possible application texture that follows the melodic shape



Figure 35: Architectural examples of a texture that follows the primary space's shape

Source: https://upload.wikimedia.org/wikipedia/commons/3/32/Langen_Foundation_Neuss_02.jpg.

Source: <http://www.richardmeier.com/wp-content/uploads/2014/07/P5.96SF20.231-1024x805.jpg>

Source: <http://s3.amazonaws.com/architectslist-photos/images/21181/original/Taghkanic-House-08.jpg?1375286935>,
thomas Phifer

Another example of a musical texture is the accompaniment appearing in the form of chords that support the melody. The example below is Chopin's nocturne, which illustrates an arpeggiated harmony surrounding the melody.

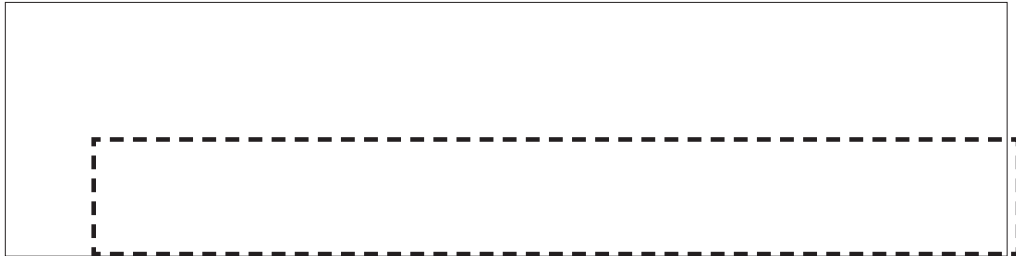


Figure 36: Arpeggios as the accompaniment
Chopin's Nocturne No. 19 in E Minor Source: Public Domain.

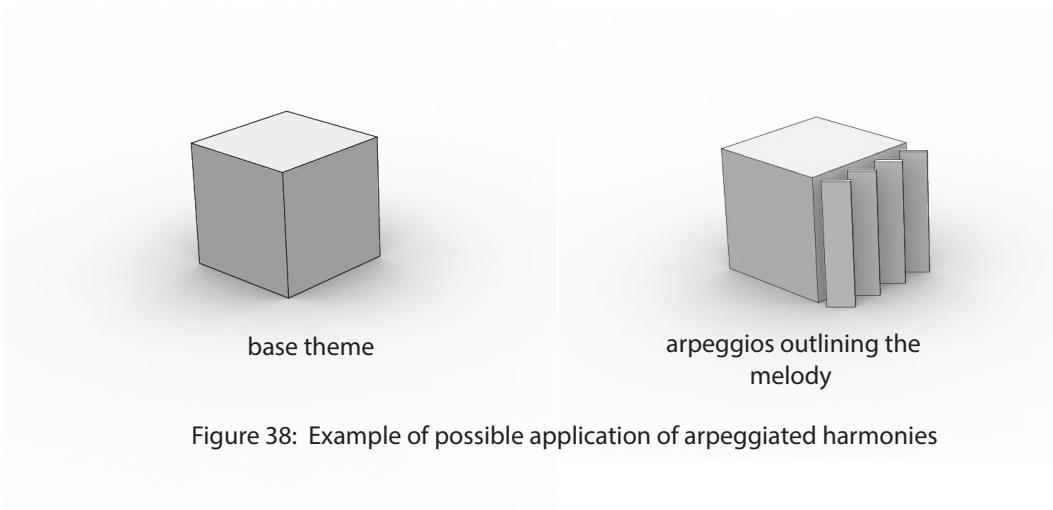


Figure 38: Example of possible application of arpeggiated harmonies

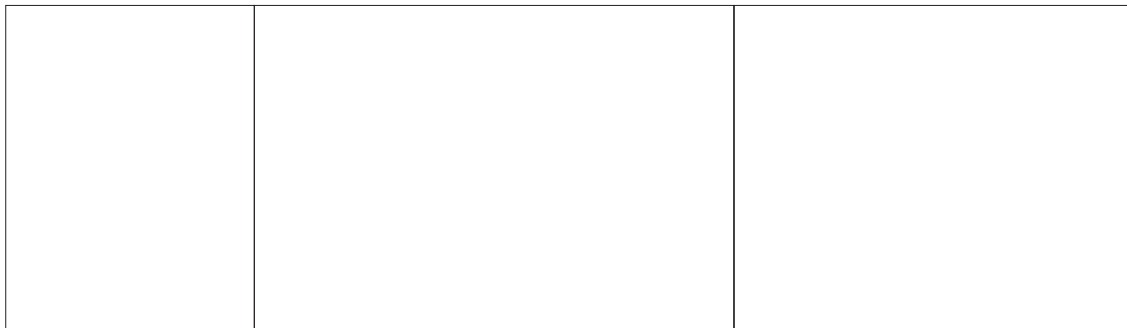


Figure 37: Architectural examples of arpeggiated supporting elements

Source: <http://imgs.abduzeedo.com/files/archi/morphosis/madrid6.jpg>

Source: <http://www.midcenturyhome.com/wp-content/uploads/2012/05/W2-STUDIO-project-mid-century-modern.jpg>

Source: http://67.media.tumblr.com/b635c474760b23bfe9d592d3c2fd5ebd/tumblr_ntx9xbnnt11s5qhgg08_1280.jpg

Counterpoint is also considered a musical texture because it is still defined as the way multiple voices are arranged amongst each other. This is often done without giving any hierarchy to a particular voice. This texture translates into architecture in the same way the previous harmonies did, in the arrangement of voices.



Figure 39: Counterpointal Texture
Bach's Invention No. 1 in C Major, mm. 1-2, Source: Public Domain

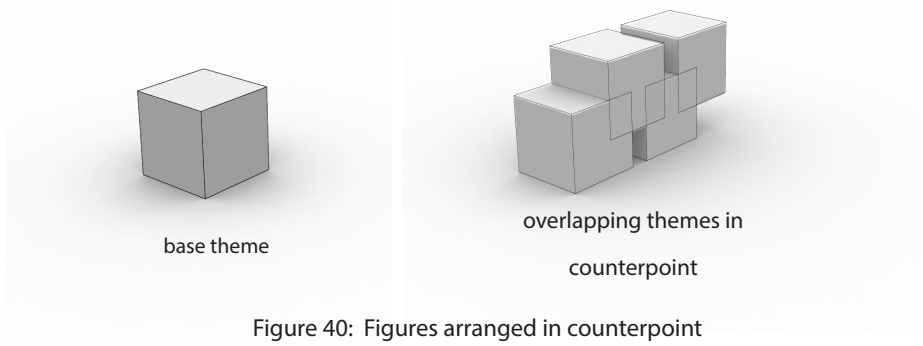


Figure 40: Figures arranged in counterpoint

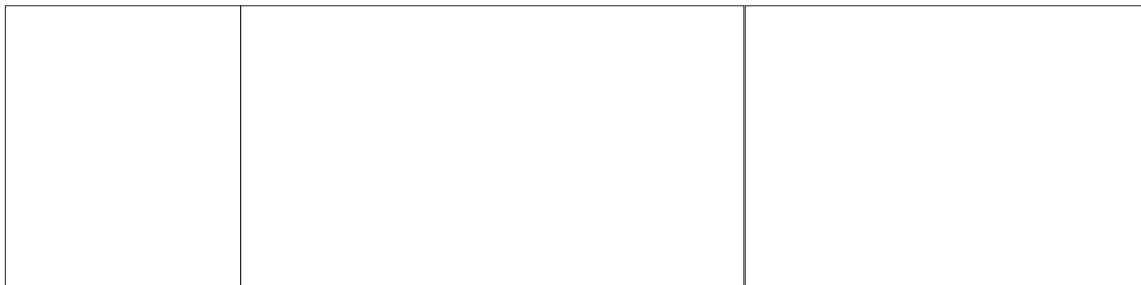


Figure 41: Examples of contrapuntal form in architecture

Source: <http://www.mak.at/jart/prj3/mak-resp/images/img-db/1453255890312.jpg>

Source: <https://www.zest-press.com/media/wysiwyg/blog/2016/04/operata-v-sidni-sega-i-w-google-culture-institute.jpg>

Source: [http://3.bp.blogspot.com/_291uGw41Ne8/S5iKk5adyXI/AAAAAAAAAB5w/IUMNMvphSHM/s640/Sanaa+\[Moriyama+House\]+02.jpg](http://3.bp.blogspot.com/_291uGw41Ne8/S5iKk5adyXI/AAAAAAAAAB5w/IUMNMvphSHM/s640/Sanaa+[Moriyama+House]+02.jpg)

COMBINATIONS OF VARIABLES

While the four composition variables are reflective of space and music in an isolated manner, these variables are almost always combined and manipulated in musical composition. The organization and combination of the variables, which are essentially 'building blocks' is what makes music discernible as an organized and creative art. Music can start to become more interesting and dynamic with the creative combination of these variables in tangent with movement and sequence, by the way that users begin to move through these elements. The variables may be combined to reflect some of the composition techniques that were discussed in the previous chapter. We will start to get into this in more detail in the following chapter.

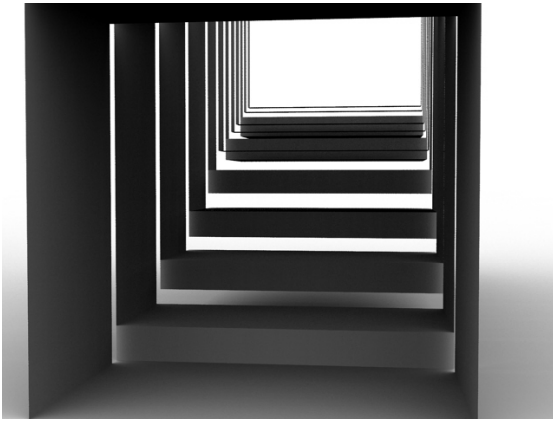


Figure 42: Increasing Pitch and Rhythm Variables

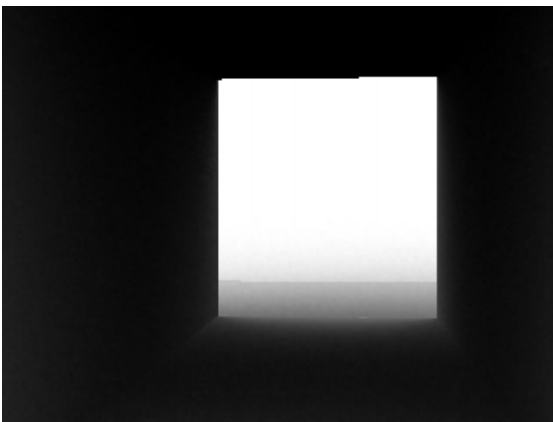


Figure 43: Volume increase
The composition technique 'Tension and Release' is illustrated by introducing a sudden volume increase from a small, enclosed space to a larger and open space.

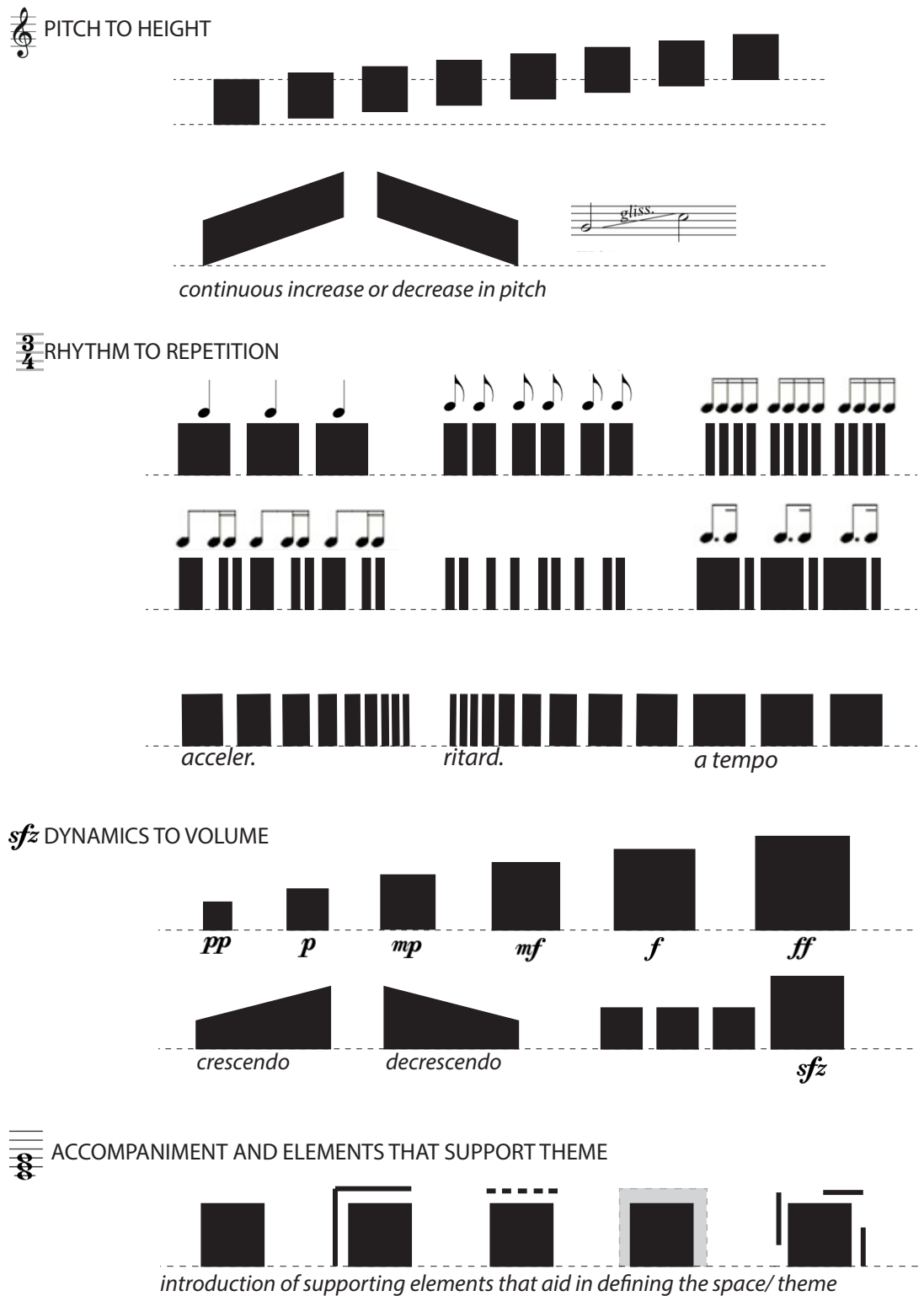


Figure 44: Summary of Variables

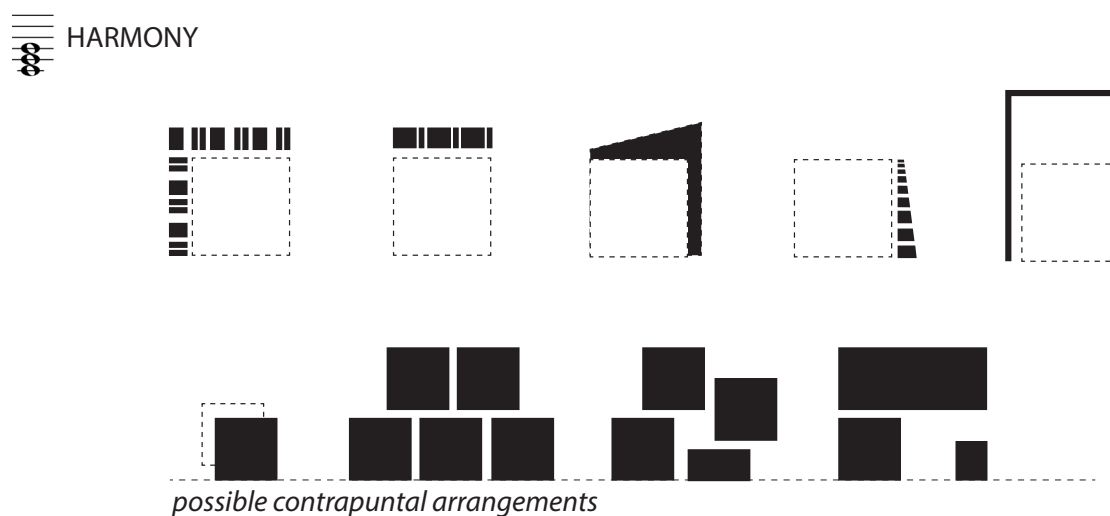
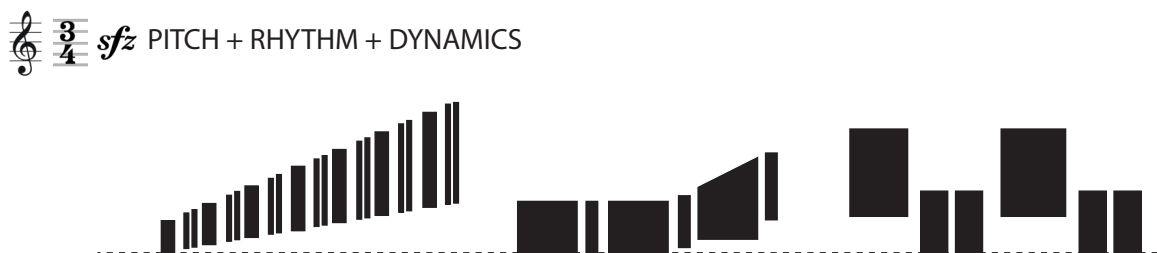
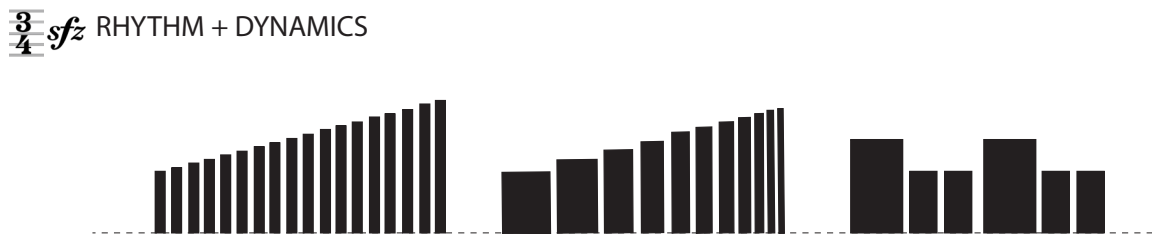
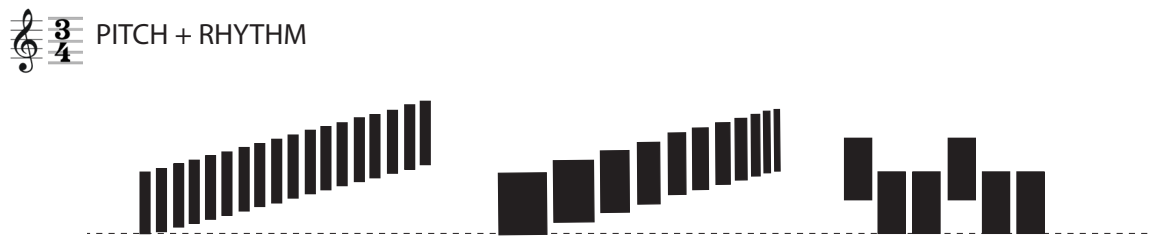


Figure 45: Summary of combinations of variables

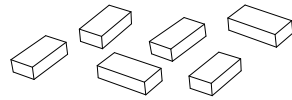
CHAPTER 5

METHODOLOGY: ORCHESTRATION

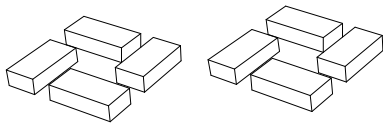
"...architecture is like music in this capacity for the symphony."⁷⁹

Frank Lloyd Wright

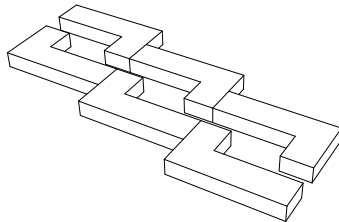
The previous chapter discussed the ways basic musical elements present themselves and are able to transform within a piece of music. It also discussed more importantly, how they correspond to architectural elements. When presented alone, these variables render themselves as meaningless noise without the arrangement and transformation within an overall organization and structure. This chapter will discuss the composition strategies that organize the variables to form a musical expression. The process of composing a musical expression through organizations of patterns can be broken down into three layers of information and organization:



COMPOSITION VARIABLE IDENTIFICATION | building blocks
+ pitch
+ dynamics
+ rhythm
+ texture

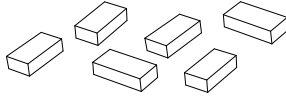


THEMATIC MODULE CONCEPTION | musical patterns
+ thematic massing and arrangement
+ patterns of variables
+ possible transformations



ORCHESTRATION | overall organization
+ musical form
+ transformation through variables
+ tonality

79 Lionel March, *Geometry of Environment*.



COMPOSITION VARIABLE IDENTIFICATION

Composition variables are the 'building blocks', or the most basic elements of composition. These variables appear in any piece of music and are identified by the notation, as discussed in a previous chapter. They work between architecture and music, in that each variable connects a musical element to a spatial feature. Below is a re-statement of the four variables:

1. Pitch - Height
2. Rhythm - Spacing or density
3. Dynamics - Scale or volume
4. Texture - Additional or supporting elements

These variables define basic ways in which architecture and music can be connected, but they also indicate the relative base point for every composition. Returning to this diagram of an octave and its associated floor levels, the ground level is associated with the first note on the score, because that was the introductory note. Every octave that the melody reaches will be equivalent to moving one story apart from the original register. In the same way, the other variables can change relative to the initial introduction.

