Architecture is not solely the design of buildings, nor is it purely one type of art; it can take many forms and engage all the senses. Architects design a space in time; in which place can reach its full potential. This is designed with the aspiration to achieve a sense of ordered unity. Very few forms of creation aspire to this form of metaphysical perfection in physical attributes.

Music is very similar to architecture, indeed, one could argue that the two are interchangeable by the insurmountable time required to create either in their purest form. Throughout history, many analogies have been made concerning music and architecture “along the narrow channels of interaction: number, rhythm, notation and proportion”. Just as one note can affect an entire song, one object can affect a room or even an entire building. Both are equally as difficult to begin as they are to complete.

With music and architecture’s intermeshed relationship, the tendency has been to perceive music as a metaphorical structure requiring translation into visual terms before becoming available to architecture. Architects have often attempted to relate the seemingly incompatible structures of music and architecture, by conveying its influence through their designs. This fascination

1 MARTIN, E. (Ed), Architecture as a Translation of Music, p57
can be seen from early philosophers and mathematicians such as Pythagoras and Plato, to the harmonic proportion systems of Alberti and Palladio, to contemporary musical buildings such as the Stretto House by Steven Holl. Each time musical influence is applied to architecture, the parameters of the transference alter; in the process, new understanding of the spatial, mathematical and temporal relationships between music and architecture is uncovered. By exploring the seam between music and architecture and its metaphorical representation within the built environment, new modes of formal translation and a new paradigm of musical space can be identified.

Music can be separated into three parts; rhythm, melody and harmony. Although these are not the sole considerations during the creation of music, everything within music will be related to one of these three aspects. Rhythm can be described as the organization of music in respect to time; the regular occurrence of beat, which gives a sense of movement. In architecture, rhythm “is a classical example of man’s special contribution to orderliness. It represents a regularity found nowhere in nature but only an order man seeks to create”. Although rhythm can be found throughout architecture such as the rhythm of classical columns, the vaults of gothic churches and the progression of repetitive housing, it is not musical in entirety. Architects such as Eric Mendelsohn and Frank Lloyd Wright often discussed music with relation to their architecture and an obvious use of rhythm can be viewed in their work, yet “architecture itself has no time dimension, no movement, and

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3 RASUMUSSEN, S.E., Experiencing Architecture, p 129
therefore cannot be rhythmic in the same way as music”. This statement is true for many aspects of the use of rhythm in architecture; therefore, this paper will not be greatly concerned with the discussion of musical rhythm in architecture. It should be noted however, where it is beneficial to this study, musical rhythm will be discussed, as it will present a greater understanding of the arguments and case studies provided.

Melody is concerned with the progression and “succession of notes, varying in pitch, which have a recognizable shape”; therefore rhythm is an important element in melody. Additionally, through its definition, melody is similar to harmony, yet has one distinctive difference; “Melody is horizontal i.e. the notes are heard consecutively, whereas in harmony notes are sounded simultaneously”. Although melody and harmony can be combined, melody is often considered more direct, as it does not require a complex musical relationship and is created by successive notes. Architecture is viewed as a whole, therefore melody, is rarely transferred to architecture. Furthermore, a melody can be harmonized, that is to say, the intervals between the notes used can remain consistent, yet the harmony of the piece can change.

This paper will predominantly discuss the metaphor of music in architecture through the musical device of harmony. Other similarities and metaphors outside of harmony, however, will be discussed where beneficial and

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4 ibid, pp 134-135
5 KENNEDY, M., Concise Dictionary of Music, p 469
6 ibid, p 469
necessary. This study will be restricted to a predominantly architectural investigation, only discussing the use and influence of architecture in music when it is beneficial to the understanding of a particular section of this study. The writings of musicians will be discussed in order to understand architecture musically. Additionally, there are many concepts of harmony; however, as this paper is concerned with the metaphor of music in architecture, it would be unwise to discuss them all during this paper. Hence, the scope of the discussion of harmony in this paper will be limited to the westernized concept of musical harmony.

This paper will begin with the discussion of creation, specifically the similarities between the creation of music and architecture. As the discussion progresses, it will attempt to discover a common bond in the creation of music and architecture. Furthermore, the investigation will highlight the key differences in the creation of architecture and music. This area of the study will be illustrated by an investigation into the work of Plato. Issues of metaphor within creation will be discussed. Notation will also be considered as a metaphorical device, aiding the design process of both music and architecture, and allowing for the preservation of them both.

The second chapter of this paper will focus on the discussion of harmony - the primary source for the use of music in architectural theory and design. Its discovery by Pythagoras will be key to the investigation into harmony, resulting in the evolution of both music and architecture. From this
investigation, evidence of musical harmonies will be highlighted in all aspects of nature – representing a musical structure imposed on the architecture of the cosmos. Through the investigation of the theories of Alberti and Palladio this study will develop an understanding of how such musical harmonies can be transferred for their use in architectural design and that the same numbers that enchant our ears, also delight our eyes.\(^7\)

Chapter three will solely consist of historical styles that represented the culture of that period and discuss how these styles help to bridge the gap between architecture and music. This section of the study will mainly concern the two cultural movements; Baroque and Serialism. As stated by Hersey in *Architecture and Geometry in the Age of the Baroque*, Baroque architecture was based on geometry, and it can be seen that music was used as the guidelines to the geometry implemented in their architecture.\(^8\) Moreover, musically influenced architecture had a grand purpose for the Baroque, as it represented a hidden meaning within design. This chapter will continue to provide further examples for the collaboration of music and architecture, through the artistic movement Serialism; specifically the work of Adolf Loos and Arnold Schönberg.

The fourth and final chapter of the paper will be concerned with architects of music; musicians or architects who had taken a profound interest in their

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\(^8\) HERSEY, G.L., op.cit., p 4
apposing field. Through their work, a greater understanding of the bond between music and architecture will be revealed, often blurring the line between them. This will be exemplified in the discussion of both the work of Iannis Xenakis and the *Stretto House*, by Steven Holl.

It is clear from the topics of discussion that there are gaps in the chronological format of this paper. After the Baroque, modern music began to develop resulting in further parallels between architecture and music. This is most prolific in the concept of Gesamtkunstwerk, in the work of Richard Wagner. However, as this is a limited study, it is not possible for every aspect of history to be discussed. Furthermore, I feel it is not necessary to discuss this period, as the correlation between music and architecture is strongest in the areas I have highlighted.

By investigating architecture through the metaphor of music, a new interpretation of architecture can be envisioned. Musical concepts and theory are used to influence, describe and define architecture. While beginning with the understanding that there is a real and tangible relationship between architecture and music, this study will involve both historical and critical studies of these relationships. By focusing on the strategies and techniques used by architects in dealing with ideas borrowed from music, this investigation will attempt to identify the relationships between music and architecture and how these can be realised in architecture design.
CREATION: MUSIC AND ARCHITECTURE

Creation is the act of bringing something into being. Many believe the original act of creation to be God bringing the world into ordered existence. Although divine creation is not believed by all, the need for creation is present in all religions and societies.\(^9\)

Creation can be argued as an attempt to relate oneself to the divine by imitating the initial creation of the cosmos, through the imitation of cosmogony. This type of creation can be seen in all art forms; in fact it is possible to define art through the term creation.\(^10\) Art can be described as the application of human creative skill by use of the imagination. Art can be used in creative terms to express a representation of oneself; it is there to convey a singular belief, of a single person or an entire society, through creation.\(^11\) In Musical Elaborations, the question arises, if we create, is it purely for the pleasure of designing, or to see our creations flourish – to be constructed or played?\(^12\) Although this will be unique to the artist, it does represent an intriguing question with regards to the intention of creation. Regardless of this, in all circumstances creation is inspired by something. Consequently the

\(^9\) In all human civilisations there is a natural desire to create; this has influenced our entire way of life. In this sense it can be seen that the need for creation moulds human existence, pushing society forward and helping cultures to advance. In some instances creation has been used to symbolise the goal, or beliefs of an entire society (for example the creation of the pyramids in ancient Egypt). In this sense creation can be inspired in many ways. It is possible that creation is provoked through need, rather than expression, however this will still be valuable in the classification and representation of an entire civilisation.

\(^10\) This can be referred to as *artistic creation*.


\(^12\) Ibid, p 14
creative process is never completely unique as inspiration (taken from another source) must initiate the creation.

**MUSICAL AND ARCHITECTURAL CREATION**

Both architecture and music do not exist without human intervention. That is to say, without the artist neither can be brought out of the ether, into existence. It is true that there are natural phenomena that already exist before creation, with regards to both music and architecture, such as harmony, yet these can only be experienced once they have been arranged and defined. They are both a construct of human imagination and creation. In *The Beautiful Necessity*, Bragdon argues that music and architecture are allied in creation; “They alone of all the arts are purely creative, since in them is presented, not a likeness of some known idea, but a *thing-in-itself*”.\(^{13}\) Bragdon further argues that “neither a musical composition nor a work of architecture depends for its effectiveness upon resemblances to natural sounds in the one case, or to natural forms in the other”.\(^{14}\) Although there are examples that would present evidence revoking this statement, such as organic architecture, Bragdon does present an interesting argument on the relation of creation to nature.

In Plato’s Republic, the topic of mimesis is introduced. The Greek word mimesis can be translated to mean ‘representation’, yet a deeper understanding would reveal that Plato used it when discussing artistic

\(^{13}\) BRAGDON, C., *The Beautiful Necessity: Seven Essays on Theosophy and Architecture*, p 15  
\(^{14}\) ibid, p 15
creation to mean imitation.\textsuperscript{15} Through this understanding it becomes clear that all creation is in fact imitation, only the degree of imitation varies. Aristotle also discusses mimesis in terms of creation. His views differed from those of Plato, however, as he considers mimesis to be just a representation of nature. However, by considering both views, it becomes clear that this is still an imitation. “Thus the more ‘real’ the imitation the more fraudulent it becomes”.\textsuperscript{16} Therefore, all things to be created already exist in our current surroundings, and the only ‘creation’ available to us is bringing these pre-existing objects into light.

Unlike the other arts, neither architecture nor music can exist without the artist, the art is not attempting to become a predefined object; it is using already existing laws and elements to become something new. “It is clear that music and architecture are both arts that don’t need to imitate things”.\textsuperscript{17} Therefore, when considered in respect to the theories of mimesis, it would seem that they are the truest of all art forms and are pure in creation as they have no mimesis with which to concern themselves – they do not imitate.\textsuperscript{18} Although this statement cannot be proven, because architecture and music must take some influence and inspiration from their surroundings, it does become apparent that out of all of the arts, these are the most unique and

\textsuperscript{15} PLATO, Republic [Translated with an introduction by LEE, D.,], p 335
\textsuperscript{16} DAVIS, M., The Poetry of Philosophy: On Aristotle’s Poetics, p 3
\textsuperscript{17} CAPANNA, A., ‘Iannis Xenakis – Architect of Light and Sound’, Nexus Network Journal
creative. To be creative, is to bring one’s imagination into being, and this can truly describe how one creates with regards to both music and architecture.\textsuperscript{19}

While they are allied in their creativity, there is a unique difference between music and architecture, which sets their creation apart. Similarities exist in the creation of both; nevertheless it is the context of their creation, which sets them apart. Architecture is the art of ordering elements spatially, whereas music is the art of ordering tones, or sounds in a temporal relationship, resulting in a unique composition. Music has a non-retrogressive basis – as music is solely based temporally it can only be viewed with the linear progression of time.\textsuperscript{20} It is true that music can be played in reverse and musical devices such as retrograde vows can be used to rearrange musical pieces with respect to time, but in these instances the music would cease to be the original composition, becoming a unique piece of music and would still be played linearly. On the other hand, architecture, being based spatially, can literally be viewed from many different perspectives, each creating a unique experience of the architecture, yet remain the same. This is the main distinction, which sets apart the experience of each art form.\textsuperscript{21} However, it is clear from the interwoven relationship between space and time, that the creation of both can be connected, albeit analogically.\textsuperscript{22} Through this investigation it will become clear that other than this difference, the creation of both music and architecture are similar, and related. To illustrate the

\textsuperscript{19} ANTONIADES, A. C., Poetics of Architecture: Theory of Design, p 13
\textsuperscript{20} MATOSSIAN, N., Iannis Xenakis, p56 and pp 172-173
\textsuperscript{21} This distinction has been discussed by many theorists involved in both fields, such as Iannis Xenakis – see Chapter 4: Architects of Music.
\textsuperscript{22} MARTIN, E., ed., Architecture as a Translation of Music: Pamphlet Architecture No.16, pp 78-79
relationship between music and architecture with regards to creation, it would be prudent to investigate and discuss Plato’s Timaeus, as this is one of the initial sources that discuss’ creation on a grand scale, with relevance to music and architecture.

In Timaeus, Plato was one of the first to write a complete description of a theory concerning the creation of the universe, describing the world God created as “a living, intelligent organism that magnificently displays mathematical order and proportion”. Although not solely its goal, the Timaeus highlights links between music and architecture, through Plato’s creation theory. Plato begins his creation theory by discussing the reasoning behind the divine creation of the universe. “…he wanted everything to become as much like himself as possible…so he took over all that was visible…and brought it from a state of disorder to one of order”. In Plato’s story, the creator, frequently referred to as Demiurge, did not necessarily create the cosmos; rather he brought order to its elements, which were already present. This type of creation is very similar to creation within architecture and music. Like the divine creation discussed in Timaeus, the elements required to create both music and architecture are already present; sound is

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23 Plato’s Timaeus primarily presents a creation story, as a response to the creation in words of the ideal city in Plato’s Republic. At the beginning of the Timaeus, Socrates states that the ideal city, described in the Republic, is beautiful, but that he longs to see it alive and in motion, in much the way that one might long to see the portrait of a beautiful animal alive and in motion. The living and moving portrait of the ideal city of the Republic is the myth of Atlantis, but before that myth can be told, the world of that myth must be generated, and this is the creation story of Timaeus.

24 Ibid, p xiii

25 Ibid, p 16

26 PADOVAN, R., Proportion: Science, Philosophy, Architecture, p 105
already created by everything around us, space is already present, it is up to us to define them by arranging their different elements.

Later in Timaeus, Plato discusses the senses, stating that they are a gift given to us so that in someway, we can become better and slightly closer to the perfection of the creator. “Likewise, the same account goes for sound and hearing – these too are the Gods’ gifts [to us]”.\textsuperscript{27} Plato continues to discuss that with these gifts comes the ability to realise such things as musical sound, harmony and rhythm. However, he also states that these “gifts” are not there for our pleasure, they are not frivolous, but they are there to increase our understanding of the world around and in turn allow us to create.

By investigating the Timaeus, it can be interpreted that Plato believed the heavens to be perfect due to their inherent order and harmony created through their architecture; in turn they produce music in their perfection. Furthermore, it can be deduced that we are unlike the heavens and lacking in grace and through creation we attempt to bring ourselves somewhat closer to its beauty. If we can create something perfect, then we can relate to the heavens. Through Plato’s Timaeus it becomes apparent that his ideas of the universe imply its creation as a result of three parts; God (the creator), architecture (order) and music (harmony). When architecture was applied to space it created order from chaos. The order created results in a harmonious universe, creating music.

\textsuperscript{27} PLATO, \textit{Timaeus} [Translated, with introduction by Zeyl, Donald J.], p 36
THE USE OF METAPHOR IN CREATION

Creation is a difficult concept to outline, as previously discussed it supposedly implies bringing something from nothing, yet through the investigation into Plato’s Republic and Timaeus it can be understood that any type of true creation is impossible as inspiration will always be taken from some source or another. With this understanding, the truest possible kind of creation is that of metaphor. In literal terms metaphor means “the application of name or descriptive term… to which it is imaginatively but not literally applicable”.²⁸ In creative terms metaphor implies the application of techniques or devices to something which one would not usually consider it to be applicable; in this study it is the use of music in architectural theory and practice. This would be demanding, as it is difficult to rid oneself of the preconceptions regarding generally accepted ideas.²⁹ Nonetheless, when possible, this would be the truest type of creation as it would require much more imagination and skill, rather than taking inspiration from something that is obviously transferable. This adaptation of the word goes far beyond the literal type of metaphor, and that of analogy. These are more comparative, only used to relate two subjects. Alternatively, with respect to creation metaphor is used within design and the creative process to literally inform certain aspects of the creation, not just in their description.

²⁸ OXFORD COMPLETE WORDFINDER, p 958
²⁹ ANTONIADES, A. C., op.cit., p 255
With regards to creation in architecture, by taking influences from sources that are regarded as unconventional, such as music, architecture can continue to evolve, rather than becoming stale or stagnant. Architecture itself can also be used in a metaphoric sense, by representing, or describing something through the architecture, which would usually not be considered to be connected. This is often presented through the artistic style of the buildings and is predominantly seen in monuments such as Libeskind’s Jewish Museum, which through its architecture presents the pain of the Holocaust. This type of representation can also be seen in musical buildings. In the design of buildings concerning music, they often try to represent music in their architecture, such as in theatres and recording studios (Although not confined to just these typologies – see *Stretto House*, Chapter 4).

It can be argued that the representation of any form is an alternative kind of metaphor, for example the graphical notation of both architecture and music. During the process of creation, there must always be some kind of representation; a metaphor of the creation that records the continual development and is evidence of the initial idea. In the musical sense this is known as musical notation, and it comes in many forms. “For a composer to convey musical ideas to a performer or the audience, the development of notation was central.”\(^{30}\) By transcribing the music, it allowed for its preservations, and also serves for any later performance of the piece. Present day standard music notation is based on a five-line staff. Pitch is shown by

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placement of notes on the staff (adapted by additional symbols called sharps and flats) and the fraction (4/4, 3/4, 6/8, etc.) shown at the beginning of a piece of music denotes the time signature.\textsuperscript{31} This musical notation forms the structure, which binds the music and represents all aspects of a musical piece. Mozart is often considered due to his unique description of musical creation; “…at last it gets almost finished in my head, so that I can see it as a while, even when it’s a long piece, at a single glance, like a fine painting or a beautiful statue”. This use of notation is intriguing, as throughout the creation of music, it would have to be translated into a visual format for its preservation. Therefore, in such instances, music was only considered in the visual realm until the entire piece was composed. Furthermore, any subsequent recreation of the music would then rely on this visual format. Hence, musical scores “became a cult object, touched by the hand of genius. Between its pages, the work existed more tangibly than in the ephemeral space of a performance. Notational representation became not simply the signifier of the musical idea, but its embodiment.”\textsuperscript{32}

The use of musical notation is similar to architecture in many ways, as it too uses a two dimensional, graphical representation in its creation (Figure 1). The creation, investigation and preservation of architecture specifically rely on a standardised graphical notation. Although this is true, often architects find it difficult to exclusively work in two dimensions; therefore other techniques

\textsuperscript{31} KENNEDY, M., Concise Dictionary of Music, p 519
have been introduced to deal with more complicated creations. Designers tend to use models in order to develop their ideas in three dimensions – investigating their creation in its intended context. The same can be said about music, as the development of music has resulted in creation by constant playing and experimentation, rather than on paper. Moreover, when the standardised musical notation is not adequate, musicians have developed other techniques of notation, that better suit their work (Figure 2). An example of this can be seen in musical graphic notation, which refers to the use drawn visual analogues in order to convey the composer’s intentions with regard to the required sounds and textures for the performance of the piece.\(^{33}\) It is used in the experimental music, created and performed by musicians such as John Cage, which in many cases is difficult to transcribe in standard notation. Another example of this can be seen in the composition Metastasis, by Iannis Xenakis, which often appears more like a technical schematic than a musical score.\(^{34}\)

Finally, it can be argued that musical buildings (architecture based on the concepts of music) are literally another type of musical notation. For in the architecture, the music is represented, within its form the essence of the music is conceptualized. Furthermore, within such musical buildings as the Stretto House, musical techniques, such as stretto, are translated and performed by the architecture of the building.