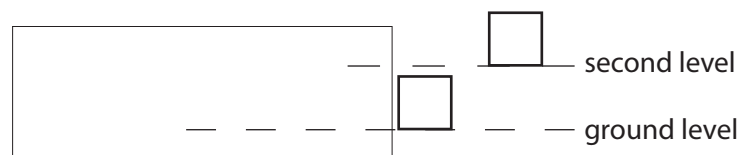


Figure 46: Relative pitch and register

As a part of the methodology, the composition variables layer refers to identifying these elements within the given composition. Because they exist within notation, the identification begins with the score. An example of identifying elements within a composition is easily done through Mozart's 'Twinkle' Variations. Beginning with pitch, we notice that there are two grouped musical lines--the first being the melody, played in the right hand; and the second is the accompaniment, which follows the general shape of the melody. We also look at rhythm, which the emphasis of beat is placed on the first note of the measure. The rhythm is a steady, even beat, which is illustrated by the vertical green lines. The dynamics are not directly referred to in this score.

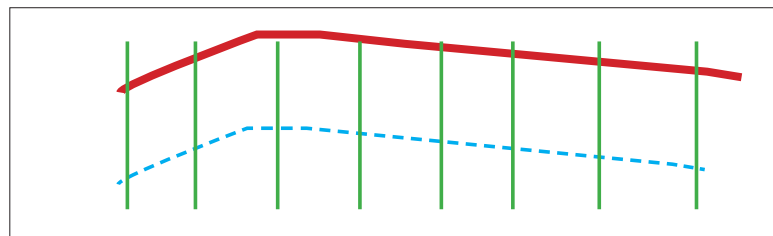
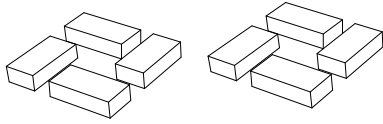


Figure 47: Composition Elements in Mozart's Theme

This process is repeatable for any piece of music, easily through notation but also through listening. Every piece has a tone, or pitch that can be identified. Every piece has a rhythm, even if it is not as symmetrical or rigid as the one shown in the example above. Every piece is played at some volume, from the nearly imperceptible to the overwhelmingly loud. And every piece has texture, whether it is one voice or multiple.



THEMATIC MODULE CONCEPTION

For the purposes of this project, we will coin the term Thematic Modules to indicate patterns and groups of arrangements of composition variables. Within overall music composition, there are smaller sections within the music that can be grouped together. They might be further subdivided into smaller sections with technical names and definitions such as phrases, motives, cadences, etc. For the purposes of transposing music into architecture, we will only focus on the overall concept that there are sections within the song. In contemporary pop songs, Thematic Modules are easily recognizable as a "verse", "bridge" or the "chorus." Classical music won't have the same structure

In the process of Thematic Module Conception, there are several steps in the analysis: the first is identification or assignment of the sections of music which will form the Thematic Modules. The following image is an example identifying the thematic modules within the short theme of Mozart's 'Twinkle' Variations. Various compositions use different techniques to terminate the module, in this case a coda is between section 1 and section 2. The termination indicator between section 2 and 3 is the trill followed by a slurred note.

Musical score for Mozart's 'Twinkle' Variations, showing three thematic modules highlighted in pink, blue, and green. The score is in 2/4 time and features a treble and bass clef. The first module (pink) is labeled '1' and ends with a trill (tr). The second module (blue) is labeled '2' and ends with a trill (tr). The third module (green) is labeled '3' and ends with a trill (tr). A coda is indicated between the first and second modules. The score is titled 'Thema'.

Figure 48: Thematic Modules found in the Twinkle

The second step in the process of Module conception is to identify the amount of elements, or voices, within the section. This is derived directly from the previous Composition Variables layer of analysis. Figure 47 below takes the first section of the Mozart variations theme, and identifies two voices: the melodic line in red, and the harmonic line just below it in blue. These two voices are the elements that will act as spatial definers.

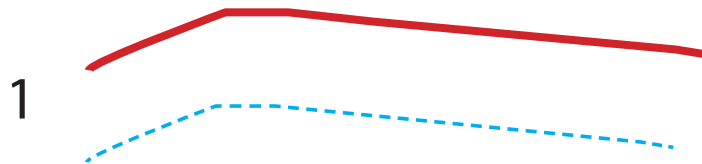


Figure 49: Voices within the Thematic Module of Mozart's 'Twinkle Variations

After identifying the voices that exist within the module, they will be arranged amongst each other. This can be linked to the X and Y axis through the score. Also, because the accompaniment in this example enters in the left hand of the piece, the accompaniment will be arranged on the left hand side of the space.

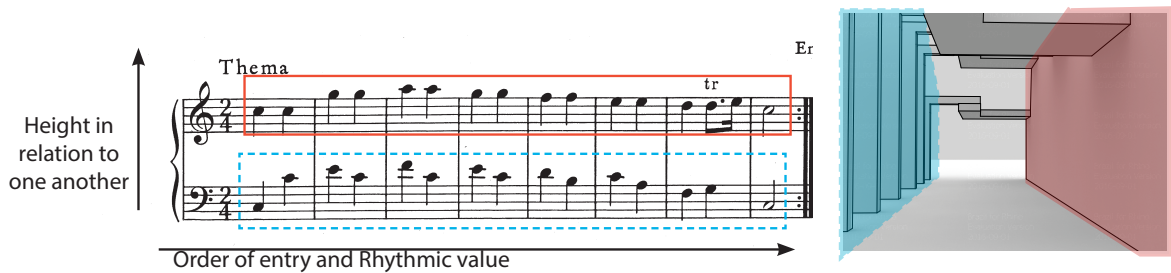


Figure 50: Arrangement of voices in the Thematic Module

Thematic Modules outline an inhabitable or defining space, whether it is of an auditory or physical nature. They do not indicate specific architectural elements such as materiality. Rather, they act as spatial boundaries or massings. The architectural elements assigned to these boundaries will be dependent on site, program requirements, user needs, or any other varying design need.

The figure below shows the module generated from our process--the vertical enclosure follows each pitch as they rise and fall, and are spaced in accordance with each new measure. The harmonic elements generally follows the melodic shape at a lower pitch, and the resulting space that is defined becomes the baseline volume.

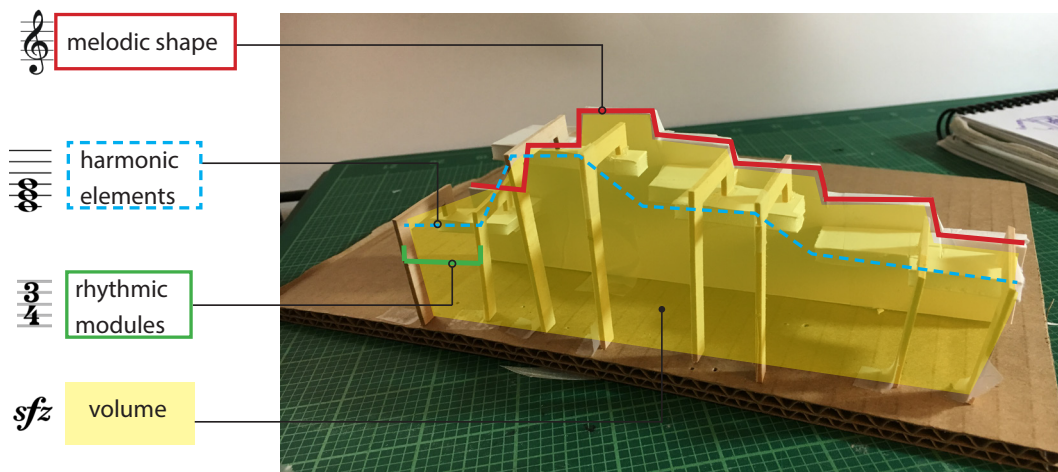
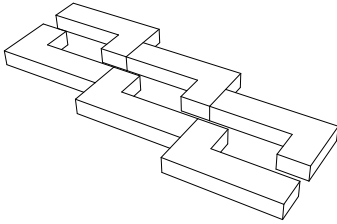


Figure 51: Thematic Conception through Composition Variables



ORCHESTRATION

The overall organization of thematic modules and the variables within them is what we will call the orchestration of the entire piece. There are several factors that affect the orchestration of a composition. The most important is Musical Form. Musical form determines the content of the composition, but also how it is ordered and put together. It is the framework by which composers may arrange their creativity.

A second factor in the overall organization is patterns of modules within musical form. These patterns may be repeated or transformed in some cohesive way.

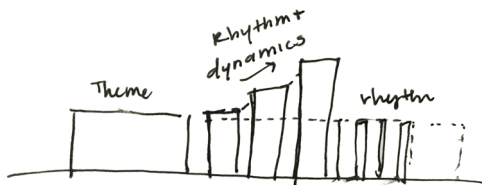
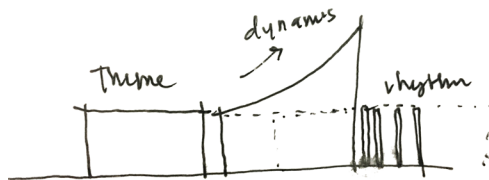
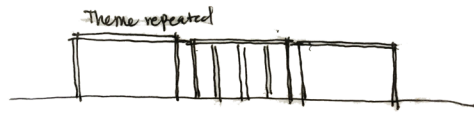
A third factor that is extracted from the overall sequence of a composition is tonality. Tonality was discussed in Chapter 3, which outlined music theory. Tonality is an important facet of music, particularly in Western Culture and music, because a large percentage of compositions are tonal. They exist within the constraints of a tonal center. This idea is related to the architectural axis, and the gravitational pull of surrounding organization to this axis.

Musical Form, Architectural Arrangement

Musical form is one of the foundational concepts of composition, and the basis for structure in music. Sound becomes music through structure, and form. The various musical forms studied so far in this project have been the Theme and Variation, and the Chaconne and Passacaglia, and the Fugue. Because musical form is essentially what organizes and structures music, it can be translated into the organizing element for architecture as well. Form would become the organizational and arranging factor to tie the composition together. It would be the catalyst for the preceding transformations discussed, upon which they are contingent. It provides the foundation, or "bass line" for the rest of the composition. These variations and transformations manifest in any genre and form of music, but are especially clearly indicated in the Theme and Variation form

Pattern Translation in Theme and Variation

The Theme and Variation encompasses a relatively straightforward concept. The over arching theme is presented at the beginning of the composition as its own short piece, or movement. The subsequent movements feature the same theme, but with different transformations. While the theme itself is transformed, the nature of the theme is retained as to maintain its character and not become a completely new song. This could be translated into architecture by applying the transformative variables to a given space or object, then arranging with the spaces or objects adjacent to one another. The basic tenants of the geometric shape or space would be maintained, with changes to its height, scale, rotation, texture and opacity. The diagrammatic figure 37 shows the concept of a beginning and ending theme, and a few of its possible transformations.



Form Translation

Like music, architecture can be conceived as a series of sequential events that we as users experience. Variation and Transformation are one way of creating interest in music and also in architecture. We can use the previous strategies and variables within the overall form of an architectural or musical composition. Musical form is the means of unifying and structuring a piece. While there are a number of forms, the one that will be used for this project to illustrate this process is the Theme and Variation. In the book *Basic Formal Structures in Music*, Paul Fontaine writes that "A set of variations can be fashioned to resemble almost any standard form. It can be of any desired length, that is, it can contain any number of variations." Because of this opportunity

for diversity, I'll be using this form to illustrate principles learned through this project. As a note, themes in music come in the form of a motif or phrase that is dependent on the composer's creativity. Similarly, Architectural themes can be any spatial theme up to the designer's creativity. In this paper, I will not focus on the creation of a theme based on musical principles, but rather only the variation and transformation possibilities.

A simple example can be used as an exercise in illustrating some of the propositions discussed. There is an infinite amount of themes in architecture, so for this project I will use a simple cubic module that illustrates a spatial principle, and can be transformed using the four variables discussed. The subject in this case will be a courtyard space for which a generic model can be created. The volumes can be defined by a desired building type or concept, however in this case, the form has been chosen arbitrarily for purposes of this exercise. Figure 39 shows a plan and perspective of a simple courtyard space, formed as a void by two long volumes. Thus, there are three components in this module, include the two L-shaped solids and the square void they create in the middle.

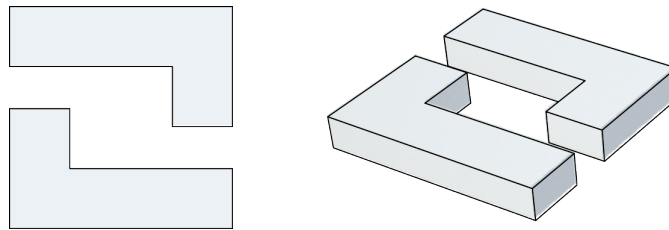


Figure 52: courtyard module

The courtyard module shown in figure 35 will act as the “theme” for further illustration. The module is simply a mirrored L-shaped form, representing a spatial arrangement pattern for hypothetical illustration. As these are simplified graphics of concepts of the musical compositional principles, the arrangement and shapes of each are not necessarily restricted to the ones shown above, but are dependent upon the composer, and dictated by building type, site context, and other typical design variables. Also, the modules shown may depict more complex translations and transformations according to the composition.

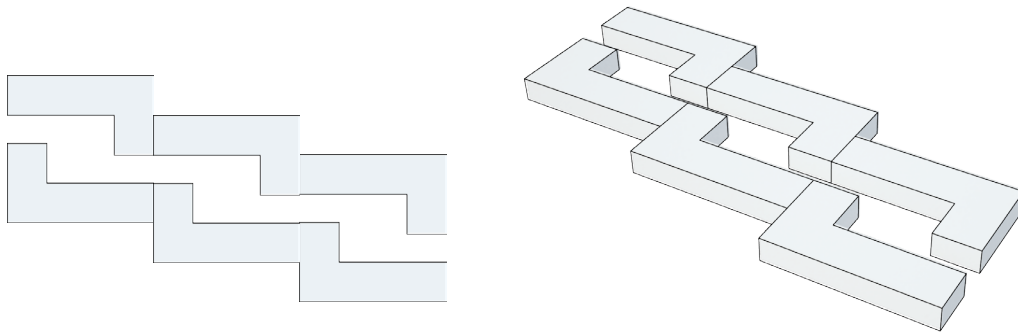


Figure 53: Module Repetition and arrangement

Figure 54: Formal Arrangement: Fugue
Series of overlapping themes, or modules

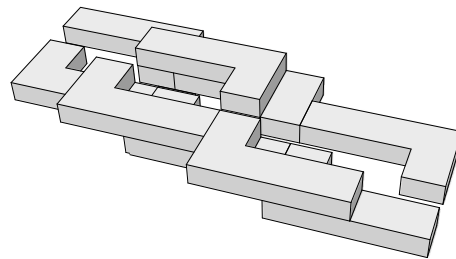


Figure 55: Formal Arrangement: Theme
and Variation
A series that transforms one theme many
times using different techniques. Each
theme is often composed as its own small
piece

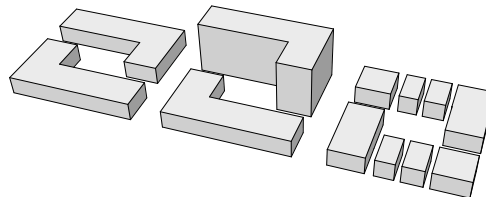
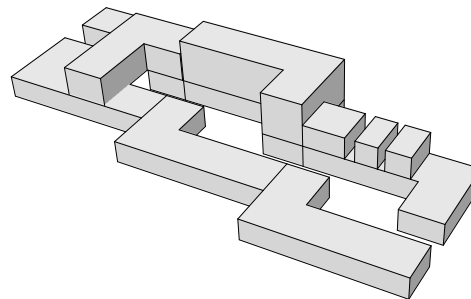


Figure 56: Formal Arrangement:
Chaconne, or Passacaglia
Continuous, repetitive bass line.
Surrounding elements might be repeated
or transformed.



Thematic Transformation

"Architecture is judged by the eyes that see, by the head that turns, and the legs that walk. Architecture is not a synchronic phenomenon but a successive one, made up of pictures adding themselves one to the other, following each other in time and space, like music" - Le Corbusier, The Modulor, P. 73

From previous discussion, we know that musical forms such as the bass ostinato is centered around a bass line, often descending. We will use this as an example to experiment with simple spatial transformations that effect only the surrounding elements without transforming the continuous "void" theme.

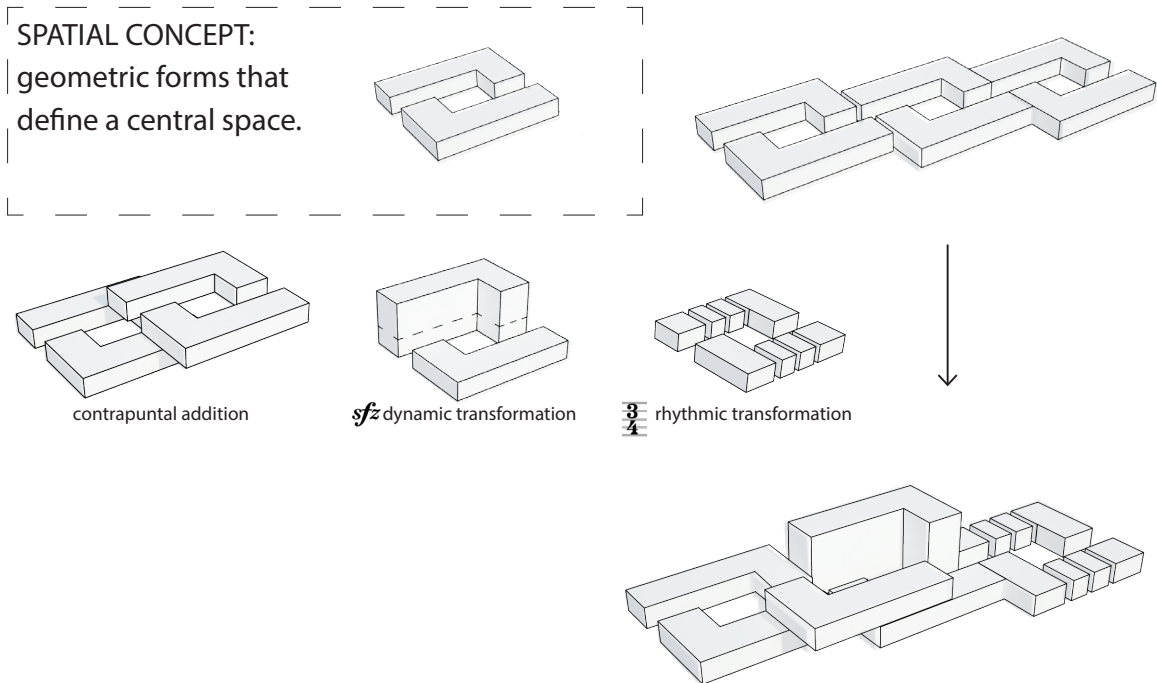
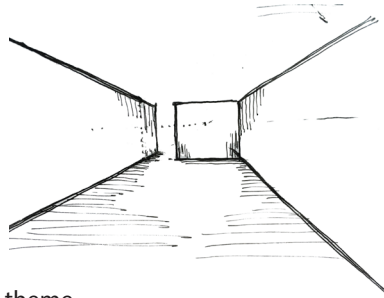
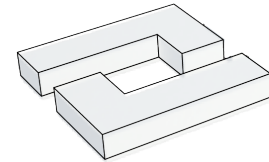


Figure 57: Thematic Transformations within Overall Form

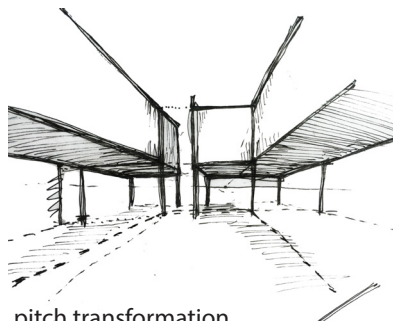
The theme presented on the right is a perspective of the middle of the courtyard module



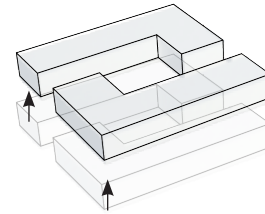
theme



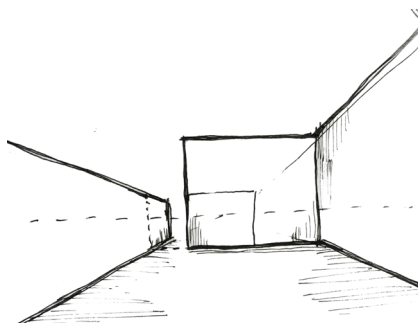
In this transformation, the "theme" stays the same, meaning the form is the same, and the user's point of view stays the same. However, the melodic elements are at a higher pitch



pitch transformation



In the next transformation, the basic form and shape are the same but the surrounding elements are now "forte", or a larger volume. Here we perceive our surrounding space as larger.



volume transformation

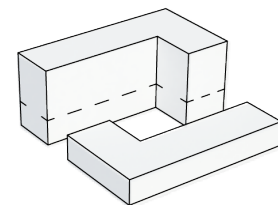
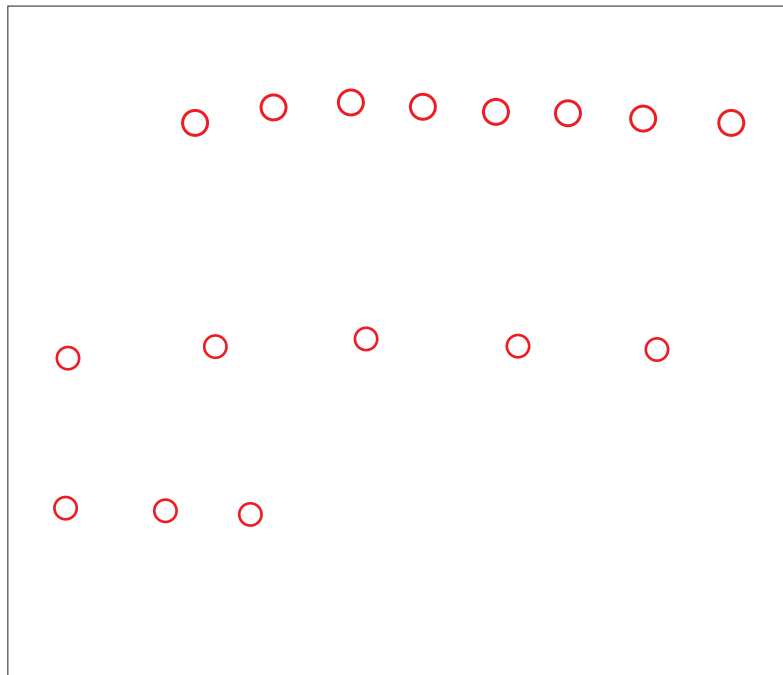


Figure 58: Perspective views of Thematic Transformations

Another exercise in transformation can be done using the Thematic Module we created with Mozart's 'Twinkle' Variations.

The second variation shows the theme being played on the second note of each measure, with a sixteenth-note ornamental rhythm. This indicates that the plane representing melody in the thematic module should be divided into sixteenth notes. The lower accompaniment generally stays the same with the rhythm changing halfway through. So the harmonic plane will also be changed according to the rhythmic values found on the score. Based on this, the generated thematic module will change accordingly.



Again, we see the original theme with its straightforward rhythm, and simple harmony.


In the first variation of the theme (left), the melodic line's rhythm is shortened from quarter notes to sixteenth notes. The corresponding notes of each theme have been circled .

Figure 59: Thematic Transformation with Mozart's 'Twinkle' Theme

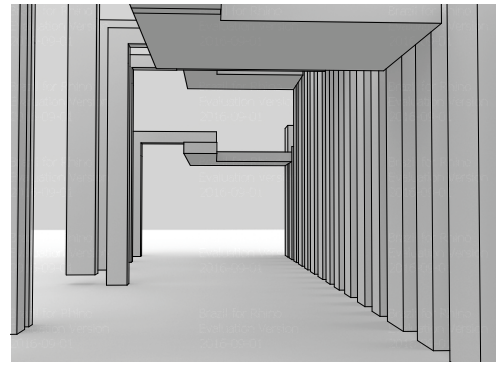
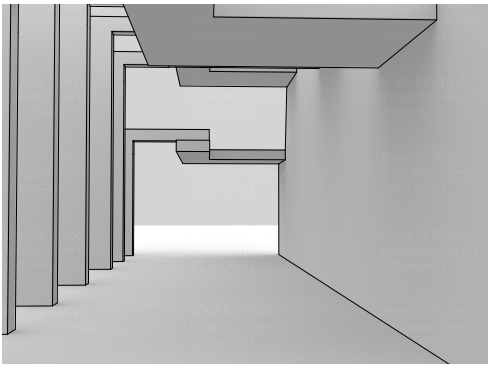
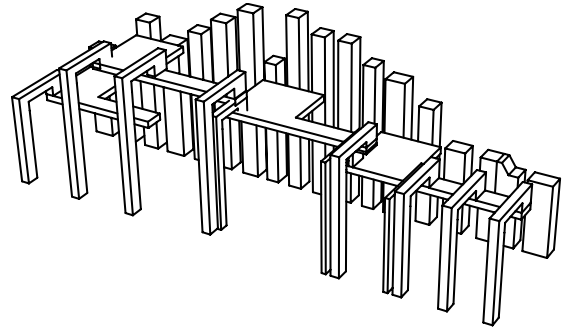
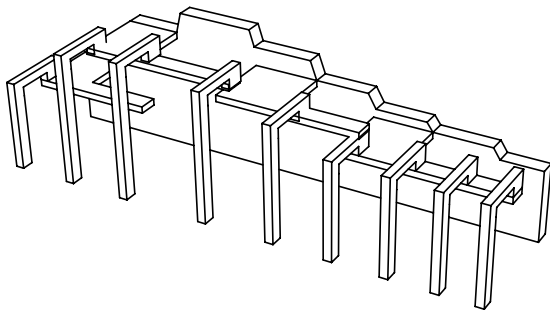


Figure 60: Comparison of Transformed Modules

Tonality

There are various configurations of sequential experience between the three sections of the piece. Music might be seen as sequences of experience. Each experience could be group in any way, from a major theme to a phrase, or a section of the composition. The listener experiences each sequence linearly, being led one direction through an auditory space.

While architecture is a three-dimensional experience, designers still have an influence on the spatial experience of the user. In placement, in the sequence of movement, etc. When translating a auditory spatial experience into a physical experience, the user might still experience each space as a sequence when the spaces are placed adjacent to one another. In other words, the user is manipulated through design to physically pass through one space to get into the next, and so on. This creates a type of sequential experience that is similar to music in the sense that we will design the sequence in which users experience a space. However, because of the physical dimensionality in built space as oppose to auditory space, there are many possible architectural configurations of sequential experience, while maintaining the same sequence.

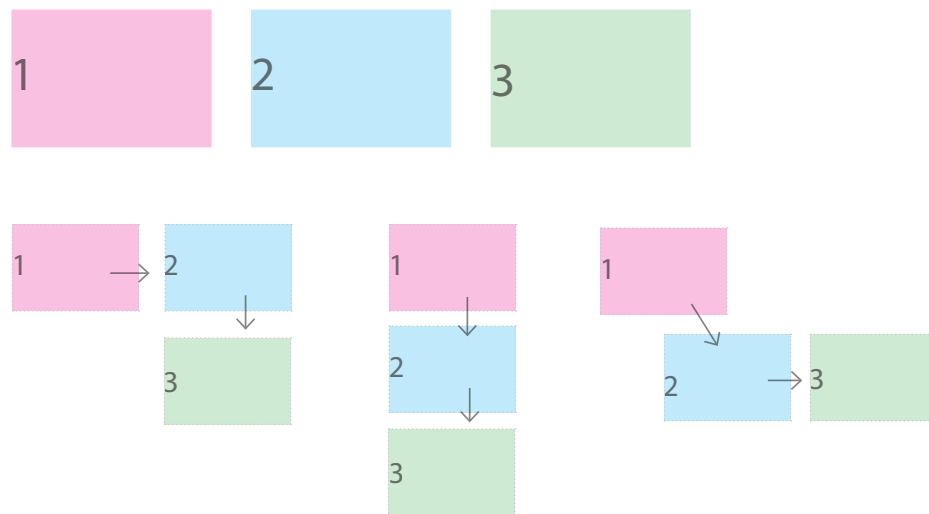


Figure 61: Potential sequences of Thematic Modules

To address this potential arbitrary decision of circulation, we will utilize the concept of tonality in music. Tonality is essentially the system of tones, or key, in which a composition is based. Modulation is a musical technique that falls within the overall concept of tonality. It can be described as the act of moving from one key to another key in the same song. This is one of the techniques discovered during the literature review, as it is used often by composers in many types of music and creates interest in a piece.⁸⁰ Modulation within a piece is sometimes subtle, but can often be identified by the change of key signature, as in an excerpt of Franz Liszt's Liebestraum No. 3 below:

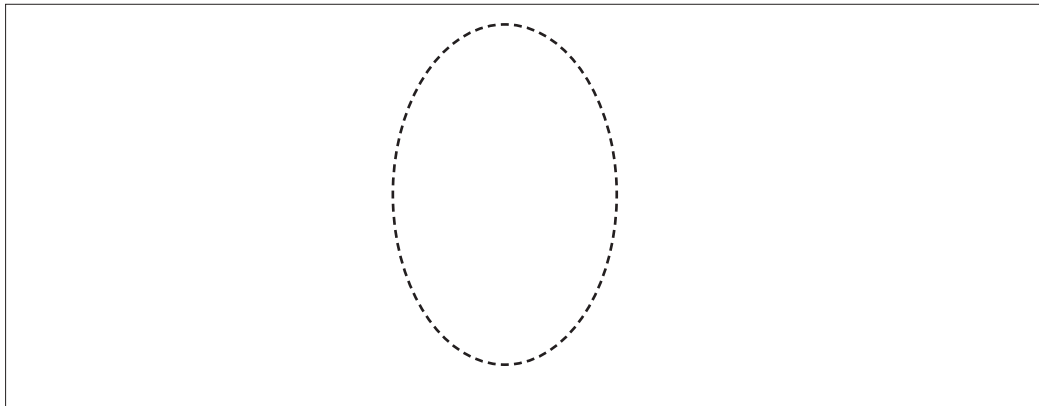


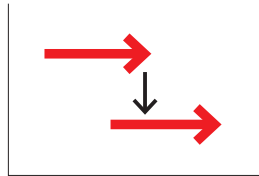
Figure 62: Modulation in Liszt's Liebestraum No. 3
Franz Liszt, Liebestraum No. 3, Public Domain.

Rudolf Arnheim, in the *Dynamics of Architecture*, points out the relationship between the architectural axis and tonality in music. He compares the axial shift within certain buildings to enharmonic modulation.⁸¹ Because there is a magnetism that both tonality and the architectural axis have in regards to organization and arrangement, these two concepts are relatable.

80 Joel Doueck, "Music and Emotion – A Composer's Perspective" *Frontiers in Systems Neuroscience* 7 (2013): 1, July 14, 2016, doi: 10.3389/fnsys.2013.00082 Elgar, Edward. "Variations on an Original Theme 'Enigma', Op. 36." From Public Domain. Mineola: Dover Publications, 1992.

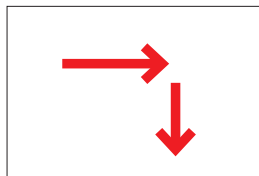
81 Rudolf Arnheim, *The Dynamics of Architectural Form*. Los Angeles: University of California Press, 1977

Through the music theory section of the literature review, there are several common types of modulation that occur in tonal music:



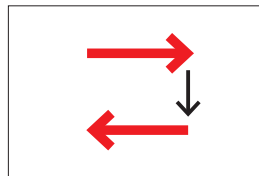
01 Shifting to an Adjacent Key

shifting key upward or down with the same melody



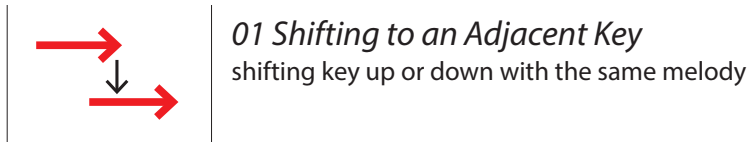
02 Shifting to a New Key and Theme

shifting to a completely different key, and melody



03 Changing Mode

shifting from a major to a minor key, or vice versa



The floor plan of the Hotel de Matignon in France is the example Arnheim cites when discussing the architectural axis.⁸² The shift in the dominant axis is clearly seen by the plan.

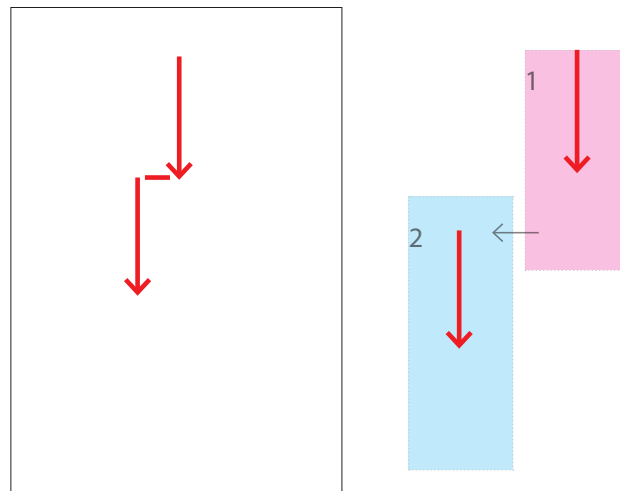


Figure 63: Axial shift in the Hotel de Matignon in France

The Hotel de Matignon Reflects the modulation to a different key. When translating this to sequence between thematic modules, the directionality of the circulation remains the same, but the axis does not. This same type of modulation is reflected in the Stretto House, one of the case studies from a previous chapter. Each structural bay is a thematic module, and after the first bay, there is an axial shift.

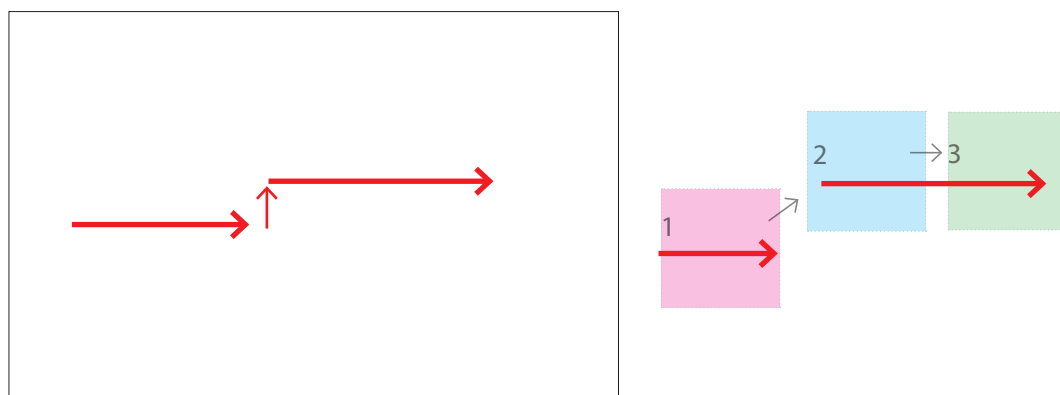
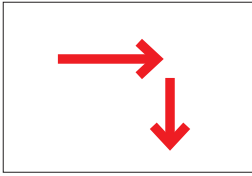


Figure 64: Axis shift in the Stretto House

82 Rudolf Arnheim, *The Dynamics of Architectural Form*. Los Angeles: University of California Press, 1977



02 Shifting to a New Key and Theme
 shifting to a completely different key, and melody

The following modulation outlines a shift from one key to another, while presenting a new theme or module. The new key signature's theme is not a continuation of the previous melody, and we perceive a different melody. This departure from the melody and key indicates a departure directionally, and thus the directionality changes.



Figure 65: Modulation in Chopin's Prelude in B-flat Minor
 Frederic Chopin, Prelude in B-flat Minor, Public Domain

Chopin's Prelude in B-flat major shifts to G-flat major in the forte section below. This is one example where the score does not notate the key signature change, but rather inserts it in the individual notes. An attentive listener is still able to perceive the modulated key, but it is not immediately obvious from the score.

Axial modulation is evident in many different buildings and plans, not just a shift of axis in the same direction as seen in the previous example, but shift of directionality in different angles as well. An architectural example is seen in the floor plan of Zaha Hadid's MAXXI Museum.

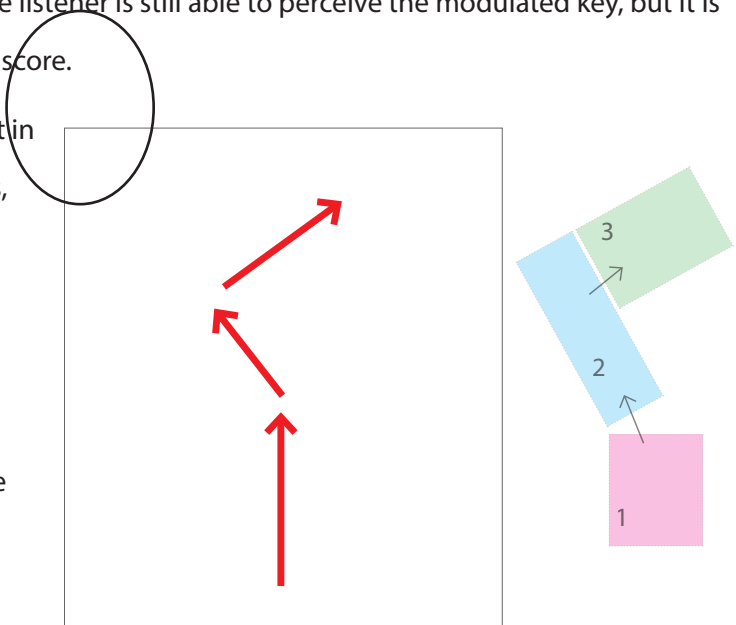
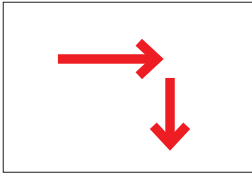


Figure 66: Example of modulation with both key and melodic shift
 Source: https://karmatrendz.files.wordpress.com/2010/01/maxxi_museum_zaha_hadid_19.



03 CHANGING MODE

shifting from a major to a minor key, or vice versa

This type of modulation is the transition between major and minor. It is often used in many forms, including most compositions that use the Theme and Variation form. Most of these compositions introduce original major key, which is followed by a minor section and then returns to the major section of the piece.

Because most people perceive major-minor keys as “opposites” - happy vs. sad, bright vs. dark, the duality of major and minor represents opposites. This suggests that spatial movement as set in motion by this transformation moves in opposite directions.

Below is an example of a change from a major to a minor key in Chopin's Fantasia Impromptu. This change of mode is notated in the score, but it is also has a different dynamic marking, so the entire feeling of the section is changed.



Figure 67: Change of mode: Chopin's Fantasia Impromptu
Frederic Chopin, Fantasia Impromptu Op. 66, Public Domain

CHAPTER 6

SYNTHESIS: FINAL PROJECT

The ultimate goal of this thesis is to provide a framework through which to design spaces that are musically inspired. The previous chapters have been informative in formulating a methodology that acts as a framework through which to use music as a generator of architectural form. The methodology includes three sequential layers through which any musical composition may be filtered. This chapter will document the process of testing the methodology with a musical composition that will be used to design a two-bedroom residential home.

The following pages document the site and music composition selection, as the setting for the proposed musical intervention. Using the music composition, the three layers of composition will be applied. The piece will be analyzed to identify the composition variables, which will be applied to three-dimensional space through formulation of corresponding Thematic Modules, and finally the Overall form and organization will be manipulated according to the form of the piece.

MUSIC COMPOSITION

The composition that will be examined is Liebestraum No. 3, composed by Franz Liszt. Liszt composed a series of three pieces titled Liebestraum. The name ` Liebestraum is translated "dream of love"⁸³ and is the third installment in the series. Liebestraum No. 3 is the composition that will be used for this project, and is the most popular of the three. Its simple, striking melody forms a theme that is introduced in the beginning of the song. Liszt repeats this theme a number of times, using clear transformation operations throughout piece. The form of Liebestraum No. 3 is reminiscent of the Theme and Variations form, but expressed in a single composition rather than multiple smaller

83 Duane Shinn, "The Story of Franz Liszt's 'Liebestraum,'" June 2, 2008, <http://ezinearticles.com/?The-Story-of-Franz-Liszts-Liebestraum&id=1219318>

pieces.



The piece was chosen for this project because of the transformational variations, which is clearly illustrated in every recurring theme. The transformations utilize the different Composition Variables and are unified in a continuous song, unlike the traditional Theme and Variation compositions.

The initial theme recurs a number of times, but they are

grouped together within the overall form of the song into distinct sections through the whole piece. These sections are divided by their movement to another key, and also by passages of lengthy embellishment. There are four distinct sections:

1. The first section presents a simple melody that is repeated several times
2. The Second section modulates to another key, as its sound increases in complexity
3. The third section modulates again, and increases. This is the climax of the piece
4. Fourth section returns to the original key and is a restatement of the first section

The transitional sections, which are embellishments that are departures from the theme and show the ability of the performer, follows the first section and precedes the last section. The first sequence sounds like it's ascending, and the second sequence sounds like it is trickling into a descent.

Nestled deep in a quiet, residential valley, the site reflects the meditative state of Liszt's Liebestraum, which is translated "Dream of Love". The two ridges surrounding the property are immediately reflective of the sequence through Liszt's Liebestraum's calm, quiet valleys over its declarative peaks. And the site's quiet, surrounded location reinforces the introverted, yet expressive nature of the composition.

Figure 68: Introduction to Liebestraum No. 3
Franz Liszt, Liebestraum No. 3, Public Domain

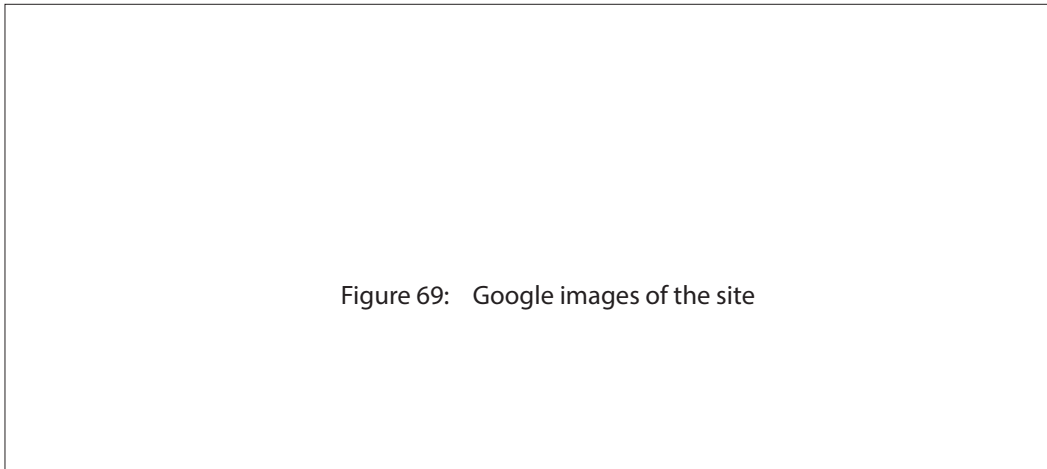


SITE ANALYSIS

1237 Hind Iuka Dr.

Aina Haina, in Honolulu, Hawaii.