\(^{33}\) ibid, p 519  
\(^{34}\) Xenakis and Holl are discussed in detail in Chapter 4.
From the connection found in the notation of both architecture and music, a further association can be seen in composition. In music, the term composition can be interpreted in three ways; an original piece of music, the creation of music and the structure of music. As musical composition can refer to a musical score as it is similar to the interpretation of architectural composition. Through this understanding, it is clear that music and architecture can be analogous in their composition; although each form has a different context the essence of each part can be the same. An example of the similarities and transference of composition can been in Steven Holl’s Stretto House.

Throughout this first chapter, architecture and music have been discussed with respect to creation. However, to fully understand their inherent bond, parallels in harmony must be investigated, as this presents the clearest connection between the two art forms.
HARMONY

Before anything else, there was number, which was introduced into architectural theory during the medieval period. Through the transmutation of religious concepts into numerical symbolism Gothic architecture and scholasticism brought the reintroduction of ancient texts. With this came a new found fascination with number which allowed the development of numerical interest within architecture.

The clearest connection that can be made between music and architecture is that of mathematics, and this can be seen architecturally by the use of geometry. Geometry forms a large part of the creation of architecture; in the past geometry and architecture were once considered one and the same, with architecture symbolising geometry in the built form. Music can also be understood through mathematics, most commonly in the form of ratios, which define the musical scales and intervals. Music allowed for the translation of number and mathematics into art, through harmony. The simultaneous combination of these notes and the ensuing relationships of intervals and chords are known as musical harmonies. Although not all music relies on harmony as its point of interest, it has been central to the development of most Western music.

35 KENNEDY, M., op.cit., pp 321-322
The development of harmony has subsequently resulted in a more philosophical conception of the term; “by harmony we generally mean a fitting, orderly and pleasant joining of diversities, which in themselves may harbour many contrasts”. ³⁶ By this description it becomes clear that harmony can be the combination of varied elements, which together complement each other. It can also be perceived that everything in the universe is run according to perfect, meticulous harmony. Such perceptions of harmony have led it to be not solely used in music, but other arts as well. Before discussing harmony architecturally, it would be beneficial to discuss the principles of harmony and its discovery by Pythagoras, so that a greater understanding of the use of musical harmony in architecture can be realised.

**PYTHAGORAS**

The term *harmony* originated from the Greek word *harmos*, which can be translated to mean, to join. ³⁷ At the time of Pythagoras music was very rudimentary, to the point where there was no understanding of musical harmony. ³⁸ However, this would change with Pythagoras, who was “concerned with the nature of musical intervals; that is, with the sound of two different notes played in succession”. ³⁹ Pythagoras experimented with musical tone with the use of the monochord. ⁴⁰ This resulted in the discovery

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³⁷ ibid, p 8  
³⁸ Pythagoras was a Greek mathematician and philosopher, who is renowned for discoveries, such as the Pythagorean Theorem. Although Pythagoras is most notably remembered for his formulation of the Pythagorean Theorem, he was also responsible for the discovery of the natural phenomena known as harmony.  
³⁹ VALENS, E. G., *The Number of Things: Pythagoras, Geometry and Humming Strings*, p 149  
⁴⁰ A single stringed instrument with a moveable bridge.
that the length of a string is directly related to its pitch. “Pythagoras confirmed his observation that any musical tone will be raised one octave whenever the string producing the tone is reduced in length by one-half”.\textsuperscript{41} Although this may seem relatively basic to any contemporary musician, at the time of Pythagoras this was a revolutionary discovery and the first step towards the discovery of musical harmony.

From this point Pythagoras began to experiment and investigate different musical intervals and the effect of playing different notes simultaneously. He began constructing the musical intervals for a ‘perfect fourth’ and a ‘perfect fifth’ mathematically, as they were the most perfect (Figure 1). Pythagoras experimented with the ‘perfect fifth’ interval as he could construct this relationship using only four numbers, “the same four numbers that make up the triangular number ten”.\textsuperscript{42} Once again this may appear quite rudimentary, but to Pythagoras and other Pythagoreans this would have been astounding.\textsuperscript{43} The discovery of the number ten within the structure of the fifth interval compelled Pythagoras to continue his investigation of the relationships between musical notes, which eventually led to his discovery of musical harmony.

\textsuperscript{41} ibid, p 149
\textsuperscript{42} ibid, p 151
\textsuperscript{43} The number ten was a very important; the triangular number ten could be constructed using the numbers 1, 2, 3 and 4, whom had many interesting properties for the Pythagoreans. Also, in Pythagorean cosmology there were ten celestial bodies: the great sphere of the universe, Mercury, Venus, Mars, Jupiter, Saturn, the Sun, the Moon, Earth and the counter-Earth. These celestial bodies were assigned musical tones, which together created harmony in the universe.
Pythagoras first realised complete musical harmony when noticing a musical relationship between the tones created by the striking of five blacksmith’s hammers. Four of the five hammers seemed to create tones, which sounded harmoniously, while one did not. After investigation Pythagoras discovered that the relationship between the weights of the harmonious hammers was 6, 8, 9 and 12 pounds. Although the ensued harmony was not due to the hammer’s weights, it did focus Pythagoras’ studies towards the relationship of simultaneous notes. Pythagoras investigated the number series 6, 8, 9 and 12 and was able to devise a clear relationship known as musical harmonies.\textsuperscript{44} Pythagoras realised that when two strings are plucked together, the most harmonious sound will be created when the two strings are equal, “or when one is plucked at ⅓, ⅔, or ¾ of the other’s length”.\textsuperscript{45} This initial discovery of harmony resulted in its investigation by many future mathematicians, musicians and architects.

It is intriguing that even during these primitive stages of investigation into harmony, the metaphorical link between music and architecture was still abundantly clear, and necessary for its initial realisation. Throughout all of Pythagoras’s investigations, his understanding of the musical harmonies required it’s translation into the physical realm. “Pythagoras also noted that a cube, the third of the five perfect solids, has twelve edges, eight corners, and six faces”.\textsuperscript{46} This example illustrates the constant reference to the geometrical

\textsuperscript{44} ibid, p 154
\textsuperscript{45} DOCZI, G., op. cit., p 8
\textsuperscript{46} VALENS, E. G., op. cit., p 154
equivalent of the music harmonies and how pivotal it was to Pythagoras’ understanding of the phenomena and its explanation in future investigations. To realise the mathematical relationships that would create harmony, Pythagoras had to translate them into geometrical forms. Indeed these forms have often been the core of his explanation and could consequently be described as architectural. Moreover, Pythagoreans often referred to the harmony of the universe through its architecture of musical spheres, describing their orbits through the harmonic principles discovered by Pythagoras. “They maintained that the universe sings and that the fast planets like Mercury sing in a higher voice than do the slow ones”.47 It is clear that for the Pythagoreans the architecture of the universe, geometric forms and musical harmony were all intricately related in the harmony of the cosmos. These concepts and relationships often moulded the thought of other mathematicians, philosophers, musicians and architects, such as Plato and Alberti.

**NATURE**

Throughout nature, an underlying pattern seems to connect all forms. When investigated “we discover perfection, an incredible order” that can leave one in awe of the world around us.48 Harmonies can be found throughout most objects, be them natural or man made, like an imposed musical structure on the physical world. Many examples of this can be found in György Doczi’s *The Power of Limits: Proportional Harmonies in Nature, Art and*

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47 ibid, p 174  
48 DOCZI, G., op.cit., p i
Architecture, the simplest of which are the harmonies and musical progressions found in the growth pattern of leaves (Figure 2). The relationship found in this natural creation indicates “that the same dinergic harmonies that delight our eyes in the shape of leaves and flowers also enchant our ears in the chords and melodies of music”.49

It is intriguing that harmonious patterns are not solely concentrated to just the formation of leaves, but other objects in nature, such as shells and even the proportions of the human form50. Spirals found in shells, such as those discussed by Doczi, are defined by logarithmic patterns, which abide by the Golden section’s proportions. It is astounding how organic growth can create such harmonious forms in all examples.

These harmonious patterns can be seen to be their most poignant in snowflakes (Figure 3). This is one of the most beautiful examples of clear harmony and uniformity in nature that can be found, with great multiplicity. “Such uniformity [yet diversity] is characteristic of all inorganic, crystalline patterns, which have more order and uniformity than living patterns”.51

Further examples of harmonious patterns can also be seen in the formation of the universe, such as the form of spiral galaxies (Figure 4). The harmonious proportions of the human body have been discussed greatly, by such people

49 ibid, p 13
The term Dinergy was coined by György Doczi. It is the pattern-forming process of the union of opposites, the concept that the Golden rectangle is made up of two unequal parts, a minor and major part that are joined in an harmonious whole.

50 The fascination in such things was not just specific to the thought of Pythagoras and his followers, but other cultures as well, such as the ancient Egyptians.

51 DOCZI, G., op.cit., p 79
as the first know architect, Vitruvius and Leonardo da Vinci (Figure 5). These harmonic proportions, which govern the physical form, define the parameters of any architecture made for human kind.

These examples clearly represent the metaphor of music in architecture. Although not human designed, the physical form of the universe, earth and all objects within it are architecture, and adhere to harmonious proportions – almost like they were specifically designed. Architecture often uses nature as precedence to design, and bases the dimensions of a building to the harmonious proportions of the human form. The physical harmonies present in the cosmos may explain to the pleasure of hearing such harmonies performed musically. We find beauty in nature and all its wonders, so naturally we should find beauty in any representation of these forms. To investigate the use of such musical harmonies in architecture, it is necessary to seek its discussion by architectural theorists and design examples, which have been influenced by proportion and harmony.

**PROPORTION**

The musical harmonies, which have previously been discussed, are a key factor in the metaphor of music in architecture – they account for much of music’s influence in architectural design. Although they may seem indirectly related, by the use of proportions in architecture it is possible to visualise musical harmonies. In order to illustrate the theories of architectural harmony, the theories of harmony in art and architecture of Humanists, such
as Leon Battista Alberti, will be discussed.