This is a quiet neighborhood with a predominately older population. The current lot is empty, owned by the City and County of Honolulu, and is approximately 9,000 square feet.⁸⁴



84 "Honolulu Land and Information System," accessed October 29, 2016, <http://gis.hicentral.com/>

Figure 70: Perspective view to the site

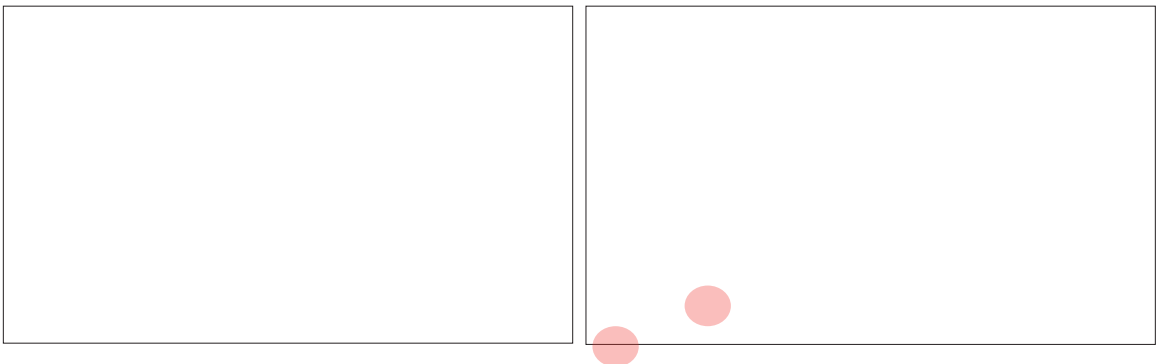
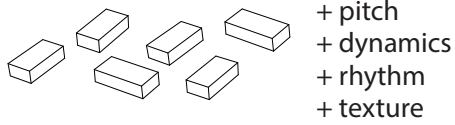


Figure 71: Views from the site



SYNTHESIS METHODOLOGY

Composition Variables | Building Blocks



The first operation within the methodology is to identify the predominant elements found within the score. This is done by examining the first theme, shown in figure 70 below and finding patterns and groups. There are three predominant elements that consistently recur throughout piece: ○ ○

- Melodic Line
- Arpeggiated accompaniment
- Descending Bass Line

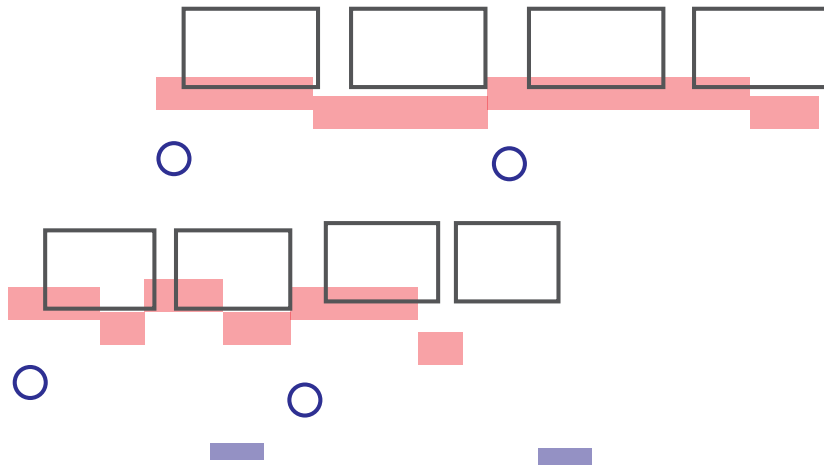


Figure 72: Liebestraum No. 3 - Basic elements on the score

We will also set standards for the forthcoming Thematic Modules using the Composition Variables based on the initial theme.

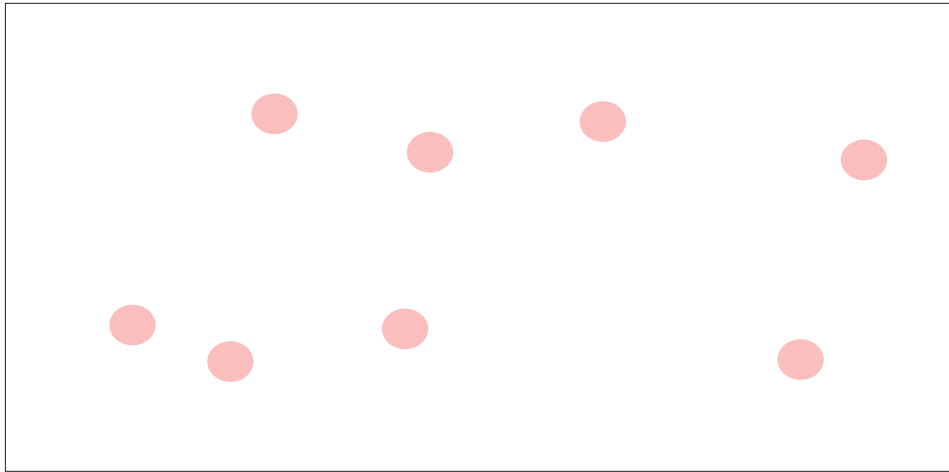


Figure 73: Liebesträum No. 3 - Theme

Each of these

themes are identified

throughout the piece.

The first three are in

figure 85, right. The

sections will be referred

to as thematic modules.

Pitch. The key signature begins in Ab, and the melodic line starts on middle C, and is sustained throughout the theme. The melody of the theme will set the base octave for subsequent transformations. The middle C octave will be ground level.

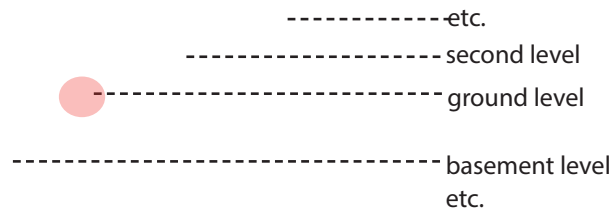
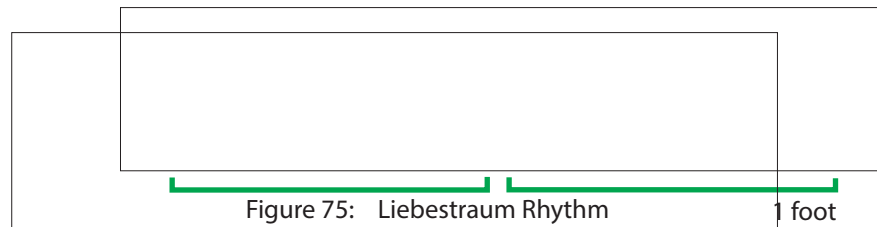


Figure 116: Sections in Liebesträum No. 3

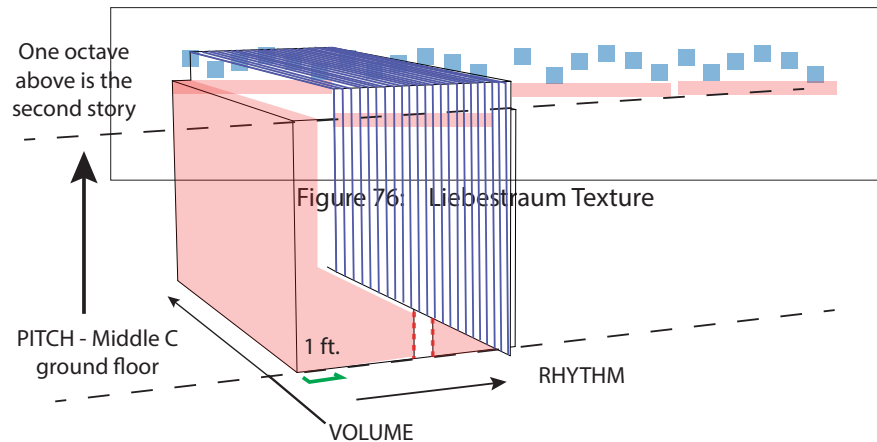
Figure 74: Octaves of C

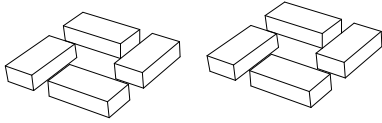
Each note below notates a different octave of the C key. Because the piece begins around middle C, ground level is attributed to this octave.

$\frac{3}{4}$ Rhythm - The theme begins with the $\frac{6}{4}$ time signature, marked 'a little brisk, with affect'. The predominant beat comes in at the beginning of each measure with the bass note \ominus . Because of the size of the house's property as well as the length of the piece, each measure will be one foot in physical space.



The harmony consists of chords that are arpeggiated, and surround the melodic line. The bass note is a prominently heard tone in the theme, but it is an extension of the harmonic chord. In comparison to the sustained dotted half notes of the melody, the harmonic chords tones are broken up rhythmically into eighth notes, one-sixth the value of the dotted half note.





Thematic Modules | Musical Patterns

- + thematic massing and arrangement
- + patterns of variables
- + possible transformations

After identifying the basic elements that are present throughout the piece, we will begin to formulate the Thematic Modules according to the framework. As an overview of the sections within the song, the introductory theme analyzed in the previous pages is repeated several times throughout the composition as Liszt's 'Thematic Transformations'. Each subsequent theme varies and is transformed as the composition as a whole reaches a climactic moment and ends back at the original theme.

1

2

3

We know that there are three voices in each theme. The Melodic Line hovers around Middle C, and is sustained, with the exception of a quarter rest midway through the theme. The accompaniment is consistently in eighth notes, and the bass note is a quarter note.

- Melodic Line
- Melodic Break
- Arpeggiated chords, faster rhythm than the melody
- Descending Bass Line
- One measure, equal to one foot in architectural space

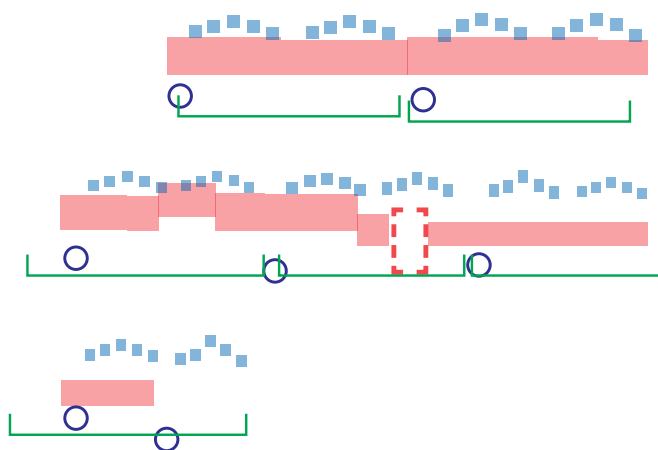


Figure 77: Voices within Thematic Module of Liebestraum No. 3

Figure 78: Thematic Conception of Liebestraum's Theme

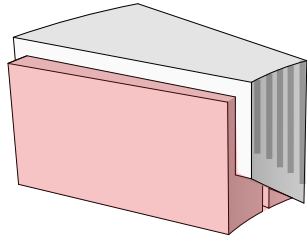


Figure 79: Massing of the Thematic Module
 Harmony enters at a higher pitch than the melody. The bassline is constantly descending, but is essentially a part of the arpeggiated harmony's chord progression.

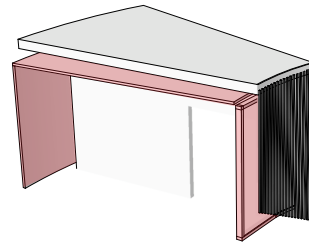


Figure 80: Spatial Boundaries in thematic module

The melody is the defining space. Users experience the melody by walking through it. The sustained nature of the melodic line alludes to a solid surface with the exception of the melodic break in each theme. The eighth note harmony breaks up that solid surface. In the introductory themes, the harmony only enters in the right hand of the performer. This is reflected in the harmonic eighth notes being experienced on the right side of the space.

Orchestration

Musical Form

After initial written and aural analysis, we can identify larger sections by grouping the recurrences of the theme according to the modulations that occur within the course of the song. In figure 79 below, each square indicates reintroduction of the theme, which is represented by the Thematic Module that was stated on the previous page. There are three times the composition modulates to another key. In addition to shifting the axis throughout the piece, there occurs transformation of the thematic module in relation to the preceding theme. The theme, or a version of it, appears 11 times, and is marked by an ending sequence.

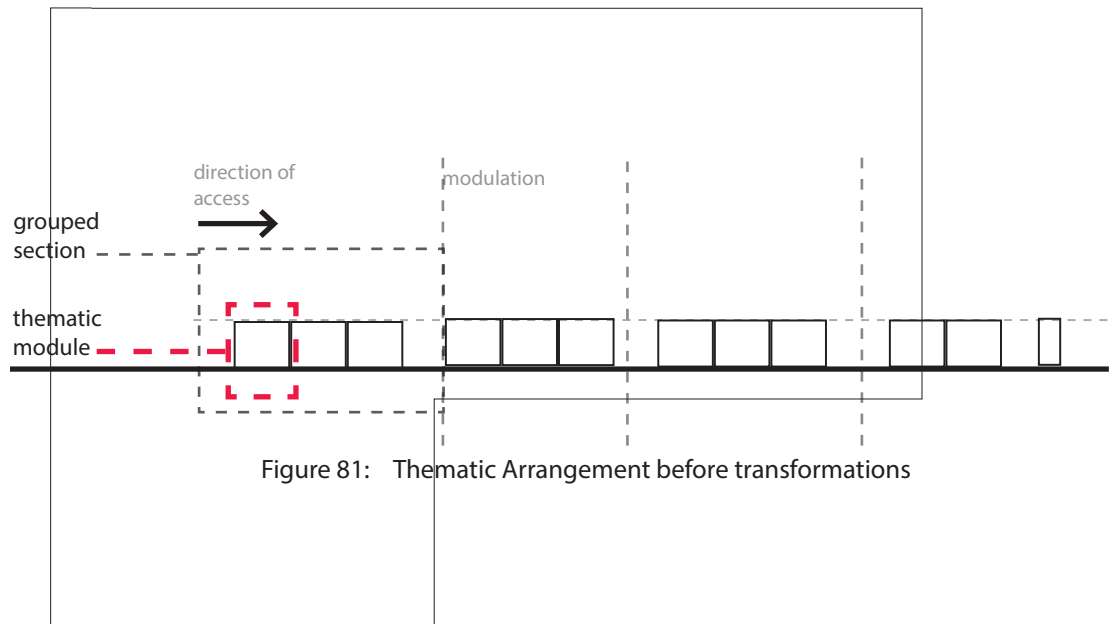


Figure 81: Thematic Arrangement before transformations

Thematic Transformations

Once the themes are laid out sequentially, we can transform each theme according to the reintroduced theme's pitch level. Here again, there are patterns. After the first modulation, the theme re-enters at a higher octave than the original Middle C. This is indicated in the elevation graph below by the second section's movement to a second floor, and the pitch continues to rise, with the addition of a second melodic tone doubling the original one in the third section. We will also map out the volume changes that are marked on the score through the course of each theme's re-introduction. Visually, can see the build-up through the song to a climax, and resolution in the fourth section.

The following pages go through the process of documenting and translating thematic transformation in each theme that occurs in the composition.

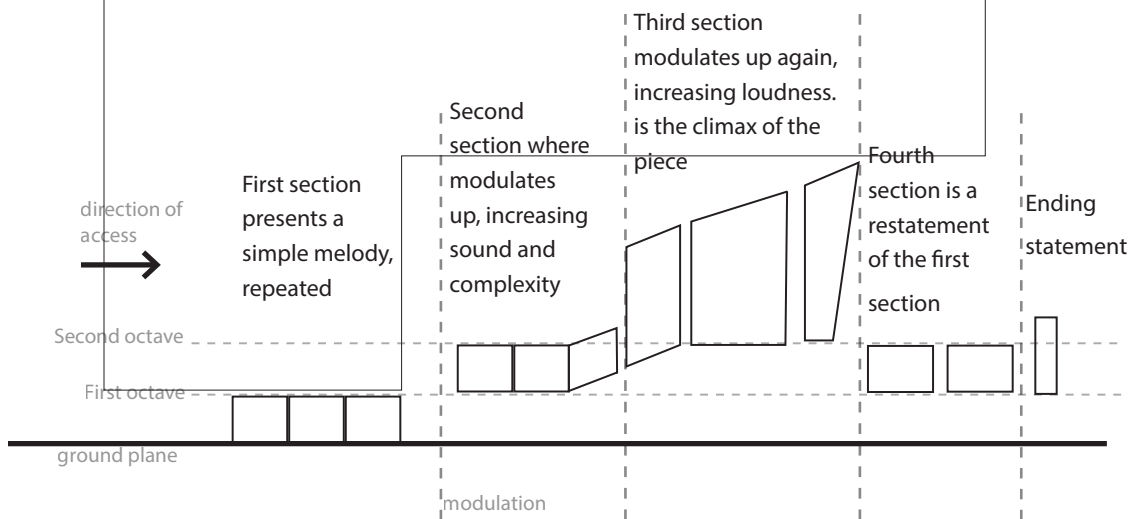


Figure 82: Overall shape of Liebestraum No

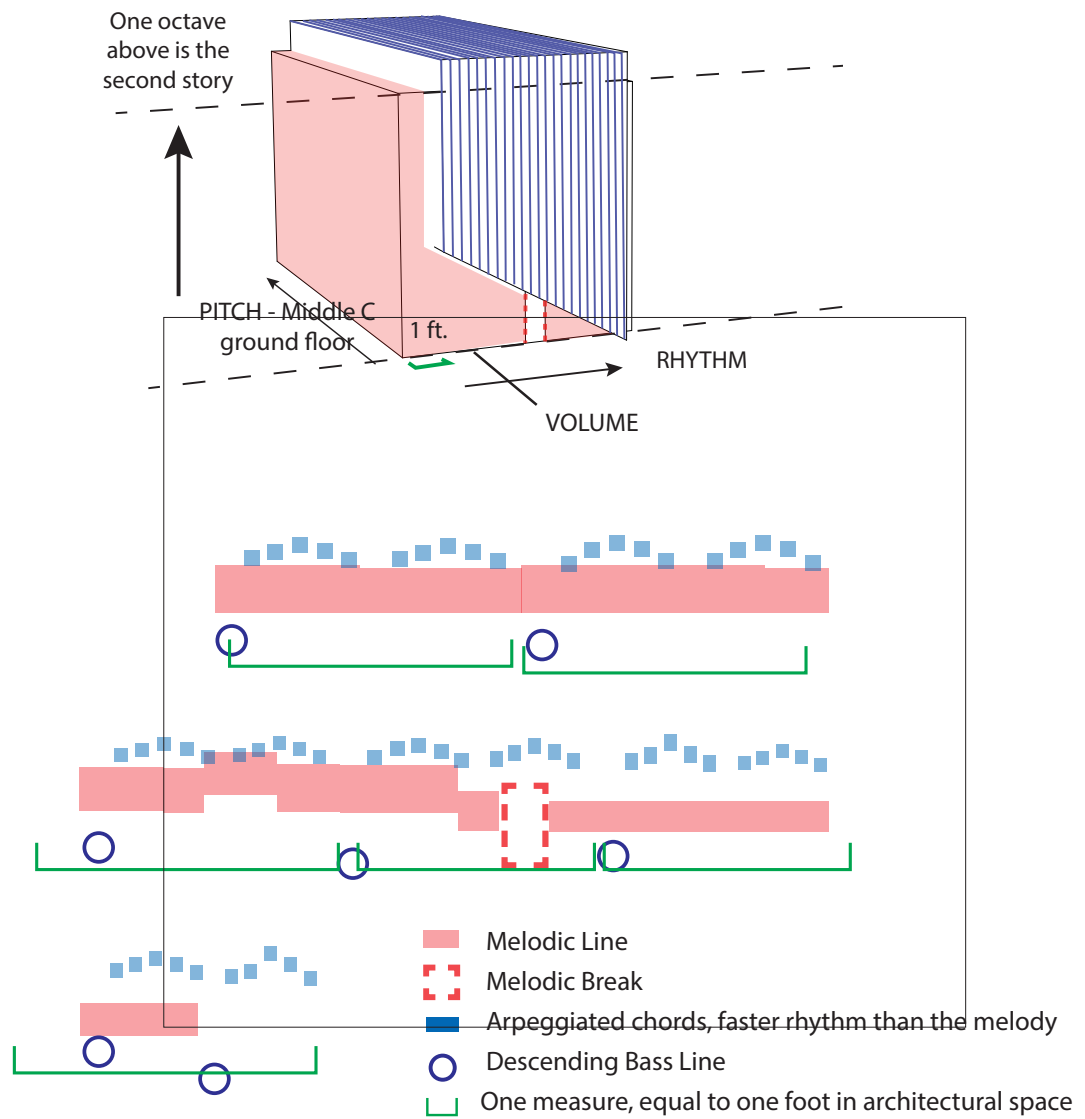


Figure 83: Thematic Transformations - Theme
 Franz Liszt, Liebestraum No. 3 - mm. 1-6. Public Domain.

Beginning with the introductory theme, notes from the score will begin to be mapped into spatial definers.

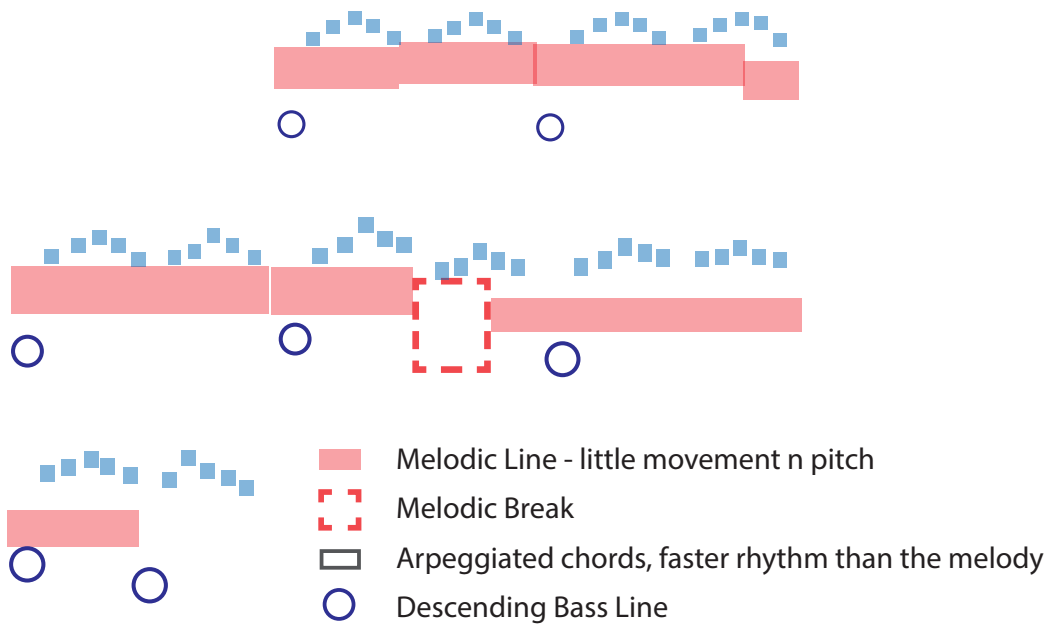
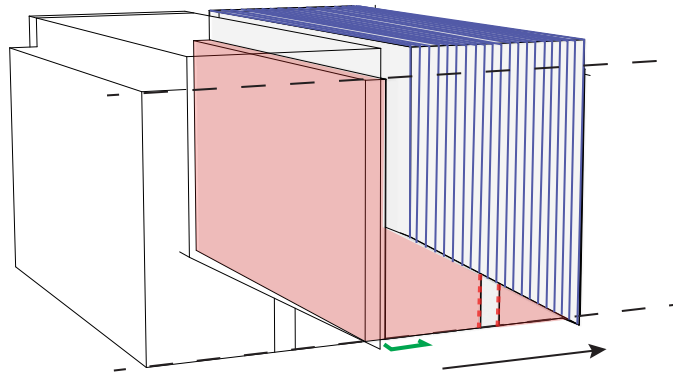


Figure 84: Thematic Transformations - First "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 7-12. Public Domain.

The first 'variation' is an echo of the introductory theme.

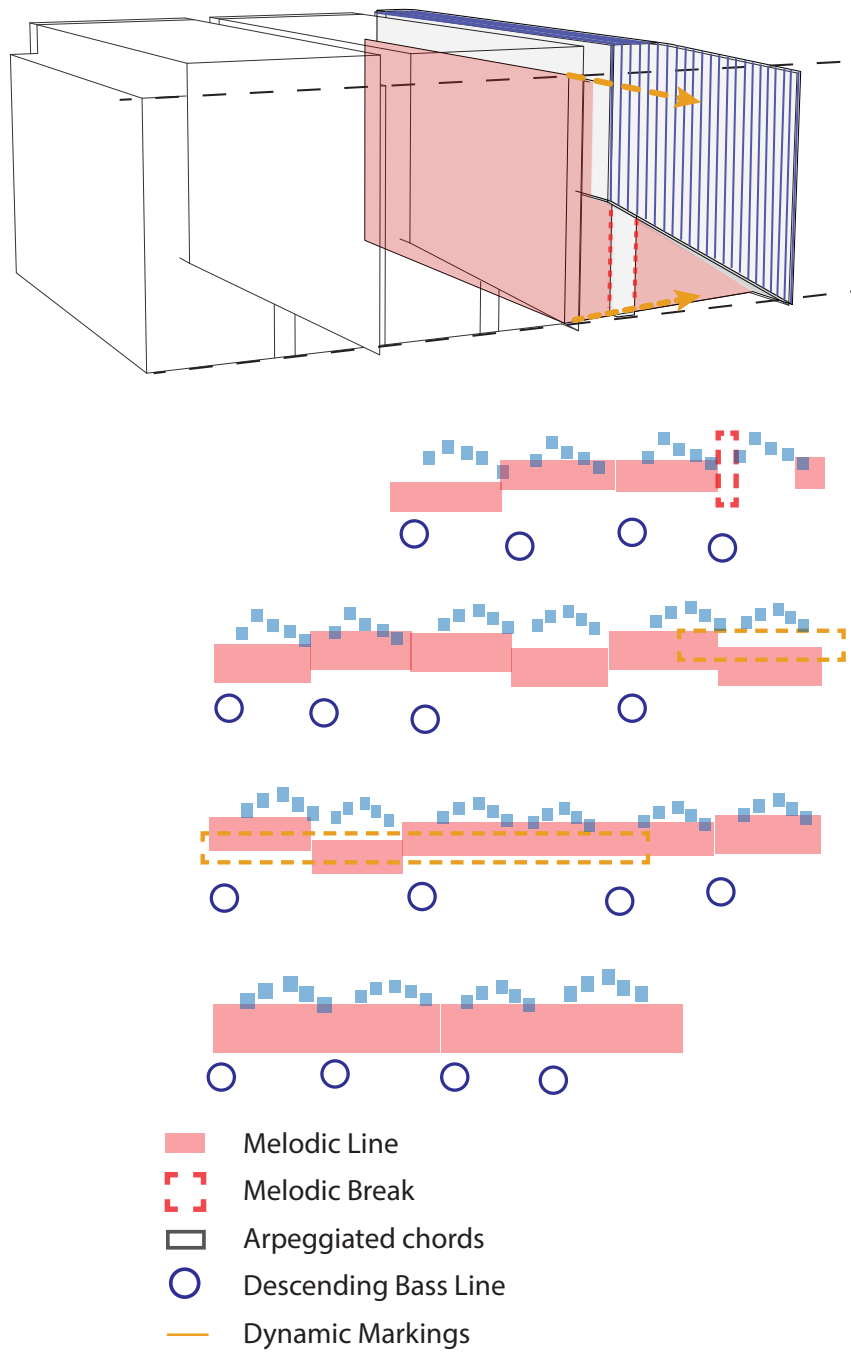


Figure 85: Thematic Transformations - Second "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 13-23. Public Domain.

This transformation generally follows the melodic line. The long decrescendo beginning in measure 17 indicated a gradually smaller space.

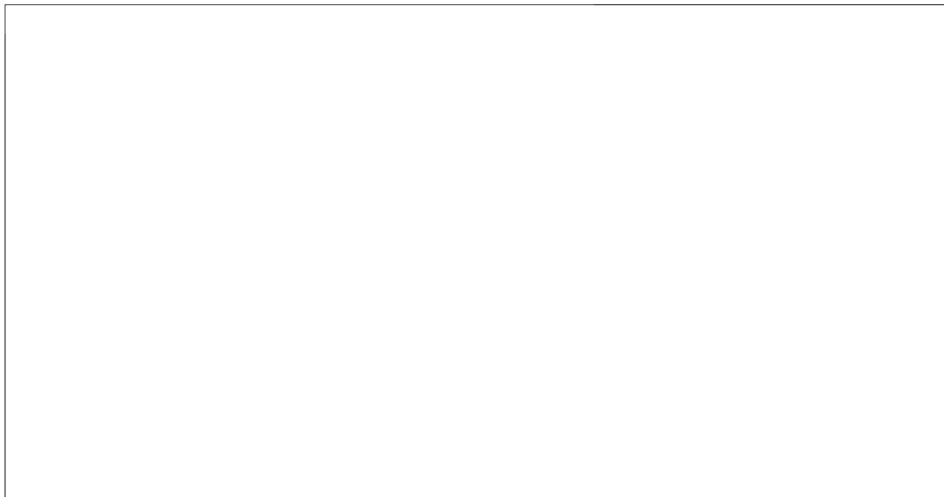
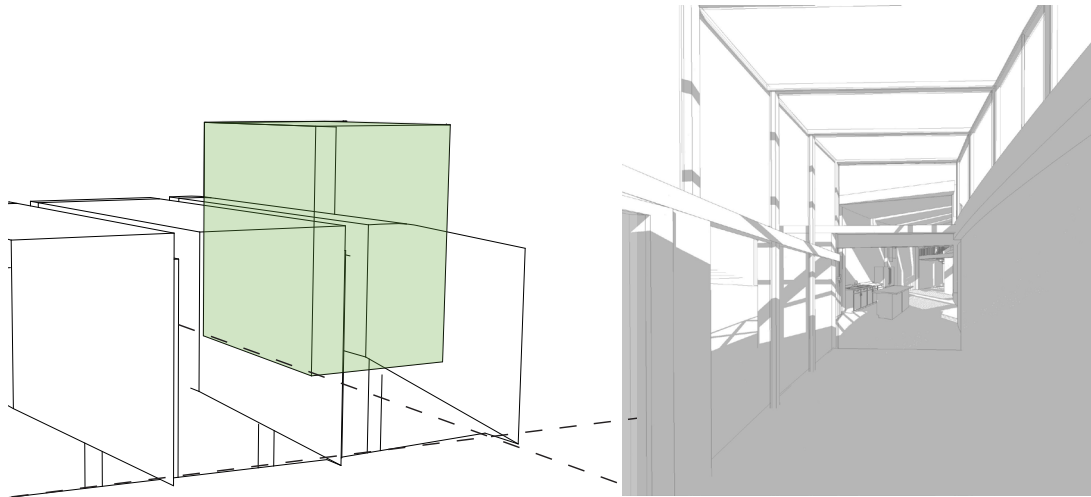
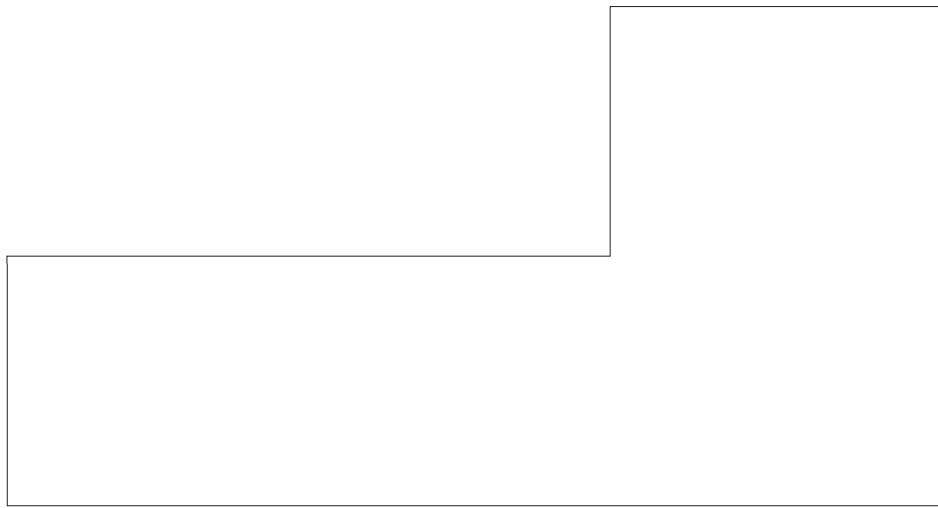
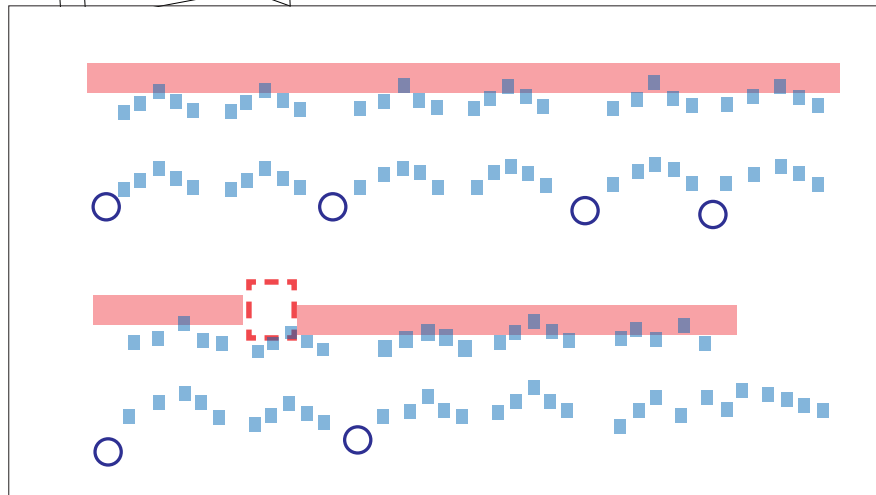
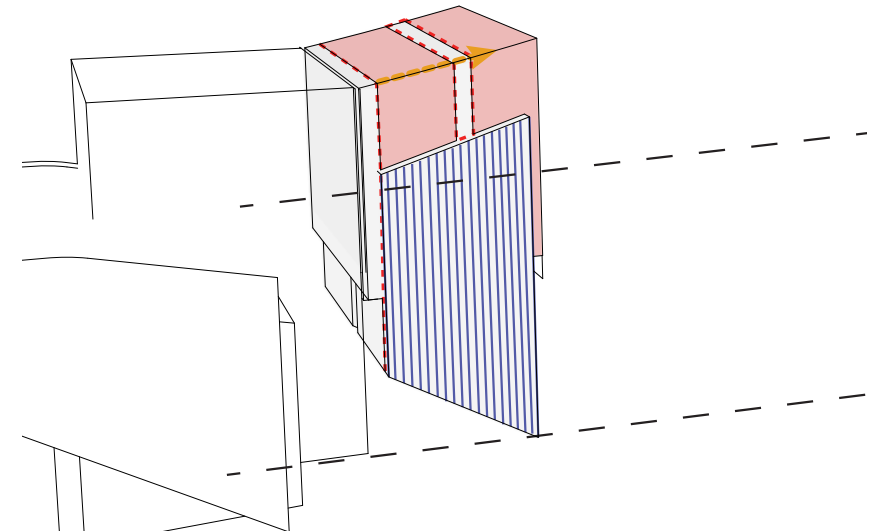


Figure 86: Thematic Transformations - Transition Section
Franz Liszt, Liebesträume No. 3 - mm. 24-26. Public Domain.

This ornamental section runs up and down the scale, transitioning from the introductory theme and its repetitions into the next section, which is played in a different key.





- Melodic Line
- Melodic Break
- Arpeggiated chords
- Descending Bass Line
- Dynamic Markings

Figure 87: Thematic Transformations - Third "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 27-32. Public Domain.

In this "variation", the melody enters at a higher register, in a different key. The accompaniment is now played at a pitch below the melody, are joined by another voice that comes in with the left hand.

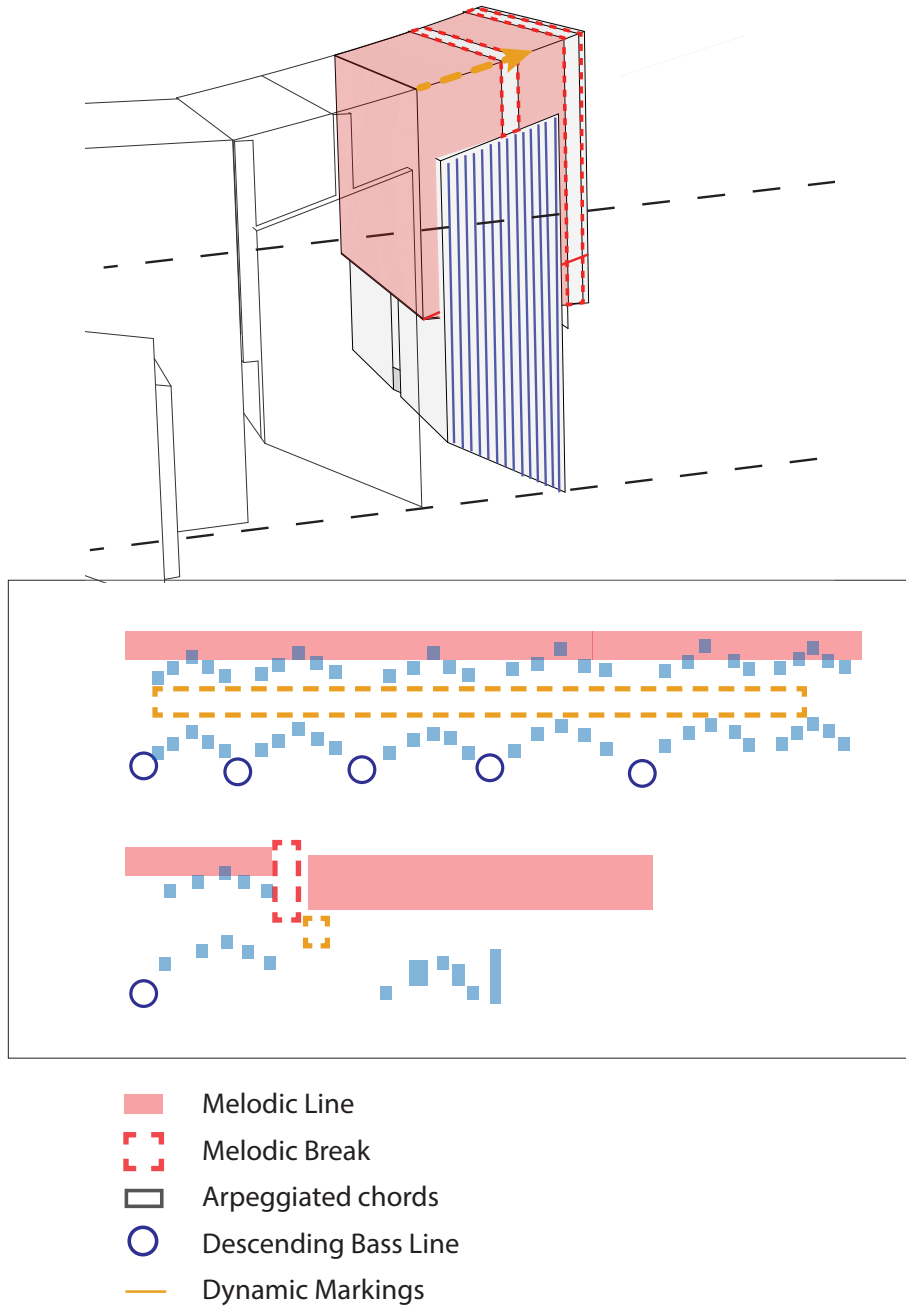


Figure 88: Thematic Transformations - Fourth "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 33-37. Public Domain.

This variation repeats the previous one, continuously growing louder, as marked by the crescendo in the score. The section ends in forte.

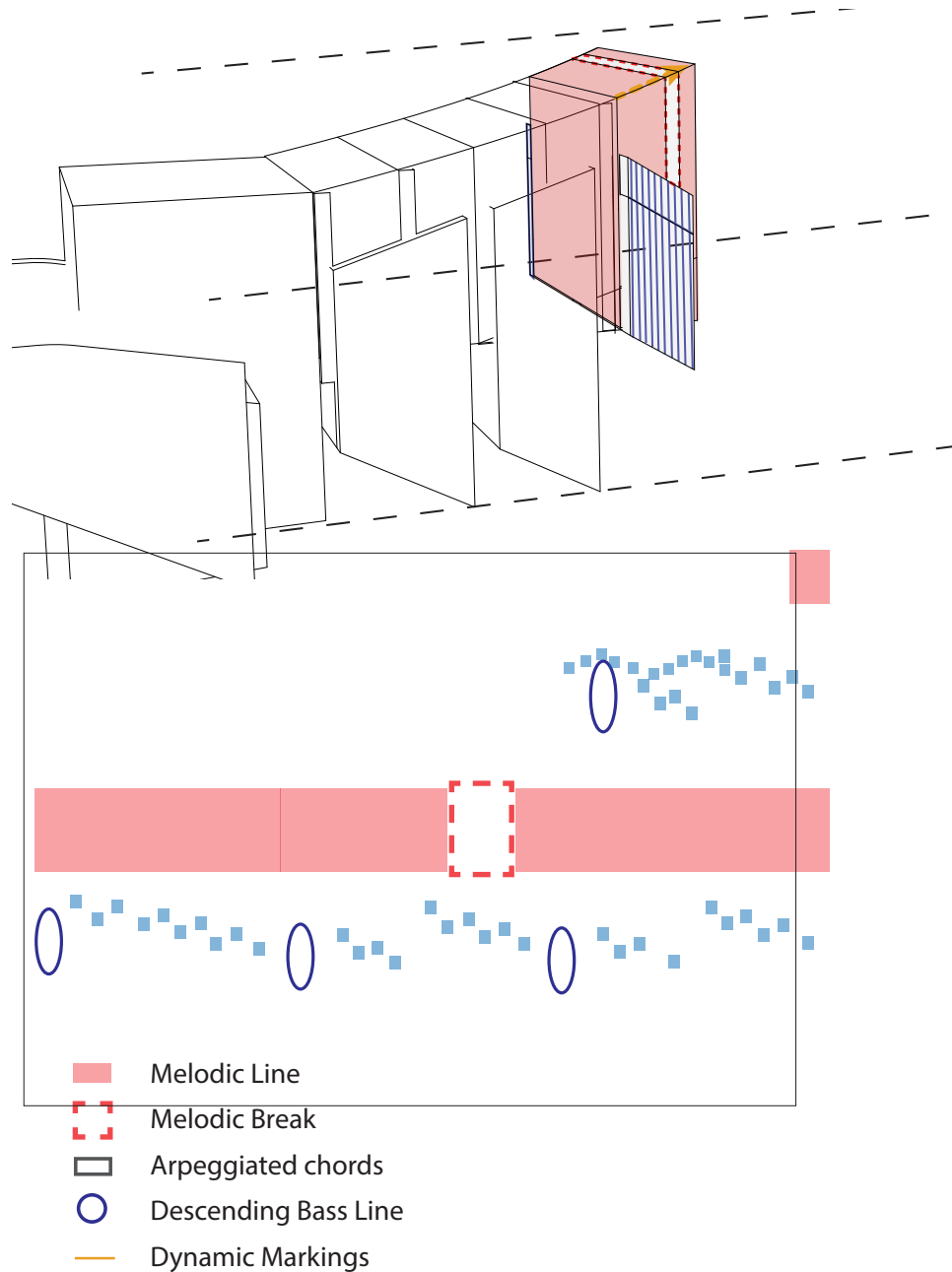
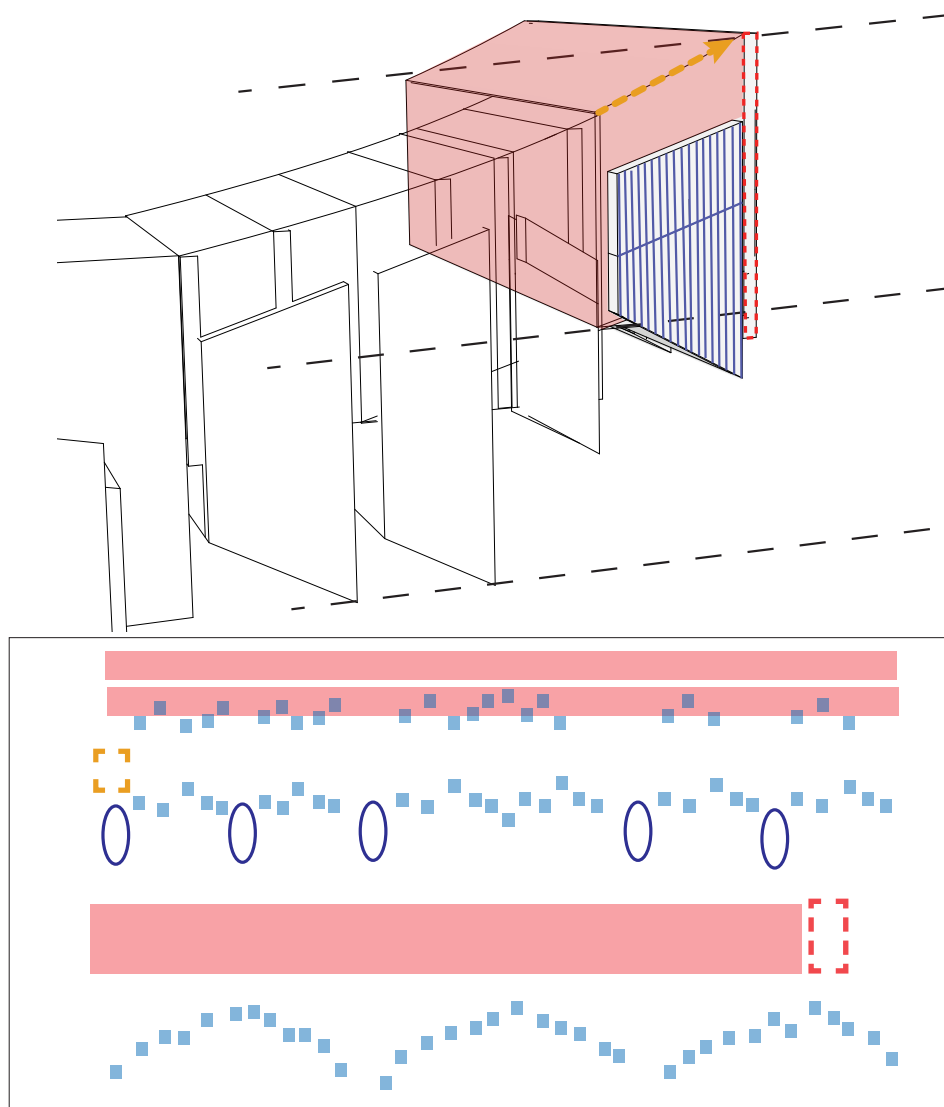


Figure 89: Thematic Transformations - Fifth "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 38-41. Public Domain.