During the fifteenth century, an emphasis began to be placed on the work of artists; music, arithmetic, geometry and astronomy, made up the Quadrivium and were known as the liberal arts.\(^2\) Together with the Trivium (Grammar, Rhetoric and Logic), they were promoted in the middle ages as vital for the education of the human being. This resulted in the elevation of theory, due to creation being considered inferior. However, this would change with the introduction of Humanism, which was a spirit of learning that developed at the end of the Middle Ages. With the revival of classical letters came a renewed confidence in the ability of human beings to determine for themselves truth and falsehood\(^3\). During the period the focus of many intellectuals began to include practise as well as theory, through the translation of texts by the old masters, such as Socrates and Plato. This resulted in the realisation of work by Humanist greats such as Alberti\(^4\).

During the 1430’s, Alberti began writing on painting and his plays began to focus on the corrupt nature of modern cities, obviously showing the influence

\(^3\) Unlike theorists, Humanists were not solely concerned with study, they concentrated on taking action, and subsequently the concept of the perfect humanist is one of all-round achievement and ‘virtue’. As a concept it promoted learning and scholarship, consequently focussing more on the human aspect, than relation to the divine, and the development of a higher standard of living.
\(^4\) Leon Battista Alberti was born in 1404 and received the best education available in the fifteenth century, studying the Latin classics at the school of Gasparion Barizza in Padua. He later studied law, but after the death of his father his focus changed more towards that of the arts, and along with his qualifications, he became secretary to the pope. When Pope Eugenius IV relocated to Florence in the 1430’s, so did Alberti and here ‘Alberti’s creative energies exploded’; he began writing about painters and influential figures and became interested in the history of the Tuscan dialect.
of humanist culture, which emerged in Florence during this period. Alberti ensured that all of his future works would contain humanist thought and furthermore, Alberti “made himself one of Italy’s three leading experts of the remains of ancient art and architecture” and he wrote the modern manual for classical buildings.\textsuperscript{55}

In his ten books \textit{On the Art of Building}, Alberti discussed all aspects of architecture – specifically, architectural proportion, “Alberti presents a mathematically... coherent theory of proportion, one that owes...to the Pythagorean and Platonic theory of cosmic harmony”.\textsuperscript{56} Alberti took influence from both Pythagoras and Plato to define the acceptable proportions of a building, and where these proportions should be taken from. As provided in \textit{Proportion: Science, Philosophy, Architecture}, Alberti explains that “For us, the outline is a certain correspondence between the lines that define dimensions; one dimension being length, another breadth, and the third height...I affirm again with Pythagoras: it is absolutely certain that Nature is wholly consistent...The very same numbers that cause sounds to have concinnitas, pleasing to the ears, can also fill the eyes and mind with wondrous delight. From musicians therefore... or from those objects in which Nature has displayed some evident and noble quality, the whole method of outlining is derived”.\textsuperscript{57} This is the first instance since the time of Pythagoras and Plato that musical harmonies have been directly attributed to beauty in

\textsuperscript{55} WESTFALL, C., \textit{In This Most Perfect Paradise}, 1974, p 57
GRAFTON, A., op.cit., p 7
\textsuperscript{56} PADOVAN, R., op.cit., p 220
architecture. Before this insight by Alberti, the application of musical theory to architecture had all but vanished, and without the belief in harmony, there was just number. However, with Alberti’s discussions, the use of music in architecture had been revitalized, drawing upon the harmonies discussed in Plato’s Timaeus to issue new considerations for the use of proportion and harmony in architectural design. This was caused by a belief that “the same relationships which determine musical intervals also determine the movements of stars and, through astrological influences, affect the events on Earth”. Similar beliefs were widespread through the Middle Ages and the Renaissance, and this directly influenced Alberti’s explanation of the beauty of certain proportional relationships between the lengths and widths of rooms by relating these ratios to those of musical theory.

Alberti began his investigation into harmony with the translation of musical harmonies into architectural proportions; he uses these proportions to define the areas of horizontal spaces, grouping them into short, medium or long (Figure 6). Alberti composes these areas much like a musician would; all proportions for the surfaces must relate and harmonize with each other, using only musical harmonies. Alberti attempts “to compose all…ratios out of the simple ratios 3:2, 4:3 and 2:1 – in musical terms, the basic Pythagorean harmonies: fifth, fourth and octave”. This ensures that the dimension of each surface is in harmony with its individual constituents. “For Alberti the

58 MALLGRAVE, H., F., op.cit., p 34
60 PADOVAN, R., op.cit., p 221
splitting up of compound proportions into the smallest harmonic ratios is not an academic matter, but a spatial experience…A wall is seen as a unit which contains certain harmonic potentialities”.\textsuperscript{61} Alberti would only use ratios that could be broken up into “the consonant intervals of the musical scale, the cosmic validity of which was not doubted”.\textsuperscript{62} Although Padovan disputes the strength of this argument in the understanding of Alberti’s and overall Renaissance architecture, it is clear that musical harmonies and their use in architectural proportions were a key aspect of his theories. Alberti continued to use this technique in definition of three-dimensional spaces and this technique influenced many of his contemporaries (Figure 7).

During the time of Alberti “music had a particular attraction for… artists because it had always been considered a mathematical ‘science’” and in his work, Alberti was striving towards the creation of harmony within architectural design.\textsuperscript{63} Therefore, many other artists and architects began to look at musical harmonies in a similar way to Alberti. The effect of this can be seen on his contemporaries, such as of Leonardo da Vinci; “for both, music and painting convey harmonies; music does it by its chords and painting by its proportions”.\textsuperscript{64} Leonardo became highly interested in Alberti’s theories, and this can be viewed in his fascination in perspective. “Musical intervals and linear perspective are subject to the same numerical ratios, for objects of equal size placed so as to recede at regular intervals diminish in ‘harmonic’

\textsuperscript{61}\textsc{Wittkower, R.}, op.cit., pp 101-2, cited in \textsc{Padovan, R.}, Op cit, p 221
\textsuperscript{62} ibid, p 221
\textsuperscript{63}\textsc{Wittkower, R.}, \textit{Architectural Principles in the Age of Humanism}, 4th ed., p 117
\textsuperscript{64} ibid, p 118
This clearly shows the influence Alberti’s theories on musical harmony in architecture had on Leonardo. Although some of Alberti’s techniques may seem strange to a modern architect, due to his strictness to the musical harmonies, they represent the rebirth of musical theory in architecture, specifically the use of harmony. For Alberti and his contemporaries “musical consonances were the audible tests of a universal harmony which had a binding force for all the arts”.

The discussion of musical harmonies as architectural proportions can also be seen throughout the writings of Andrea Palladio. Palladio, like Alberti, wrote a treatise on architecture, titled *Four Books on Architecture*. This discourse took influence from the writings of Alberti as it includes a similar theory on architectural proportions. Throughout his work, several discussions were made concerning the proportion of rooms; Palladio stated seven of the most beautiful and harmonious proportions, which will be used in the design of rooms (Figure 8). As discussed by Wittkower, the measurements chosen for these proportions almost perfectly reflected harmonious musical intervals. Furthermore, he expanded upon this statement by providing several methods for constructing the proportions of a room; “Like Alberti, Palladio recommends that the height of rooms should be either the harmonic,
geometric or arithmetic means of the lengths and breadths”. However, his work is not to be solely contributed to the influence of Alberti, as many other theorists can be seen to have influenced Palladio. In his *Four Books on Architecture*, “Palladio seems to be the first Renaissance architect to apply the Vitruvian concept of ‘symmetry’: that is, to relate the corresponding measures of several interconnected spaces”. The ensued relationship created by the interconnecting spaces can easily be compared to the development of a musical composition – as each part of the music progresses, it is inherently similar and connected to the piece that came before it. This type of relationship can often result in the creation of rhythm both in a musical composition and an architectural one. Although it is clear that throughout the writings of Palladio, he discusses and recommends the use of harmonic (musical) proportions within architectural design, to fully comprehend their use within architecture, built examples by all of the architects and theorists mentioned, must be discussed.

**MUSICAL HARMONY IN ARCHITECTURE**

The first built examples to be discussed are the Parthenon, Athens and the Athena temple, Priene (Figures 9 and 10). The two temples are of contrasting styles (the Doric and Ionic style, respectively), yet both seem to be defined by their use of musical harmonies. “The front columns of the Parthenon with their seven spaces embody the 3:4 ratios…the corresponding musical harmony of the fourth-diatessaron… [and the] fifth-diapente harmonies. In

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69 PADOVAN, R., op.cit., p 233
70 ibid, p 234
the Athena temple, 2:3 and 3:5 relations of columns approximate the root harmony of diapente”. This clearly shows a consideration of Pythagorean theories about harmony and their beauty when translated into visual forms. “The Athena temple is about twice as long as it is wide... embodying the 1:2 harmony of octave-diapason. The Parthenon’s plan corresponds to two reciprocal golden rectangles, thus echoing the diapente harmony”. “The pronaos of the Athena temple is in 3:4 proportion, while the naos or celle in both temples, and the treasury or virgin’s chamber in the Parthenon are in golden proportion”,71 Both buildings were dedicated to the goddess Athena, therefore being of utmost importance. This implies that both Greeks and Romans must have considered musical harmonies to a high regard as they were used in the design of their most significant buildings.