This shorter variation continues to grow in loudness and tempo. The accompaniment still consists of arpeggiated chords played at the same tempo as previous variations, however these are arranged in a descending manner within each chord change.



- Melodic Line
- Melodic Break
- Arpeggiated chords
- Descending Bass Line
- Dynamic Markings

Figure 90: Thematic Transformations - Sixth "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 42-47. Public Domain.

This section grows in volume, with the FF marking doubling the previous space, the melodic line is doubled an octave, indicating a higher pitched space.

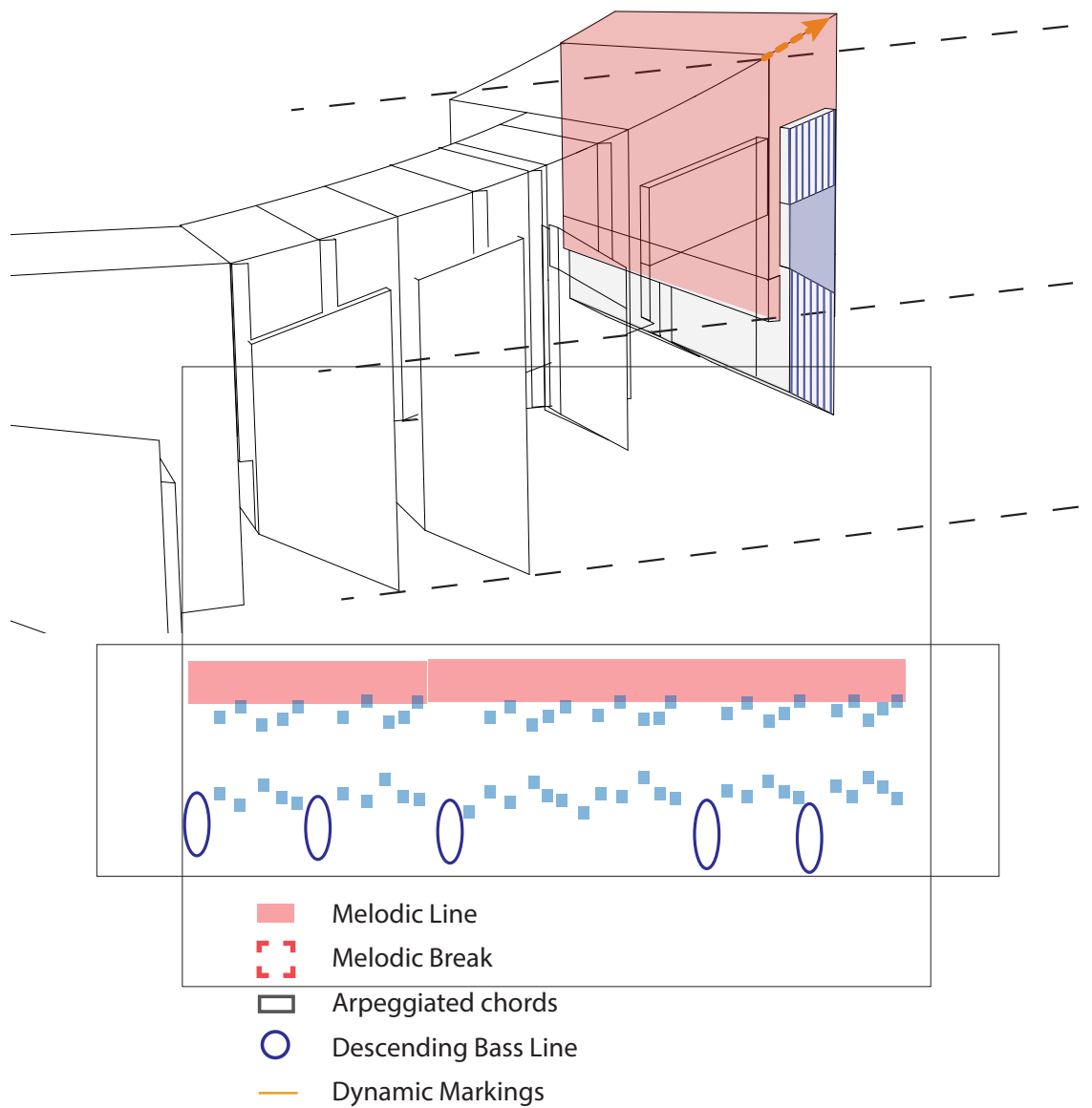
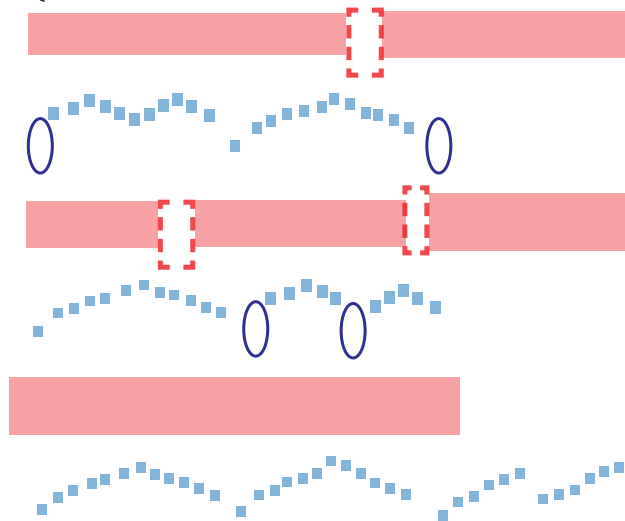
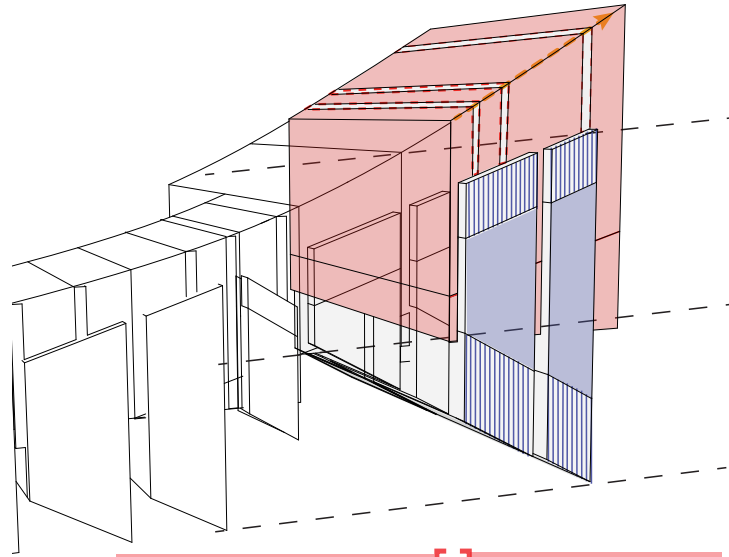


Figure 91: Thematic Transformations - Seventh "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 48-50. Public Domain.

This short section leads to the climactic moment that is revealed in the next module. The pitch seems to ascend as the tempo and volume grow.



- Melodic Line
- Melodic Break
- Arpeggiated chords
- Descending Bass Line
- Dynamic Markings

Figure 92: Thematic Transformations - Eighth "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 51-59. Public Domain.

This "Variation" encompasses the climax of the piece, being the loudest, and most dense section of the piece. The melodic line is doubled throughout the section.

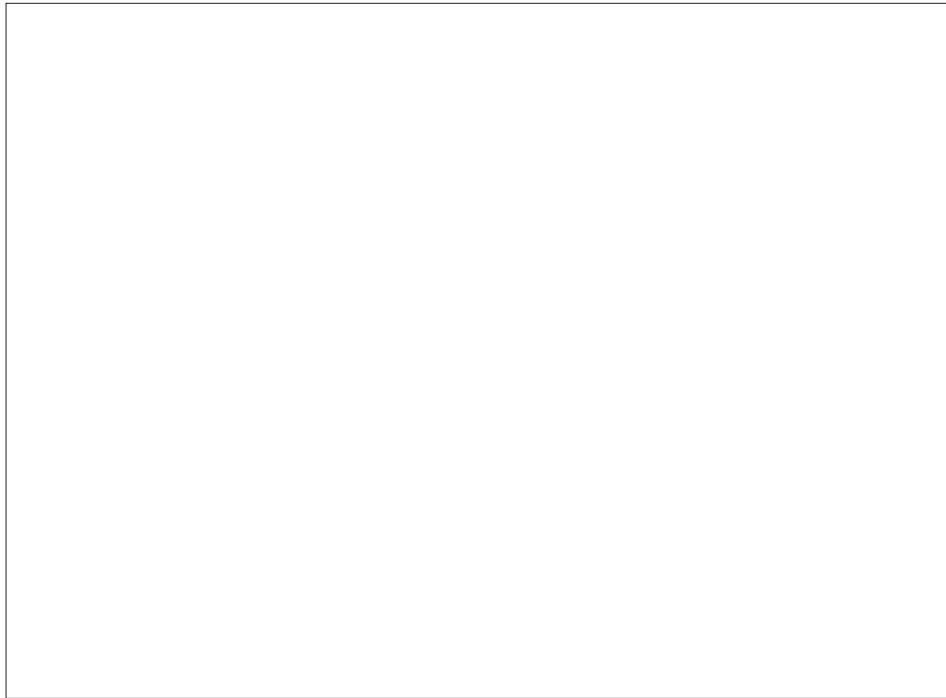
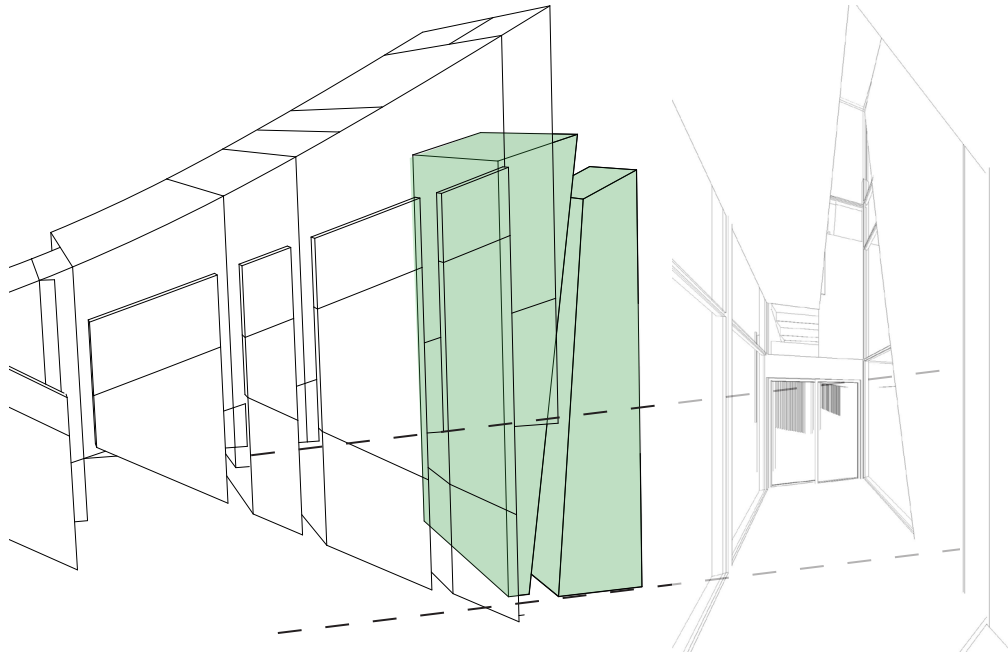


Figure 93: Thematic Transformations - Transitional Section
Franz Liszt, Liebestraum No. 3 - mm. 60-61. Public Domain.

Second transitional section exhibits runs that descend to the next section.

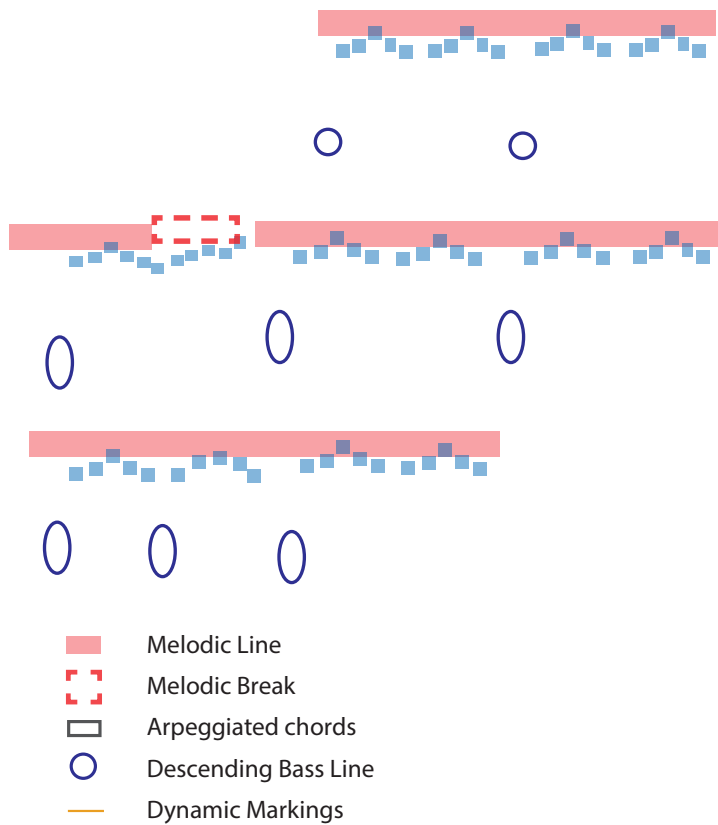
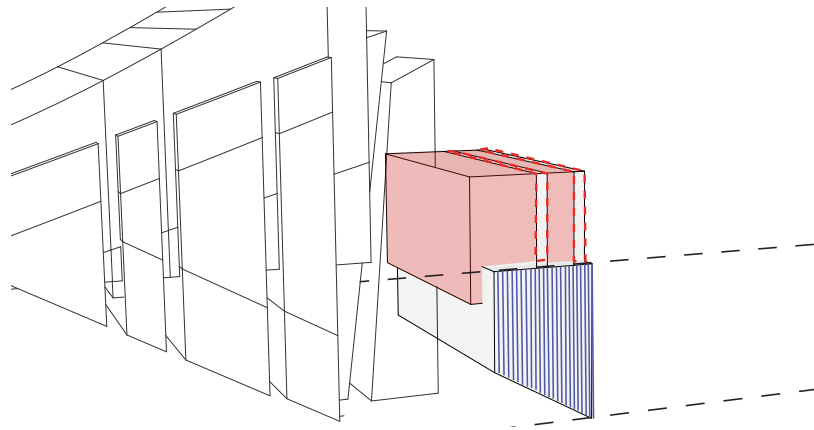
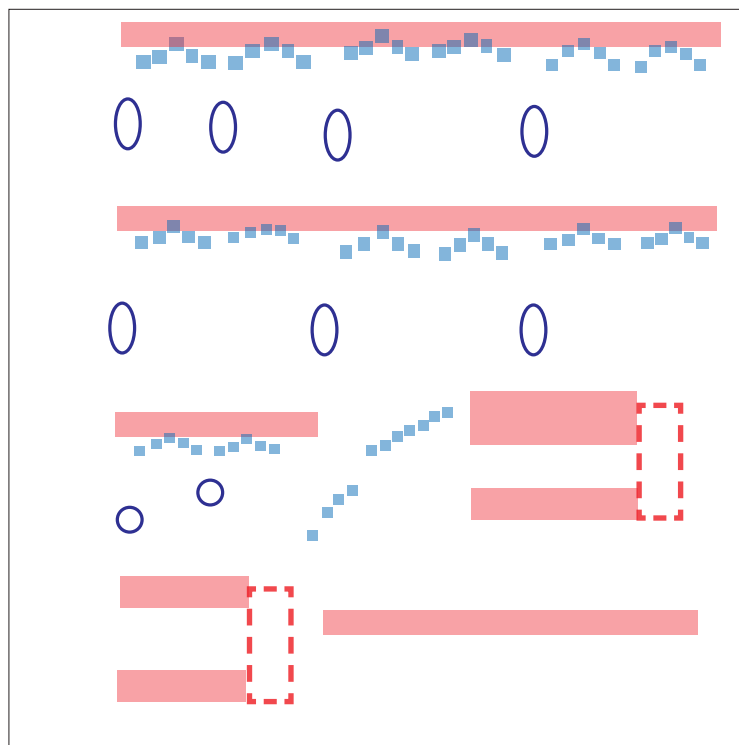
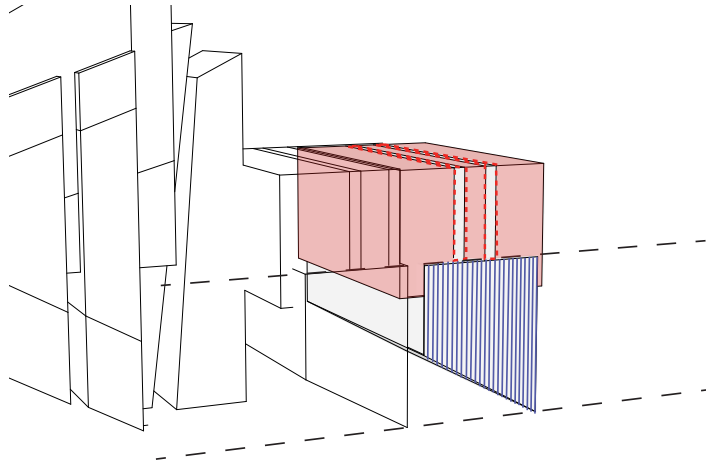


Figure 94: Thematic Transformations - Ninth "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 62-68. Public Domain.

The transitional sequence leads directly into the next section, which is a restatement of the original theme. The exception to the original theme is that the melody is played in a higher octave. Also, a few ornamental notes appear above the melody.



- Melodic Line
- Melodic Break
- Arpeggiated chords
- Descending Bass Line
- Dynamic Markings

Figure 95: Thematic Transformations - Final "Variation"
 Franz Liszt, Liebestraum No. 3 - mm. 69-83. Public Domain.

The conclusion of the song begins by as an echo of the previous section and ends with a quiet reprise.