The examples outlined above seem to indicate that musical harmonies were in fact the key factor for the design of both the Parthenon and the Athena temple. However, many have investigated the Parthenon, resulting in different interpretations of its proportions. It is clear that some alterations have been required in the musical interpretation of the proportions for both of these buildings and this can also be true for the investigation for many other ‘musical’ buildings. Obviously, some margin of error must be allowed for the construction of the buildings during times where any competent degree of accuracy was impossible in comparison to contemporary standards. The same stance can be taken when discussing buildings supposedly designed by

71 DOCZI, G., op.cit., p 110
Alberti, as he gave “no account of any building that he actually designed”.72 Due to Alberti’s lack of description in the use of proportion in his designs, there is a great amount of difficulty in deciphering the correct proportion system implemented in the architecture of buildings, supposedly designed by Alberti. There have been many investigations into the proportions of San Sebastiano, such as those by Wittkower (Figure 11), Rykwert and Tavernor, Padovan and Borsi, each resulting in a different interpretation of the proportions. Due to the buildings many reconstructions it has been made difficult to find any corresponding proportions. Wittkower’s interpretation of the original design does result in a more harmonious building, however contrasting interpretations have also been made by Rykwert and Tavernor (Figure 12). Padovan conducts his own investigation (Figure 13), resulting in a proportional system, which abides by the dimensions presented in an early drawing of San Sebastiano by Antonio Labacco, sketched shortly before its completion (Figure 14).73 The resulting interpretation states that the major proportions of San Sebastiano are 6:10:16, and an approximation of the Golden Section of 3:5:8.74 This naturally would represent a harmony in the building, as it would abide by perfect proportions. Yet, the methods used in the discovery of these proportions required a large margin of error.75 Furthermore, it is clear the proportions supposedly used in the design of San Sebastiano are not compatible with Alberti’s system described in *The Art of

72 PADOVAN, R., op.cit., p 225
73 ibid, p 225
74 The numbers 6, 10 and 16 have great significance in ancient number theory, 6 being a perfect number as it is the sum of its own factors, 10 was also considered a perfect number by Plato, and 16 being the sum of the two.
75 Once again this may be considered negligible due to the time of its construction).
Building. Although the reasons behind this are not clear, it shows that not every building, which appears to abide by harmonic proportions, was deliberately designed for this consideration. However, an investigation by Borsi seems to present an authentic argument towards the use of Alberti’s harmonic proportions in San Sebastiano, also abiding by the proportions presented in the drawing by Antonio Labacco. “Thus the sides of the columns are half the size of those of the vault, which results in a ratio 1:2: Alberti’s diapason.” Borsi presents further examples of Alberti’s proportion system throughout his investigation of San Sebastiano (Figure 15). Borsi’s explanation seems to be the most likely method of design used by Alberti and presents a clear case of his strict adherence to harmonic proportions. Yet, it can never be proven, which technique Alberti used in his design.

Similarly, the work of Palladio does not exclusively use the proportions outlined in his theories. In Architectural Principles in the Age of Humanism, the author examines several villas designed by Palladio, such as the Villa Rotunda. As stated by Wittkower, “Palladio took the greatest care in employing harmonic ratios not only inside each single room, but also in the relation of the rooms to each other, and it is this demand for the right ratio which is at the centre of Palladio’s conception of architecture”. Although many would agree with this statement as it is evident from the writings of Palladio that he considered the use proportions at utmost importance, this is not accurately representative of his full body of work. In Wittkower’s

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76 BORSI, F., Leon Battista Alberti [Translated by CARPANINI, R.G.], p 207
77 WITTKOWER, R., op.cit., p 72
discussion he only considers eleven out of Palladio’s designs (Figure 16) – a miniscule amount when considering that Palladio himself discussed forty four different building designs in his *Four Books on Architecture*. However, it is still clear from Palladio’s discussions that harmonic proportions were very significant to his architectural thought as according to Wittkower “out of 153 room length/width ratios from the building plans presented [by Palladio]… ninety-seven can be interpreted as ratios which correspond to musical ratios”.\(^{78}\) Nevertheless, with further investigation into the geometry that governs the architecture of Palladio, ratios can be found that are not typical of harmonic proportions, in fact, some ratios found in the villa Rotunda can be found to converge to the square root of three.\(^{79}\) However, although it is difficult to find such musical harmonies, one can never be certain how they were employed in specific designs. Therefore, unless specific instructions were recorded on how Palladio designed his buildings, it is unlikely that the exact implementation of musical harmonies can be found.

Through the use of examples, it can be seen that not all musical harmonies present in buildings are intentional. However, this should not discourage one in the investigation of musical harmony in architecture and architectural theory. It is true that not all cases of harmonic proportion in architecture will have been purposefully designed for this, yet neither could they all be coincidental. As Alberti wrote “The very same numbers that cause sounds to have concinnitas, pleasing to the ears, can also fill the eyes and mind with

\(^{78}\) MITROVIC, B., ‘Andrea Palladio's Villa Cornaro in Piombino Dese’, *Nexus Network Journal*

\(^{79}\) PADOVAN, R., op.cit., p 236
wondrous delight".⁸⁰ Therefore, if one attempts to design a building, which has proportions that are pleasing to the eye, then these may coincidentally be pleasing to the ear as well, when performed musically. However, it is clear from this discussion that the use of harmony, specifically musical harmony, and proportion has been important in the development and consideration of architectural theory and design. Furthermore, the texts written by Pythagoras, Alberti and Palladio, as well as other literary greats are comprehensible cases for the use of musical techniques and music theory in architectural theories, which consider music to bring clarity to chaos, whereas its use in architecture, such as geometry and proportion (harmonies), bring order. While harmony and creativity are both important in defining the relationship between music and architecture, it is also important to demonstrate how these two notions, as well as others, influence each other and help to bridge the gap between music and architecture.

THE CROSS POLLINATION OF MUSIC AND ARCHITECTURE

Near to the time of their inception, both music and architecture were considered very similar due to their relationship with mathematics and geometry. Yet, as they developed, they began to separate, each taking on new techniques and concepts of their own, such as separate concepts of harmony and rhythm. With each new civilisation came an evolved, but different interpretation of both architecture and music.\textsuperscript{81} In some instances, the similarities inherent to both music and architecture were emphasised by this change resulting in them becoming united through similar techniques, goals and concepts.\textsuperscript{82} By discussing both the Baroque era and Serialism, this study intends to exemplify how music may influence architecture, in a manner that represents the ideas, philosophies and culture of that era, such as a unique perception of harmony.

**BAROQUE**

The term Baroque refers to a period of art, architecture and music during the 17\textsuperscript{th} and 18\textsuperscript{th} centuries.\textsuperscript{83} Baroque was highly influenced by the Renaissance, however many consider this period to be less fruitful than its predecessor,\textsuperscript{83}

\begin{flushleft}
\textsuperscript{81} See Chapter 1 for discussion in respect to creation
\textsuperscript{82} Such as Pythagoras’ discovery of harmony, which linked the harmony of both architecture and music during this period
\textsuperscript{83} BUKOFZER, M., *Music in the Baroque era from Monteverdi to Bach*, p 2
\end{flushleft}

The Baroque style was highly influenced by the Renaissance period that preceded it. The Renaissance was an influential cultural movement, usually considered to have originated in the 14\textsuperscript{th} Century, which brought about a period of scientific revolution and artistic transformation, at the dawn of the modern age. It was primarily focused on the revival of antiquity, from influences such as the ancient Greeks. This resulted in the reintroduction of classical styles, ideas and techniques into the built environment, which were highly influenced by ancient philosophies.
and its influences and ideas were less focused and without reason. With investigation however, it becomes clear that above all, Baroque architecture was based on geometry, much like the architecture of ancient times, and this led to its aesthetic splendour.\textsuperscript{84} The Baroque can be known as the last collective European attempt at resolving the use of harmony within design and creation. Throughout the Baroque period the development of Baroque music ran parallel with that of Baroque art and architecture, therefore, they shared similar influences and concepts.\textsuperscript{85}

The Baroque era was highly influenced by the philosophies and concepts of the ancient Greeks. In an attempt to relate to the divine, Greek architecture was primarily influenced by nature and the heavens. This is true of the Baroque and was further accentuated by the fascination in cosmology. It has often been argued that there was an “intimate connection... between the revolutionary cosmology... and the Baroque art and architecture that more or less coincided with its development”.\textsuperscript{86} In the centuries previous to the Baroque, focus was primarily on the universe, its formation and composition. During the Baroque there was a cosmological revolution, resulting in new theories from Johanne Kepler, who developed upon the previous theories of Copernicus. Kepler revolutionised the current conception of the universe, realising several universal laws and theories. His theories were highly orientated towards an acknowledgment of order in the universe, relying

\textsuperscript{84} HERSEY, G.L., \textit{Architecture and Geometry in the Age of the Baroque}, p 4
\textsuperscript{85} BUKOFZER, M., op.cit., p 2
\textsuperscript{86} PADOVAN, R., op.cit., p 261
heavily on geometry and mathematics to describe his conception and composition of the world around him.\textsuperscript{87} Kepler used architectural forms to illustrate how the planets were arranged in our solar system and described the universe using terms such as harmony and order (Figure 1). The theories of Copernicus were further developed by Galileo Galilei and culminated in the work of Isaac Newton, whose theories and universal laws are still used today to describe and study the universe through mathematics.\textsuperscript{88}

Wittkower argues that with the changing cosmological principles, architecture began to turn away from geometry and proportion.\textsuperscript{89} Even though the universal theories of the time were changing dramatically, the developing conception of the universe was becoming more harmonious and unified, reducing nature down to mathematical formulae.\textsuperscript{90} Indeed, some authors such as Sigfried Giedion (1941) and Wylie Sypher (1955) go as far as to describe the emerging universal laws under the same collective name; Baroque.\textsuperscript{91} This new interpretation of the universe was “based on geometry and musical harmony, whereby a new scale of values was introduced, assigning everything a place according to its degree of ‘perfection’”.\textsuperscript{92} It is only natural that the cosmological discoveries leading up to and during the Baroque would be of some influence to the architecture of the time, as most designs considered the divine, nature or the heavens. When investigating the architecture of the

\textsuperscript{87} ibid, p 247
\textsuperscript{89} WITTKOWER, R., The Changing Concept of Proportion, p 117
\textsuperscript{90} PADOVAN, R., op.cit., p 7
\textsuperscript{91} ibid, p 261
\textsuperscript{92} NORBERY-SCHULZ, C., History of World Architecture: Baroque Architecture, p 7
Baroque it is obvious that this relationship was created using geometry within the designs of Baroque architecture, as “it comes from an age when architects…could think of buildings as ‘studies in practical mathematics’”.93

The basic numbers behind most of the geometry used in music and architecture of the Baroque are known as effable and ineffable shapes. In simplest terms, an effable shape is a number, which can be expressed as an exact fraction, offering certain clarity in its calculation. With the inclusion of ineffable shapes and numbers within designs, it might be expected that a sense of imperfection may be felt. These, however, only helped to accentuate the intentions of the Baroque.94 With the use of ineffable shapes, a distinction is created within the design between perfection and imperfection. This would have seemed unfamiliar to the previous Renaissance, as it concentrated solely on perfection, stating that “the sign of perfection in a work of art was that it could not be changed, not even in the smallest detail, without destroying [its] beauty”. In contrast, the Baroque aimed “not to represent a perfect state, but to suggest an incomplete process and a movement towards its completion”. Furthermore, “this is why the formal relationships [became] looser, for the Baroque is bold enough to turn the harmony into a dissonance by using imperfect proportions”.95 Not only does the use of dissonance represent the main difference, which separated the Baroque from that of the Renaissance, but it also embodies the common bond between all of the arts under the

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93 HERSEY, G.L., op.cit., p 5
94 As argued by HERSEY, G.L. in Architecture and Geometry in the Age of the Baroque
95 WÖLFFLIN, H., Renaissance and Baroque, pp.65-7 cited in PADOVAN, R., Proportion: Science, Philosophy, Architecture, p 266
Baroque. During the age of the Baroque, architecture took a similar development to music; although it had become more mathematical, constraints from the Renaissance had been removed, allowing for more freedom in design. With further investigation into the Baroque architecture, other similarities between the different art forms of music and architecture arise.

The introduction of dissonance in Baroque music can be attributed to Vincenzo Galilei, who was accredited for many Baroque techniques.\textsuperscript{96} Galilei can also be attributed to being one of the first to experiment with an equally tempered scale. His music tempered sound into a unique and equal musical order, which was later developed in the work of other Baroque composers, most notably Johann Sebastian Bach. The music composed by Bach was very complex, similar to the complexity found in Baroque architecture, and required the use many different musical keys. Bach used the tempered scale as it freed his work from the constraints of the mean tone temperament.\textsuperscript{97} The well tempered scale allowed Bach to use “all keys all tones and semitones, in the major as well as the minor modes”; the inherent freedom of a tempered scale resulted in its use in the work of Bach and was most distinguished in his piece \textit{The Well-Tempered Clavier} (1722).\textsuperscript{98} This use of the tempered scale was a unique development in the Baroque and represents a human intervention into what was natural. A parallel use of temperance can be witnessed throughout

\textsuperscript{96} BUKOFZER, M., \textit{Music in the Baroque era from Monteverdi to Bach}, p 26
\textsuperscript{97} The mean tone temperament was the apposing system of musical tuning during the time of Bach.
\textsuperscript{98} BACH, J.S., \textit{Das Wohltemperirte Clavier}, cited in BRUHN, S., \textit{J.S. Bach's Well-Tempered Clavier: In-depth Analysis and Interpretation}, p 1
Baroque architecture. It can be seen that many of the devices used within the architecture of the Baroque were tempered versions of those used within the Renaissance. In many cases the Baroque twisted, squeezed, pulled and distorted Renaissance forms, creating something new and unique. The Baroque was a skewed take on Renaissance architecture and a key example of this can be seen in the Solomonic columns (Figure 2).\textsuperscript{99} Although not unique to his architecture, the development of the spiral column can be viewed most remarkably in the designs of Guarino Guarini. It can be seen from the writings in Guarini’s treatise \textit{Architettura} (1686), that the columns used within his architecture were a tempered version of the standard classical column. Guarini uses simple graphical representation to illustrate the temperance of the classical column, from a shaft with straight flutes, to a shaft with twisted flutes, to a shaft with twisted flutes and hyperwhorls (spiralled shaft – see Figure 3).\textsuperscript{100}

Baroque musicians often represented their treatise graphically, conveying the music using architectural forms. These graphical representations were often similar to those used by Kepler to describe the universe (Figure 1). In his diagrams of the solar system, each celestial body was placed on a crystal geometric form, which governed its motion and position in the cosmos. These cosmic forms were thought to have their own sound, producing a \textit{cosmic}

\textsuperscript{99} The Solomonic column is characterised by a spiralling shaft and is related to biblical descriptions of the two columns, which flanked the entrance to Solomon’s temple, destroyed by the Babylonians in 586 BC.
\textsuperscript{100} HERSEY, G.L., op.cit., p 126

Other examples of Solomonic columns can be seen in the architecture of both Francois Blondel (1705-1774) and Gian Lorenzo Bernini (1598-1680) specifically in the design of Bernini’s St. Peter’s and Baldacchino.
During the Baroque, “heaven-derived musical sounds... [could] be translated into visual form”. Furthermore, it was believed that this geometry could be read musically, and unheard melodies were present in the cosmos. This implies a relationship between the architecture of the universe and music, giving music a similar heavenly stature to geometry. This description can be easily applied to the architecture of the Baroque, as their geometry is in fact closely related to music. This cosmic music is not only depicted through the architecture itself, but is also shown more literally in the paintings and sculptures within many Baroque buildings, as viewed in the dome of the Royal Palace Chapel, Madrid (Figure 4). Although no music can be heard due to their rigid state, angels within the artwork are often depicted to be singing. This shows a more exact expression of the Baroque attempt to relate their architecture to music, and also shows a relationship between their art and the cosmos, by representing music through the use of heavenly forms.

These links between architecture and music were clear during the Baroque in fact, some Baroque musicians and architectural theorists such as Blondel and Bernini began to explore the relationship between the two. This was the focus of the work of Blondel, who had a revolutionary outlook on music and architecture; he directly discussed architectural forms, as designed through music. Although such links had been discussed before by other Baroque theorists, it had only been implied, rather than explored completely.

102 HERSEY, G.L., op.cit., p 6
103 WÖLFLIN, H., op.cit., pp.65-7 cited in PADOVAN, R., op.cit., p38
work of Blondel, there are clear, graphical representations of the preferred forms, showing them to be a direct translation of musical notes (Figure 5). Furthermore, Blondel developed his technique by discussing and illustrating the translation of musical chords into architectural forms, such column designs (Figure 6). These architectural forms can literally be read as music; they can be notated into musical form, and played, as if written for that purpose. It would seem that the architecture translated into music by Blondel is another form of musical notation, capturing the sound in stone, rather than on paper. It can be argued that this is an attempt to relate the architecture of the Baroque to the divine; like the cosmos, the musically defined architecture now represents a hidden order.

The influence of music on Baroque architecture can be seen in other, built examples, such as Bernini’s Baldacchino in St Peter’s church. Bernini’s Baldacchino was created by constant use of mathematical ratios, which persistently reflected music (Figure 7). Although it cannot be proven that music was the basis for this design, it would appear that Bernini had at least been influenced by music, as his continual referencing to musical ratios could hardly be coincidental. Even if that is the case, this architecture can easily be interpreted musically, and Hersey has gone as far as to transcribe the design into musical notation (Figure 8). Showing music in written form purely serves as proof that architecture can be translated into music (and vice versa), it helps to illustrate the similarities between the Baroque arts as the

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104 This can be found in Blondel’s *Cours d’Architecture*
105 The use of musical geometry can also be seen in the column design of Giambattista Piranesi’s funeral candelabrum, which displays perfectly dissonant musical intervals.
106 For further discussion on this topic, see Hersey’s text *Architecture and Geometry in the Age of the Baroque.*
geometrical ratios used to define this piece of architecture, would not be uncommon in a Baroque musical composition.

In the Baroque designs, musical influence helped to define and give greater purpose to the individual elements, and further relate the architecture to the cosmos. Music was also used to provide the guidelines to geometry implemented in the architecture. When seen through the eyes of the Baroque, musically influenced architecture had a greater purpose; in this sense it once again shows the world in relation to its creator and cosmos, through a progressive state. The Baroque design in both architecture and music was correlated with the culture of its era.

SERIALISM

Serialism was a 20th century revolution in composition, “whereby traditional melodic, harmonic, rhythmic, tonal rules and conventions were replaced”.107 Furthermore, “serial music is that in which a structural ‘series’ of notes governs the total development of the composition”.108 The theory of serial thinking emerged first in music, developing from Arnold Schoenberg’s twelve note system. Before Serialism, the arts had become separated to an extent, which made it impossible to decipher any common features. Similar to the Baroque, Serialism soon became a “philosophy of life” due to its universal theory and spread to most aspects of life, including architecture.109

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107 KENNEDY, M., op.cit., p 665
108 ibid, p 665
109 BANDUR, M., Aesthetics of Total Serialism: Contemporary Research from Music to Architecture, pp 6-7
Serialism evolved in a time where musical development had almost come to a standstill; historicism resulted in popular music’s ever changing façade, these were only superficial developments, its technical substance remained the same. Therefore, the development of popular music was a fraud, with no real changes happening at all. Composers such as Schönberg realised this; attempting to construct their own musical language, which represented their own era, rather than reiterating historical examples. They revoked the standardised musical devices from their compositions, attempting to create something unique, based on order and clarity. To discuss the relationship between the music and architecture of Serialism, the remainder of this chapter will concentrate on the work of Arnold Schönberg and Adolf Loos, before referring to other architectural examples that took influence from Serialism.