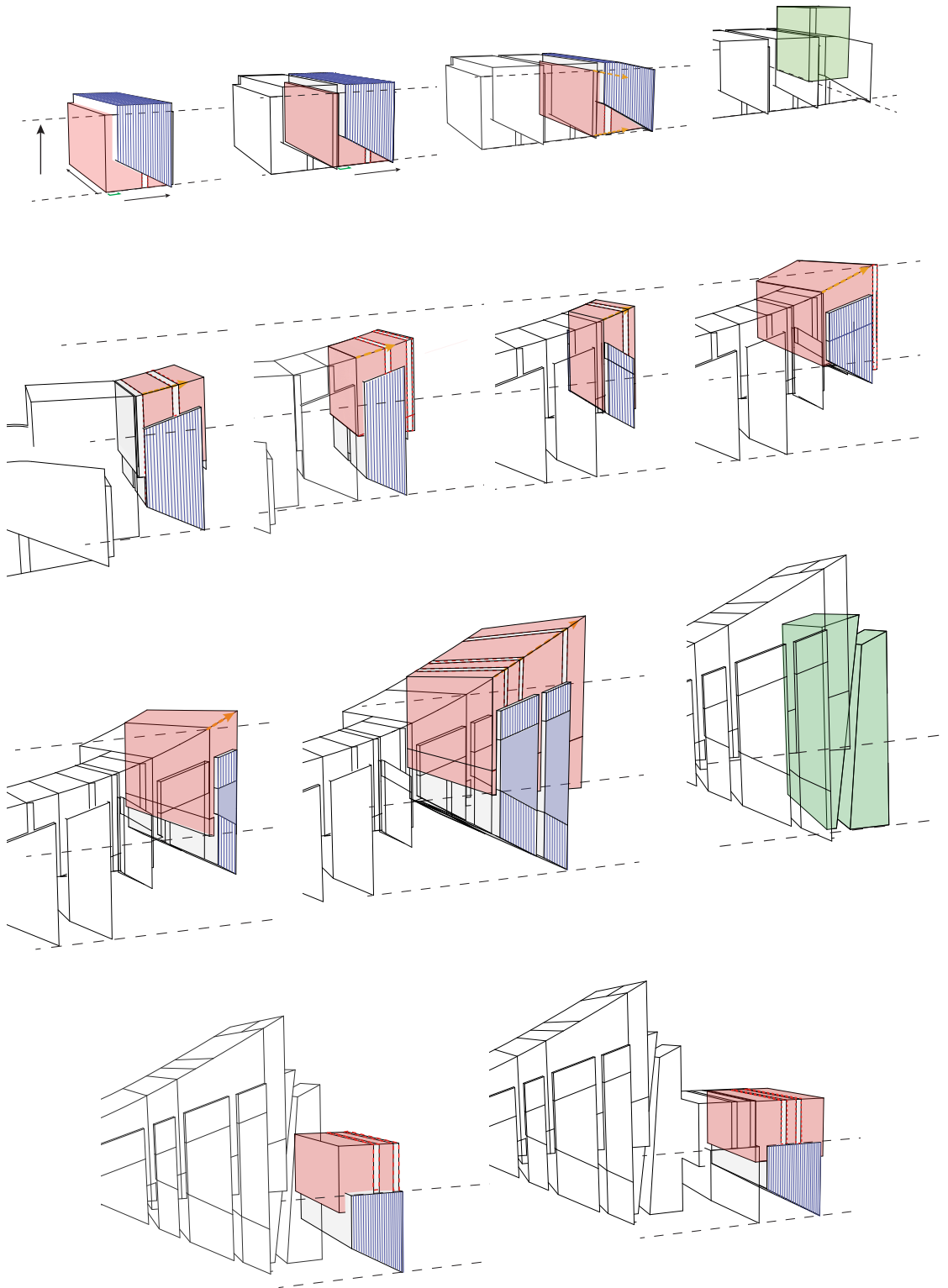
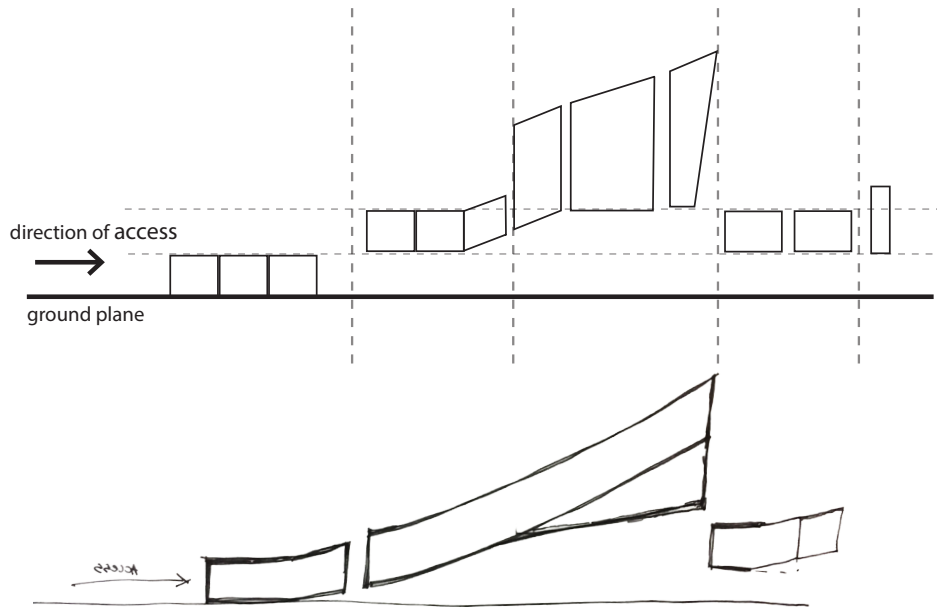
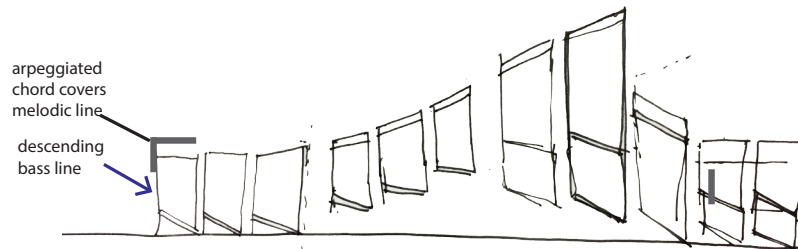


Figure 96: Summary of Thematic Transformations

Below is a summary of the overall movement of each voice:



Overall movement of the melodic / Thematic line follows general shape of thematic modules



Overall movement of the Accompaniment and bass line

The bass line and grouped chords appear to be separate entities, but are structurally part of the same chord, so they will be distinguished, but also connected in the harmonic representation above.



Massing the Transitional Spaces - Musical flourishes in between themes

Figure 97: Overall movement of each voice

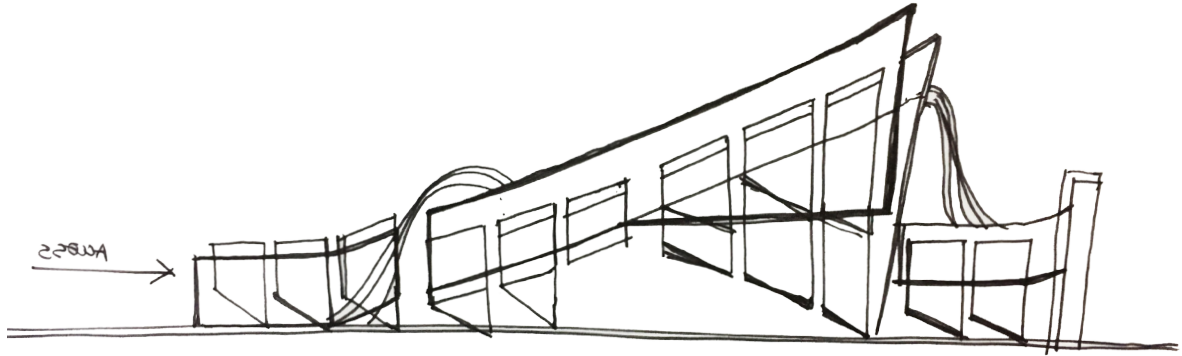


Figure 98: Combined massing

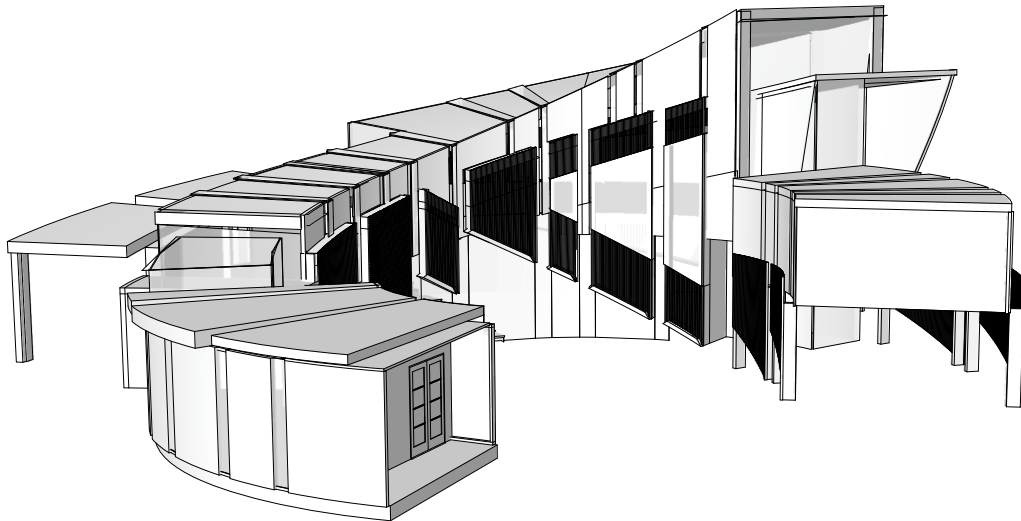


Figure 99: Perspective view of the combined massing

Tonality

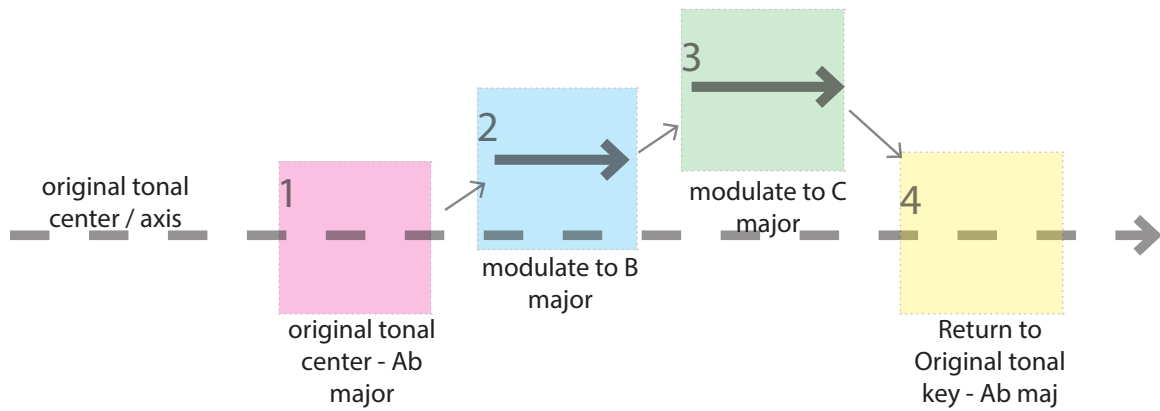
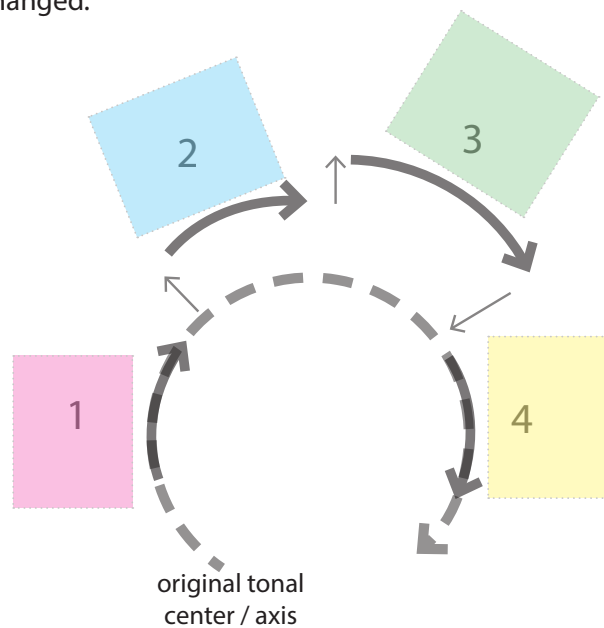


Figure 101: Modulation throughout piece

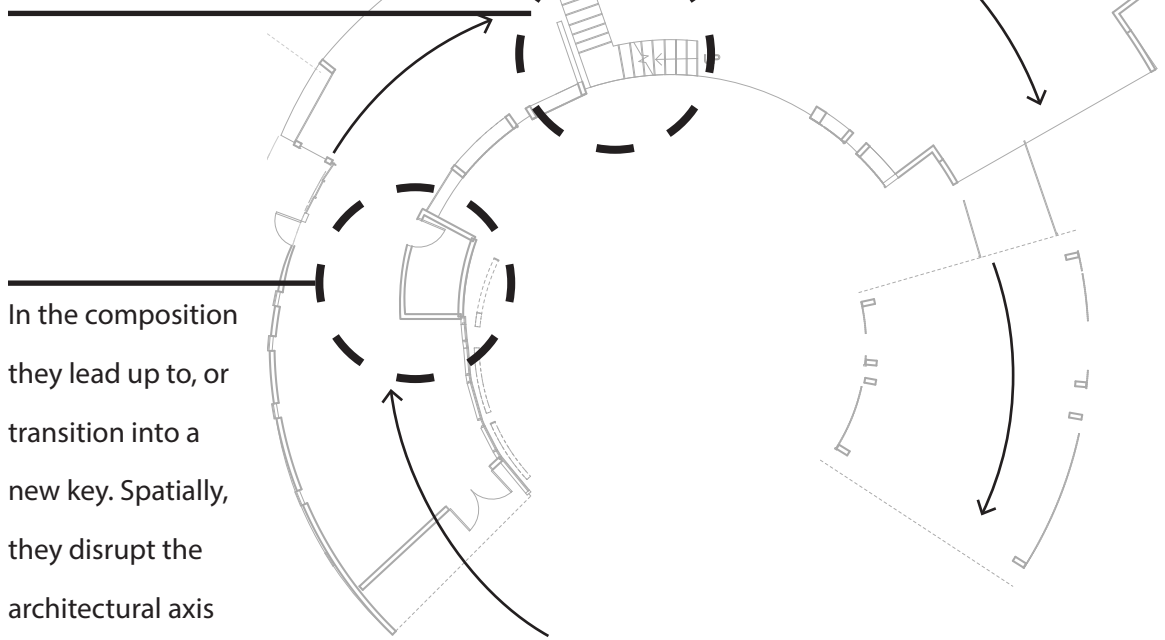
The piece modulates to three different keys, indicating an axial shift every time the key signature changes. The directionality of the circulation stays the same since the theme itself remains unchanged.

Figure 100: Return to Tonal Center

The axis is then bent into a circular shape, with subsequent modulations following the shape of the original axis. The circular axis is reflective of the return to the composition's original key signature.



"axis modulators"
indicated in the
composition by musical
sequences that are
followed by a key
change



In the composition
they lead up to, or
transition into a
new key. Spatially,
they disrupt the
architectural axis
and lead into a
shift in circulation
that reflects the
shift in key.

Figure 102: Axis Modulators within Floor Plan

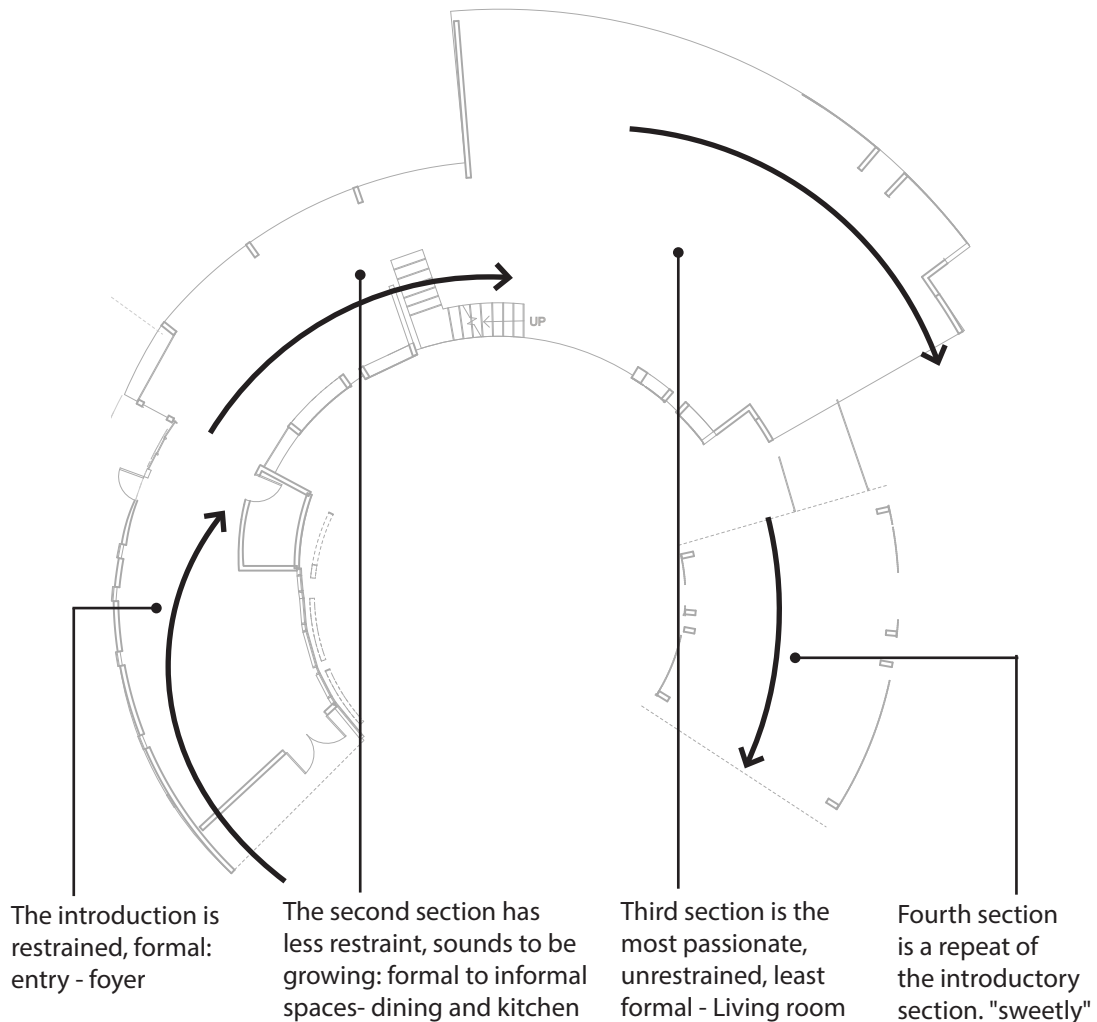


Figure 103: Sequential Movement through first floor plan

With each subsequent thematic transformation, the markings and dynamics of the composition indicate an increase in speed and passion. Liszt marks this as "always increasing" and "gradually more passionate". This is a move away from the initial quiet, sweet, and restrained melody that is introduced in the theme. There is a formality that accompanies the restraint in the beginning of the song. And as the theme is transformed multiple times, is shown to be more personal and passionate. Spatially, we might relate this to the transition from formality to more personal, unhindered spaces that follow. Formality and unhindrance in the composition would correlate to use in terms of its movement from guest to living spaces.