During the birth of Serialism, there was a cultural phenomenon that contributed to the development of philosophy and intellect like no other. Hapsburg Vienna was the cultural centre, composed of almost every great mind, from all fields of intellect and art. This must be considered in the discussion of both Schoenberg and Loos as most cultural leaders of that time were close acquaintances, allowing them to easily share ideas and philosophies. The development of all philosophical and artistic thought in Hapsburg Vienna was “intimately and consciously related to... the critique of language and society conducted by Karl Kraus”. Most intellectuals of the time

\[110 \text{ ibid p 15} \]
were directly related to the thought of Kraus, using his influence in their respective fields; “for Loos, this was architecture and design; for Schönberg, it was music”. Loos took the philosophies of Kraus and translated them into architecture; waging a war against ornamentation within art, which was developed in his essay *Ornament and Crime*. As stated in *Wittgenstein’s Vienna* “according to Loos, the architect like any other craftsman should follow the plumber as his model, not the sculptor”.$^{111}$ It is clear from this statement that Loos considered form purely based on aesthetics unnecessary. Furthermore, it became obvious that Loos “wanted to banish every non-functional element from architecture”, instead believing that by creating something that is rational and efficient it will inherently become beautiful.$^{112}$

Arnold Schönberg was a close acquaintance of Loos and his work took parallel influence, which resulted in many similarities.$^{113}$ Schönberg’s style was analogous to that of Loos; it did not solely focus on the creation of aesthetics, rather it gave merit to the technical aspects of music, which in turn would create a more truthful, more efficient aesthetic. Schönberg once stated that “In music... there is no form without logic”.$^{114}$ He believed in simplicity of music, which would return it to a previous, grander state. Like Loos, Schönberg considered music to have developed with unnecessary ornamentational elements, which hindered its evolution. Schönberg represented a new discipline in music; his twelve-tone technique being the

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$^{111}$ JANIK, A., and TOULMIN, S., *Wittgenstein’s Vienna*, p 93
$^{112}$ BANDUR, M., op.cit., p 77
$^{113}$ GRAVAGNVOLO, B., *Adolf Loos: Theory and works*, p 30
$^{114}$ JANIK, A., and TOULMIN, S., op.cit., p 106
structure behind all of his work\textsuperscript{115}. It is clear from his work that Schöenberg strictly believed in technique and structure of composing, rather than how the music sounds. In his compositions there was literally no harmony – the commonly conceived perception of harmony was not utilized in any of his work, as it attempted to move away from this. “This is because Schöenberg... [believed], how a composition sounds, [had] no importance”. This reveals a direct link with the work of Loos, for in his design, how the architecture appears is rarely considered; rather the emphasis is placed on structure and efficiency of design. Similarly to Loos, “his work as a composer becomes...a critique of society”. Schöenberg also published essays on his theories, arguing against the previous development of music. He attacked the music of the late Nineteenth Century for merely conforming to what was accepted, rather than challenging previous musical theory and creating something original. Janik and Toulmin described that Schöenberg’s work was striving for truth, through creation of clarity “the artist attains beauty without willing it”.\textsuperscript{116}

The work of Loos and Schöenberg represents the philosophies and ideas of Hapsburg Vienna in the early Twentieth Century and the birth of Serialism; architecture without ornaments was mirrored in the atonal music of

\textsuperscript{115}Arnold Schonberg developed the twelve-tone system, where traditional harmony and tonality was abandoned. The musical notes in a given piece were no longer united and organized by a key; instead they were independent and unrelated. Schonberg’s twelve-tone musical scale of the 1920s arranged all twelve notes of the scale in an abstract, mathematical pattern. Accustomed to the harmonies of classical and romantic music, audiences generally resisted modern atonal music. Only after the Second World War did it begin to win acceptance.

\textsuperscript{116}JANIK, A., and TOULMIN, S., op.cit., pp 110-111
Schönberg.\textsuperscript{117} Their work was a critique of their period; attacking aesthetics, not accepting the norm, but challenging their individual fields. Not only did their work influence many of their contemporaries, it also had a lasting effect throughout the Twentieth Century. The composition Moses und Aron by Schönberg was used as a primary source in the design for Daniel Libeskind’s Jewish Museum, Berlin (Figure 9). The forms used in the design for the Jewish Museum were created through serial thinking and Libeskind created a ‘serial code’ for the building (Figure 10).\textsuperscript{118} Le Corbusier’s Modulor was seen as a structural tool, helping to define the dimensions and scale in the composition of a building (Figure 11). Other architectural icons, such as Frank Lloyd Wright argued against the use of superfluous elements in his architecture, showing a clear parallel with the thought of Loos and Schönberg. It is obvious that there are noticeable similarities between each of the examples presented and the work of Loos and Schönberg. In addition, each of them represents the thought of leading architects of their time, clearly expressing the thought of their culture and a beneficial use of musical theory within architecture theory and design.

\begin{footnotesize}
\textsuperscript{117} GRAVAGNOLO, B., op.cit., p 41
\textsuperscript{118} The effect of Serialism also influence Tschumi and Eisenman. In their work they not only showed a clear avoidance of symmetry and repetition comparable with musical Serialism, but also the conscious turning away from automatically accepted features.
\end{footnotesize}
ARCHITECTS OF MUSIC: THE WORK OF XENAKIS AND HOLL

Throughout this study, theories of the inherent similarities between music and architecture have been discussed in order to give a greater understanding of the bond between the two. It has been seen that their creation, the use of metaphor, the discovery of harmony and the representation of culture are key elements in the unique link, which unites them both. However, the role of the single artist has yet to be considered exclusively in the investigation of music and architecture. Through this study it has been revealed that the creation of both are related to one another, so much so that it is unsurprising that many artists have been involved, or taken interest in both. Naturally, both architecture and music have been a source of inspiration for the other since their conception, many great architects have been directly influenced by music and this can be seen by the effect it has had upon their work. In these cases it can be said that their architecture is purely a representation of the music that influenced them, transforming it from sound into a physical entity. For the purpose of this study, these artists will be referred to as architects of music.

Many architects, composers, designers and musicians have been given the title architects of music, nonetheless for the case of this study this list will be restricted to those who have been involved in both, or have provided
influence to their opposing field.\textsuperscript{119} Through the research conducted for this investigation, the following have worked or given influence to both fields; Le Corbusier, Arnold Schönberg, Pythagoras, Frank Lloyd Wright, Johann Sebastian Bach, Adolf Loos, Steven Holl, Plato, John Cage, Iannis Xenakis, Leone Battista Alberti, Francois Blondel and Frank Gehry. Even though this list does not fully accredit all who have contributed to both fields, these few have openly spoken and used the influence of both architecture and music, within their work. In each case, these artists have actively used the influence of both fields, which has blurred the barrier between the two, creating astounding examples for the ‘metaphor of music in architecture’. To highlight the importance of their individual work, the remainder of this chapter will concentrate on the work of Xenakis, and Steven Holl.

**IANNIS XENAKIS**

Iannis Xenakis becomes the epitome for the discussion of the metaphor of music in architecture and architect of music, as this is a unique example of someone completely involved in both fields. Xenakis is largely renowned for his work as a composer, but he was also an architect. Xenakis was a unique man, able to bridge the gap between architecture and music naturally.\textsuperscript{120} Through the discussion of Xenakis and his thoughts regarding the fields of music and architecture, it will become apparent that the boundaries separating music and architecture may be broken, and that both fields are related through common influence and technique.

\textsuperscript{119} CAPANNA, A., op.cit., p 1
\textsuperscript{120} As if they were one and the same
The manner in which Xenakis perceived the world is the sole contributor to his unveiling of the common bond between music and architecture. All of his work was filled with the thought of a mathematician, this being the basis for all of his compositions (both musical and architectural). “His way of working…closely resembles that of a philosopher of science than that of an artist, whose instinctive creations are sometimes controlled only by aesthetical aims”.\textsuperscript{121} His thought was more logical, much more so than any conventional artist. He was creative; a necessary component in the collaboration of music and architecture. His work was motivated by a “need to find the underlying connections between” architecture and music, to do this “he located problems which were common to both architecture and music in order to satisfy the sense of cohesion and unity of thought which his intellect demanded”. This represents the key to the understanding of Xenakis; never satisfied with taking the easy road, rather he enjoyed to be challenged; connecting his two fields of interest being the biggest challenge of all. “In architecture he could develop ideas by articulating them in space, while in music he could arrange them in time”.\textsuperscript{122}

Xenakis initially studied as an engineer and a mathematician. While working with Le Corbusier, he began to realise the full potential of the relationship between music and architecture. Xenakis identified the key difference between the two; “physical space may be approached…in a multitude of

\textsuperscript{121} CAPANNA, A., op.cit.
\textsuperscript{122} MATOSSIAN, N., \textit{Iannis Xenakis}, p 55
directions as a building is viewed from above, below and from all sides, but music is perceived always in one direction, and one order, as it unfolds in time”. This concept is pivotal to understanding the relationship between music and architecture, without it, the two can never be related. From this description it can be translated that music and architecture are the same, only their context is different; for architecture is design in space, music is design in time. This fascination in the relationship of architecture and music, and the more specific relationship between space and time can be seen in many of his compositions, particularly *Metastaseis* (Figure 1). In his work, Xenakis attempted to refer to music, and the relationship of space and time more scientifically, primarily involving a modern Einsteinian view of this concept. Other concepts in this piece concerned “mass, surface, the straight line, or ruled surfaces and plan”.123 All of these forms are obviously architectural, and are clearly the result of working with Le Corbusier. Although Xenakis himself denied such a correlation between his music and the work of Le Corbusier, it would be naive to disregard the influence of Le Corbusier’s work on the music of Xenakis.124

Through Xenakis’ work in architecture and music, he allowed his development in one to inform the other. “[He] found that problems in architecture were the same as in music”.125 Due to Xenakis’ perception of both architecture and music, he was able to deal with problems uniquely, for

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123 MATOSSIAN, N., *Iannis Xenakis*, pp 55-56  
124 *ibid*, p 56  
125 INTERVIEW WITH XENAKIS, 1997, cited in MATOSSIAN, N., op.cit., p 69
example, if a problem arose in his compositions, he could draw on his architectural knowledge to solve it. The work and investigation Xenakis had performed in the creation of *Metastaseis* directly influenced his work in architecture, as the two developed in parallel. At the time, Xenakis was working under Le Corbusier on the design for *Couvent de St Marie de la Tourette*, where he developed the design for the façade. It can be seen that his solution was completely musical. Le Corbusier referred to the façade as “musical screens of glass” (Figure 2). The design for the glass screen was designed using the *Modulor*, based on an asymmetrical pattern, which gave rhythm and fluidity to the façade. The influence of *Metastaseis* can be seen throughout the three façade design for La Tourette; it can be seen to be the origin of its fluidity and traces of golden section can also be found. *Metastaseis* also influenced his other architectural works, as both continued to develop simultaneously.