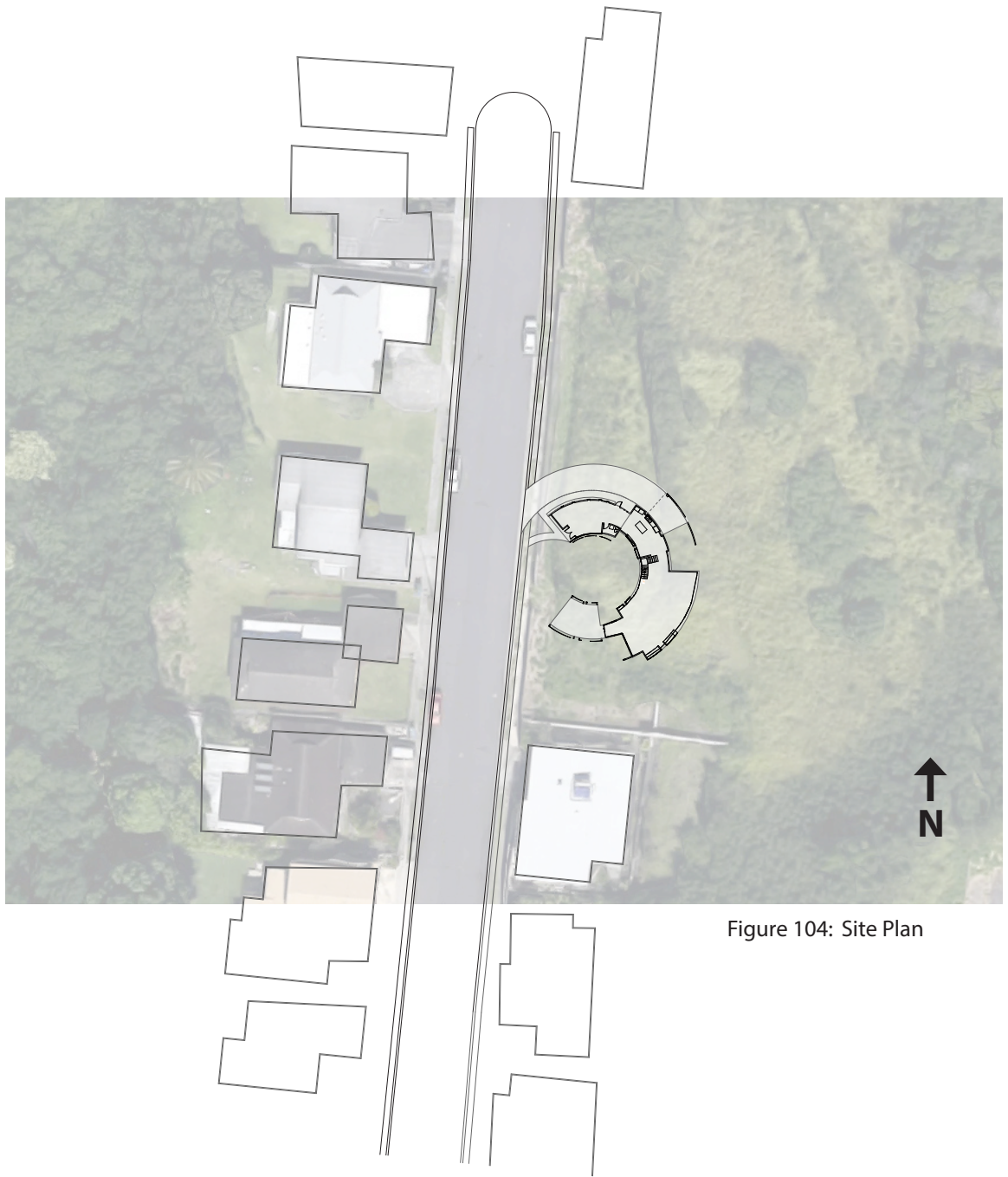
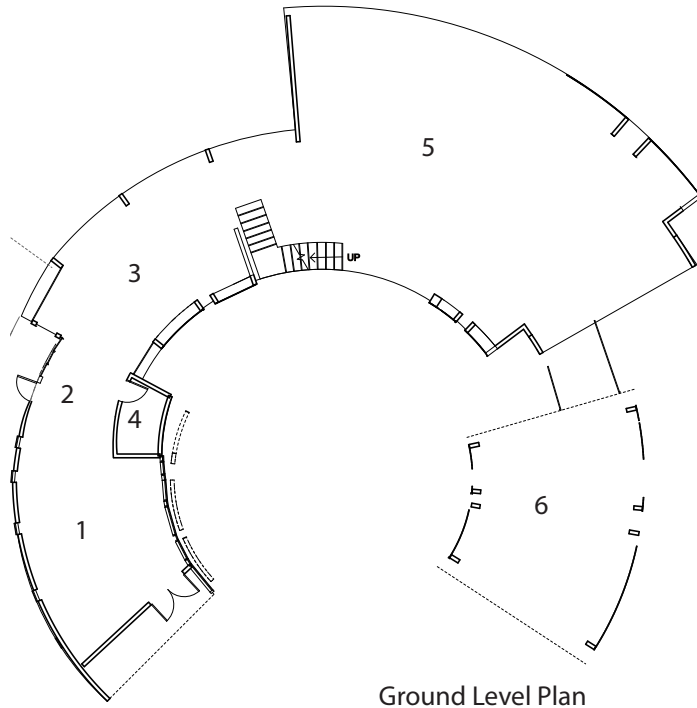
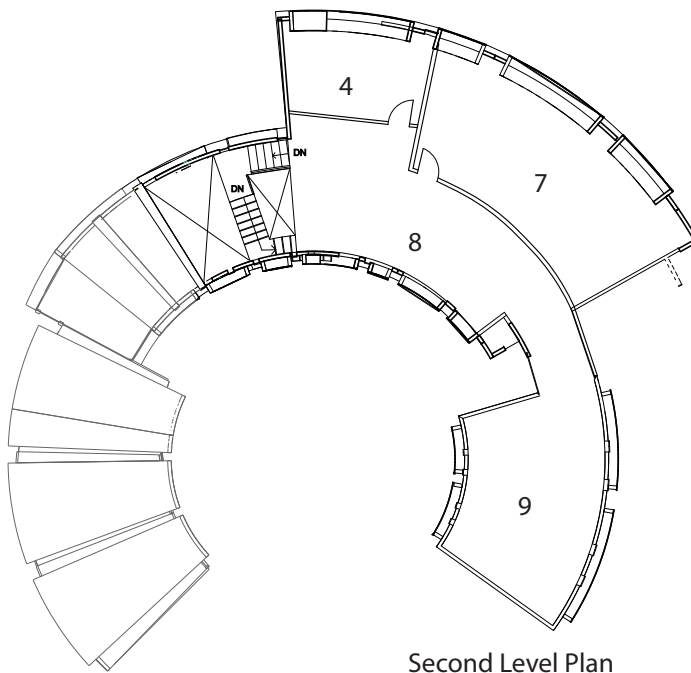


Figure 104: Site Plan



Ground Level Plan



Second Level Plan

- 1. Entry / Foyer
- 2. Side Entry
- 3. Kitchen / Dining
- 4. Bathroom
- 5. Living
- 6. Covered Exterior area
- 7. Bedroom
- 8. Hall
- 9. Multi-use room



Figure 105: Final Floor Plans



Figure 106: Entry Foyer, First section

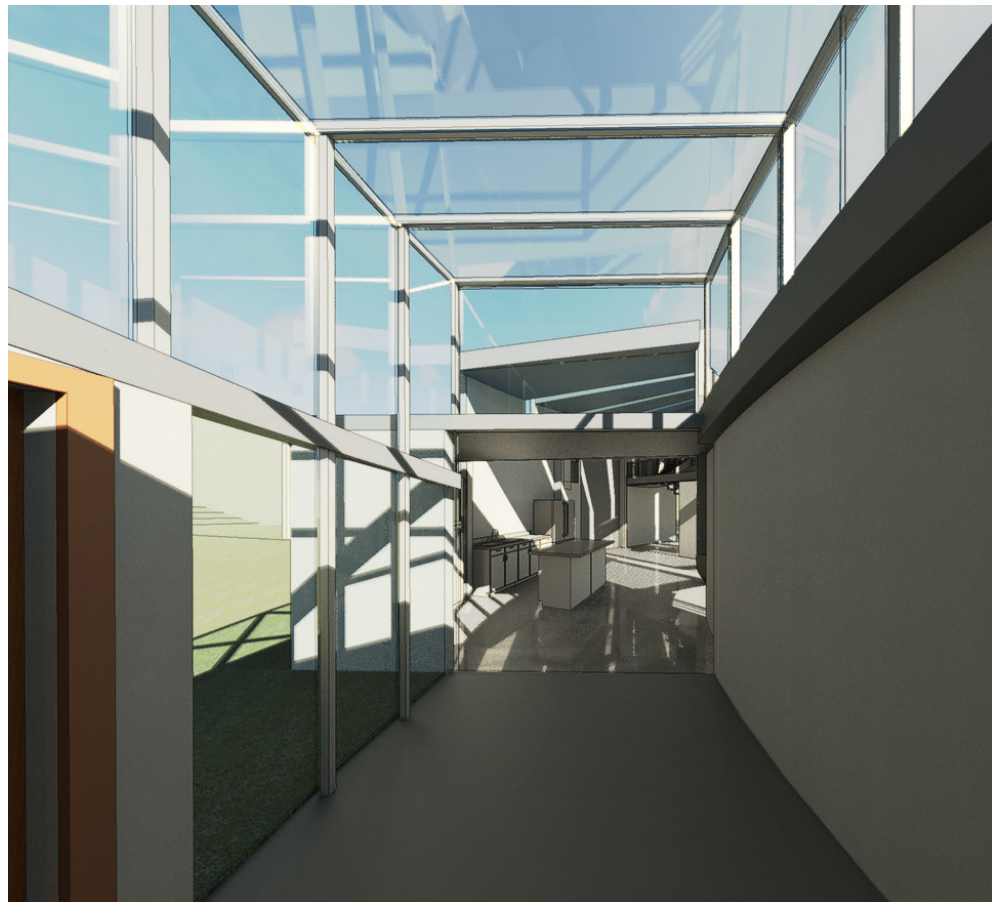


Figure 107: Carport Entry, Transitional section

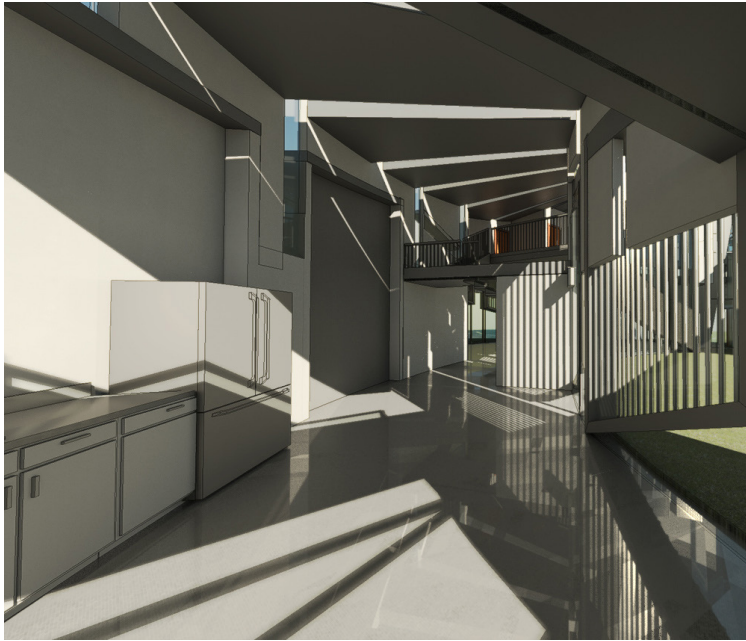


Figure 108: Kitchen and Dining, Second Section



Figure 109: Lanai Exit,
Transitional section

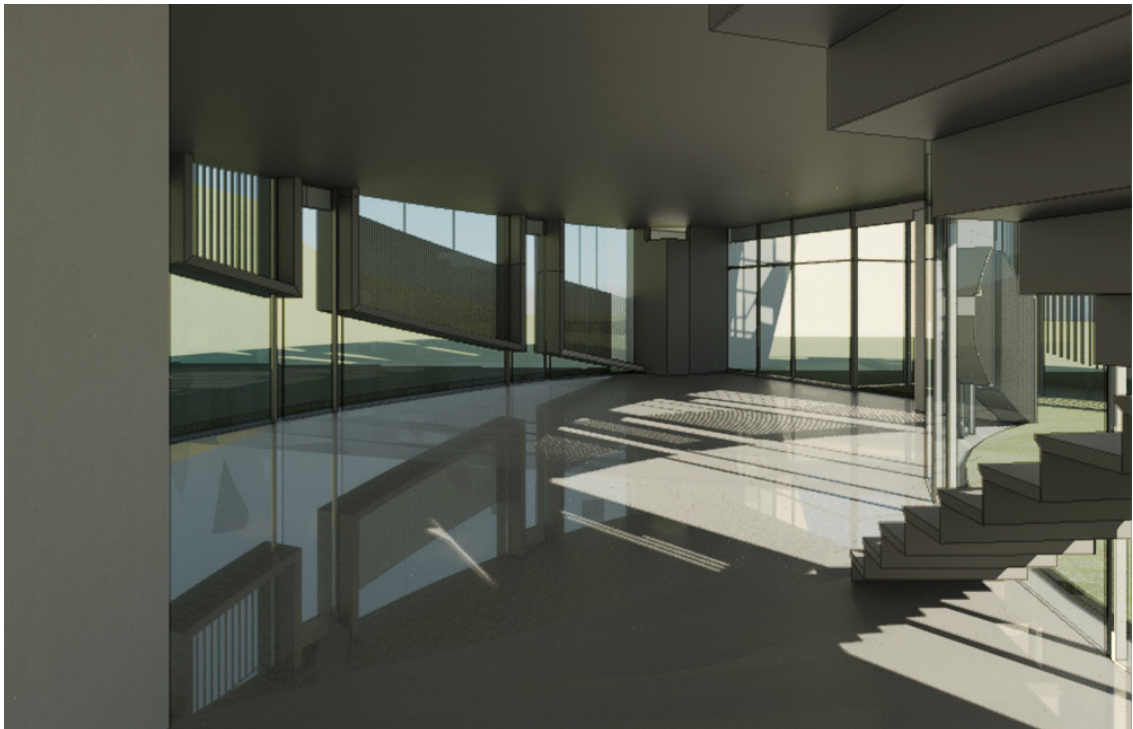


Figure 110: Living Room, Third Section



Figure 111: Second Floor Hall, Third Section



Figure 112: Bedroom, Fourth Section



Figure 113: Exterior Perspective -- Approach



Figure 114: Exterior Perspective

BIBLIOGRAPHY

- Arnheim, Rudolf. *The Dynamics of Architectural Form*. Los Angeles: University of California Press, 1977.
- Bach, J.S. "BWV 780 Invention". Teoria.com. <https://www.teoria.com/en/reference/i/invertible-counterpoint.php>. Accessed May 7, 2015.
- Bach, J.S. "Violin Partita No. 2 in D Minor, Chaconne". From Public Domain. ed. Alfred Dorffel. Leipzig: Breitkopf und Hartel, 1879. http://imslp.org/wiki/Violin_Partita_No.2_in_D_minor,_BWV_1004_%28Bach,_Johann_Sebastian%29. Accessed May 7, 2015.
- Baker, Geoffrey. *Le Corbusier: An Analysis of Form*. New York: Spon Press, 1996.
- Bartok, Bela. "Music for Strings, Percussion and Celesta." From Public Domain. New York: Boosey & Hawkes, 1939. http://imslp.org/wiki/Music_for_Strings,_Percussion_and_Celesta,_Sz.106_%28Bart%C3%B3k,_B%C3%A9la%29. Accessed May 7, 2015.
- Berry, Wallace. *Form in Music: An Examination of Traditional Techniques of Musical Form and their Applications in Historical and Contemporary Styles*. New Jersey: Prentice-Hall, Inc., 1986.
- Bishop, Philip. "Theory Ornaments". Mole Valley Music. <http://www.molevalleymusic.co.uk/TheoryGradeOrnaments.htm>. Accessed May 7, 2015.
- Boecklin, Arnold. "Isle of the Dead". 1880. Artchive. Accessed November 8, 2015. http://www.artchive.com/artchive/B/boecklin/isle_of_the_dead.jpg.html.
- Capanna, Alessandra. "Music and Architecture: A Cross Between Inspiration and Method". *Nexus Network Journal* 11 (2009): 257-272
- Christ, William, Richard DeLone, Vernon Kliewer, Lewis Rowell and William Thompson. *Materials and Structure of Music, Volume 1*. New Jersey: Prentice Hall, Inc., 1972.
- Christ, William, Richard DeLone, Vernon Kliewer, Lewis Rowell and William Thompson. *Materials and Structure of Music, Volume 2*. New Jersey: Prentice Hall, Inc., 1972.
- Clarke, Joseph. "Iannis Xenakis and the Philips Pavilion" *The Journal of Architecture* 17 (2012) 213-229. Accessed April 7, 2015. doi: 10.1080/13602365.2012.678641
- Cochrane, Tom. "Composing the expressive qualities of music" in *The emotional power of music: multidisciplinary perspectives on musical arousal, expression, and social control* (Oxford: Oxford University Press: 2013).

- Douek, Joel. "Music and Emotion – A Composer's Perspective" *Frontiers in Systems Neuroscience* 7 (2013): 1, July 14, 2016, doi: 10.3389/fnsys.2013.00082
- Elgar, Edward. "Variations on an Original Theme 'Enigma', Op. 36." From Public Domain. Mineola: Dover Publications, 1992.
- Eitan, Zohar. "How Pitch and Loudness Shape Musical Space and Motion" in *The Psychology of Music in Multimedia*. United Kingdom: Oxford University Press, 2013.
- Fontaine, Paul. *Basic Formal Structures in Music*. New York: Meredith Publishing Company, 1967.
- Gillespie, John. *The Musical Experience*. California: Wadsworth Publishing Company, Inc., 1968.
- Goetschius, Percy. *The Larger Forms of Music Composition: An Exhaustive Explanation of the Variations, Rondos and Sonata Designs, for the General Student of Music Analysis, and for the Special Student of Structural Composition*. New York: G. Schirmer, Inc., 1915.
- Green, Douglass. *Form in Tonal Music: An Introduction to Analysis*. New York: Holt, Rinehart and Winston, Inc., 1965.
- Gurewitsch, Matthew. "Music; a Visual Requiem That Inspired Rachmaninoff" *The New York Times*, January 6, 2002. Accessed November 8, 2015. <http://www.nytimes.com/2002/01/06/arts/music-a-visual-requiem-that-inspired-rachmaninoff.html?pagewanted=all>
- Higgins, L.N., "Music and Architecture", *The Musical Times*, 66 (1925):509-510. Accessed March 28, 2015. <http://www.jstor.org/stable/912830>.
- Hildebrand, Grant. *The Wright Space Pattern and Meaning in Frank Lloyd Wright's Houses*. Seattle: University of Washington Press, 1991.
- Hodges, Wilfrid. "The Geometry of Music," in *Music and Mathematics: From Pythagoras to Fractals*. ed. John Fauvel, Raymond Flood and Robin Wilson, 91-112. New York: Oxford University Press, Inc., 2003.
- "Honolulu Land and Information System," accessed October 29, 2016, <http://gis.hicentral.com/>
- Holl, Steven. "Architectonics of Music," *32BNY*, Accessed April 1, 2015, <http://architectonicsofmusic.com/am>

- Jencks, Charles. "Architecture Becomes Music". *Architectural Review* 233, no. 1395 (2013): 91-108
- Karlin, Fred and Rayburn Wright. *On the Track: a Guide to Contemporary Film Scoring*. New York: Routledge, 2004.
- LaBelle, Brandon. *Acoustic Territories: Sound Culture and Everyday Life*. New York: Continuum, 2010.
- Lam, William. *Perception and Lighting as Formgivers for Architecture*. New York: McGraw-Hill, Inc, 1977.
- March, Lionel and Philip Steadman. *The Geometry of Environment: An Introduction to Spatial Organization in Design*. Cambridge: MIT Press, 1974.
- Merriam-Webster's Collegiate Dictionary. 11th ed. Springfield, MA: Merriam-Webster, 2003. Also available at <http://www.merriam-webster.com/>
- Morgan, Robert. "Musical Time/Musical Space". *Critical Inquiry*, 6 no. 3 (1980): 527-538. Accessed March 11, 2015. <http://www.jstor.org/stable/1343107>.
- Mozart, Wolfgang Amadeus. "12 Variations on 'Ah, Vous Dirai-Je Maman'". Public Domain. ed. Louis Kohler and Adolf Ruthardt. *Variationen fur Pianoforte Solo, 24-30*. Leipzig: C.F. Peters, n.d. Plate 6695. http://imslp.org/wiki/12_Variations_on_%22Ah,_vous_dirai-je_maman%22,_K.265/300e_%28Mozart,_Wolfgang_Amadeus%29. Accessed May 7, 2015.
- Newman, William. *Understanding Music: An Introduction to Music's Elements, Styles, and Forms--for both the Layman and the Practitioner*. New York: Harper & Row, Publishers, 1961.
- "Nocturnes: Claude Debussy". LA PHIL. Accessed November 8, 2015. <http://www.laphil.com/philpedia/music/nocturnes-claude-debussy>
- Ojeda, Oscar Riera, ed., *The New American House: Innovations in Residential Design and Construction*. New York: Whitney Library of Design an imprint of Watson-Guption Publications, 1995.
- Pater, Walter. *The Renaissance*. Toronto: Random House, Inc., 1919.
- Reti, Rudolf. *The Thematic Process in Music*. London: Faber and Faber, 1961.

- Rosenfield, Karissa. "Video: A Conversation with Steven Holl inside the Daeyang Gallery & House" 10 Jul 2012. ArchDaily. Accessed 07 May 2015. <<http://www.archdaily.com/?p=253378>>
- Schwarm, Betsy. "The Hebrides, Op. 26: Overture by Mendelssohn". Encyclopedia Britannica. Accessed November 8, 2015. <http://www.britannica.com/topic/The-Hebrides-Op-26>
- Shinn, Duane. "The Story of Franz Liszt's 'Liebestraum,'" June 2, 2008, <http://ezinearticles.com/?The-Story-of-Franz-Liszts-Liebestraum&id=1219318>
- Sterken, Sven. "Music as an Art of Space: Interactions between Music and Architecture in the Work of Iannis Xenakis," in *Resonance: Essays on the Intersection of Music and Architecture*. ed. Mikesch Muecke and Miriam Zach, 21-51. Ames: Culicidae Architectural Press, 2007
- Spencer, Peter and Peter M. Temko. *A Practical Approach to the Study of Form in Music*. New Jersey: Prentice-Hall, Inc, 1988.
- Steven Holl Architects. *Stretto House*. New York: The Monacelli Press, Inc., 1996.
- "Stretto House". Steven Holl Architects, accessed March 3, 2015, <http://www.stevenholl.com/project-detail.php?id=26>
- Schweitzer, Vivien. "When Bach Laid Bare His Own Soul", *New York Times*, October 21, 2011, Accessed April 13, 2015, http://www.nytimes.com/2011/10/23/arts/music/jennifer-koh-to-play-bachs-partitas-and-sonatas.html?_r=1
- Tan, Siu-Lan, Annabel J. Cohen, Scott D. Lipscomb and Roger A. Kendall, ed. *The Psychology of Music in Multimedia*. United Kingdom: Oxford University Press, 2013.
- "The Jewish Museum, Berlin" *The Guardian*, October 11, 2007. <http://www.theguardian.com/artanddesign/2007/oct/11/architecture.museums>
- "Theory over Famous Mendelssohn 'Fingal's Cave' Overture" *BC News*. December 16, 2010. Accessed November 8, 2015. <http://www.bbc.com/news/uk-scotland-glasgow-west-12008512>
- Thorpe Davie, Cedric. *Musical Structure and Design*. London: Dennis Dobson, 1953.
- Unwin, Simon. *Analysing Architecture*. London: Routledge, 2014.
- Vergo, Peter. *That Divine Order: Music and the Visual Arts from Antiquity to the Eighteenth Century*. London: Phaidon Press Limited, 2005
- Vitruvius. *The Ten Books on Architecture*. trans. Morris Hicky Morgan. New York: Dover Publications Inc., 1960

Von Simson, Otto. *The Gothic Cathedral*. New York: Bollingen Foundation Inc., 1956

Williams, Glenn. "Translating Music into Visual Form: The Influence of Music in the Work of Bertram Brooker." *Canadian Art Review* 27 (2000) 111-122. Accessed March 27, 2015. <http://www.jstor.org/stable/42631208>.

Xenakis, Iannis. *Formalized Music: Thought and Mathematics in Music*. New York: Pendragon Press, 1992

Xenakis, Iannis. *Music and Architecture: Architectural Projects, Texts, and Realizations*. New York: Pendragon Press, 2001