The initial sketch for Metastaseis was designed using architectural and graphical notation to the extent that it appeared more like a technical drawing, rather than a musical score, showing graphs of mass motion and the structural beams of the piece, with pitch on one axis and time on the other. Certainly, this design became the basis for the Philips Pavilion, which had no flat surfaces but rather the hyperbolic paraboloids of his musical masses (Figure 3). The concept of Metastaseis and the transference of mass can be

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127 TREIB, Marc, *Space Calculated in Seconds: The Philips Pavilion*, p 88
   The Modulor is a system of human proportions devised by Le Corbusier.
viewed as the basis behind Xenakis’ design for the Philips Pavilion (Figure 4). Le Corbusier initial concept was to design a building through organic synthesis; a vessel, which contained colour, light, rhythm, poem and sound with people passing through. Xenakis took this initial concept and infused it with his personal development from the work on Metastaseis. Xenakis used his knowledge of mathematics and his musical thought to create an architectural form that was fluid; representing transference of mass, but also one that allowed for a synergy of light and music within. In the case of the Philips Pavilion, Xenakis believed it to be an occasion, which brought architecture and music together, resulting in an intimate connection (Figure 5).

From the beginning, Xenakis refused to acknowledge barriers between music and architecture, using each field to inform the other. As one development occurred in music, its ideas were transferred to help in his progression in architecture, and vice versa. His ideas were solely based on mathematics, and a constant fascination with the relationships of mass, energy, space and time. Xenakis was a unique example for a true architect of music; not only was he involved in both fields, but his influence led to development in both. Being one of the first to utilise information technology in his work he showed other artists the way forward, and through his astounding work he lifted the barriers between architecture and music, illuminating their common bonds. Through the investigation of Xenakis, it is clear that there is a real relationship

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129 LE CORBUSIER, Le Poeme Electronique, 1958, cited in MATOSSIAN, N., Iannis Xenakis, p 110
130 XENAKIS, I., Formalized Music: Thought and Mathematics in Composition, p 10
between music and architecture, and their cross pollination is only limited by our imagination.

**STEVEN HOLL’S STRETTO HOUSE**

The influence of music can be seen throughout the work of Xenakis, which aided the development of musical thought in architecture. The effect of this can be observed in contemporary musical buildings. In an attempt to further define the links between music and architecture, this paper will culminate on the architect Steven Holl.\(^{131}\) Holl has been interested in music for much of his life and this influence can be seen throughout several of his buildings, most notably in his design of a Texas home; *Stretto House*, where the building was designed as a parallel to a musical score.

After his first introduction to the site for the Stretto House, Holl became focused on its *aqueous* condition, as there were already four ponds and four dams present (Figure 6). Holl “wanted somehow to embrace the condition of the water flowing over the dams”.\(^{132}\) With this in mind Holl searched for a concept for the design, which would allow him to “make a connection to the idea of ‘flowing’”.\(^{133}\) As previously stated, Holl had always been interested in the links between architecture and music, resulting in the decision to “explore the musical concept stretto, which is analogous to the site’s overlapping

\(^{131}\) Holl believes highly in concept, considering it above anything else within all of his designs; he refers to concept as something which derives a design...disappears completely in the phenomena of the physical reality and yet intuitively the abundance of the idea may still be felt.

\(^{132}\) HOLL, S., ‘Work in Progress: Texas Stretto House’, *Architectural Record*, p 136

\(^{133}\) ibid p 136
ponds”.134 This allowed Holl to create a natural harmony between the site and edifice.

The musical concept *stretto* can be defined as musical entries piling up, culminating in an over-lapping, fast conclusion.135 “A particular piece of music was chosen for its extensive use of *stretto* – Bela Bartok’s *Music for Strings, Percussion, and Celeste*”, which Holl drew most inspiration for his design, allowing the concept of *stretto* to become present in all aspects of the building.136

When comparing the two pieces, *Stretto House and Music for Strings, Percussion and Celeste*, the most obvious comparable design features help to outline similarities between the two pieces, while the less apparent links help to consolidate the bond between the building and the music. The most evident similarity linking the two pieces is their layout and orientation. Like many fugal compositions, *Music for Strings, Percussion and Celeste* begins with a subject, in this case being the note A and this is expanded upon by the introduction of more instruments, which continue to involve the original subject. This focus is continued throughout the first movement and even though the entire piece is separated into four movements, material from the first can be seen as providing the basis for the later movements. By looking at the Stretto House, it then becomes visually apparent that the musical

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134 HOLL, S., *One House Series: Stretto House*, p 7  
135 KENNEDY, M., op.cit., p 709  
136 HOLL, S., op.cit., p7
composition has clearly been recreated in the architectural forms present. Like the composition of *Music for Strings, Percussion and Celeste*, the main house is divided into four distinct sections (Figure 7 and 8), representing four movements as in the Bartok piece.\(^{137}\) It also appears that each section is very similar; from the exterior, each subsequent section is respectively just a reinterpretation of the first.

From the exterior of the building, other comparisons can also be observed between the two works. As the title of Bartok’s composition suggests, the piece was written to be played by specific instruments; strings, percussion and celeste.\(^{138}\) These instruments can be grouped into light (string instruments) and heavy instruments (percussion and the celeste), which helps to emphasize the stretto of the musical piece. This would have been apparent to Holl during the early stages of design and this is why it has been integrated into the building as one of its key design features as a reinterpretation of a continuing concept used by Holl, know as “the stone and the feather”.\(^{139}\) The Texas vernacular was the natural means to facilitate this style, as this would give homage to the site of the building, so Holl designed the building using a combination of masonry (heavy) and metal (light) construction (Figure 9).\(^ {140}\) This has been further accentuated by certain design elements, which are used throughout the Stretto house. Like the building materials, Holl has used specific forms to convey and light/heavy combination to promote the *stretto*

\(^{137}\) HOLL, S., *Intertwining*, p 30
\(^{138}\) Celeste is in fact, another kind of percussion instrument
\(^{139}\) HOLL, S., *Parallax*, p 255
\(^{140}\) FRAMPTON, K., *Steven Holl Architecture*, p 358
in the Stretto House. Holl attempted to create a spatial relationship between the building and the music; “where music has a materiality in instrumentation and sound, this architecture attempts an analogue in light and space”. This relationship is shown by the forms produced using different materials; for the masonry sections of the house the design is purely orthogonal in plan, but for the metal sections, the design is curvilinear in section (Figure 10). The basic forms for the roof were in fact inspired by a piece of work by Paul Klee. Klee’s *analysis of a musical score* (Figure 11) can be found in the literature surrounding Stretto House and can be viewed as the basis for the design of the curved roof; creating another link between the Stretto House and music outside of its influence from the Bartok piece.

The entire building can be seen to have an obvious progression and rhythm through the site. “The plan modules shift back then slightly forward on the site as the house slopes gradually downward from the limestone-paved front terrace at the southwest corner to the other open court at the northwest end”. As the building progresses, it is obvious through its elevation that it is developing (Figure 12), flanking the east bank of the river and initial dams, the house flows downward into a culmination at the rear courtyard.

141 MORTEO, E., ‘Steven Holl, Texas Stretto House, Dallas’, *Domus*, p 57
142 GAROFALO, F., *Steven Holl (Architecture/Design S.)*, p 30
143 Klee is a 21st century artist. His work is heavily influenced by music, being a competent violinist himself; much of his work was based on music and much like a musical score, was meant to be read from left to right.
144 BENEDIKT, M., ‘Stretto and Style’, *Progressive Architecture*, p 54
The final exterior comparison between the Stretto House and *Music for Strings, Percussion and Celeste* is the design of the guest house. During the first movement of *Music for Strings, Percussion and Celeste* the subject is inverted, this is known as “a retrograde vow, where you play the same notes [only] upside down and backwards”.\(^{145}\) This technique has been paralleled in the design of the guest house. Here, Holl has used the same materials as seen in the Stretto house; although instead of copying the basic features of the building he has used an orthogonal design in section and a curvilinear design in plan (Figure 13), clearly presenting an inversion of the design for the main building, further representing the musical concept.

These few characteristics form the foundation for the Stretto House design, showing the most obvious connections with the Bartok. As previously discussed these techniques help to create the initial representation of the music, after further exploration other similarities and adaptations of the music help to consolidate the concept and embody each aspect of the music within Holl’s design. To fully understand how Holl has translated the music into architecture, it is clear that all of these links must also be considered.

Throughout most of his work, Bela Bartok’s is known for his use of mathematics, giving his music a sense of order, solidarity and cohesion, in the case of *Music for Strings, Percussion and Celeste*; he has used the Golden Section as a guideline to the composition of the music. Like Bartok’s composition, the

\(^{145}\) HOLL, S., ‘Work in Progress: Texas Stretto House’, *Architectural Record*, p 136
internal spaces of the Stretto House are designed according to the Golden Section. “The flowing spatial sequence [of the interior] was designed in a series of ... overlapping perspectives. The proportions were [then] fine-tuned according to the Golden Section ratio.” This use of the Golden section throughout the interior spaces give them a sense of order, familiarity, and harmony, however this technique is not solely reserved for the design of the spaces; a trace of the golden section can be found in the design of features such as the windows and other furniture within the house. This continuous use of the Golden Section helps to present the house as a singular entity, giving cohesion to all the elements contained within. As the house develops, each new component introduced feels at ease, as it is designed and positioned using the rules of the Golden Section. This was an intentional design feature created by Steven Holl; being in contrast to another concept, which gives a sense of rhythmic progression and flow to the Stretto house, known as _aqueous space_.

The term aqueous simply means something that is water based. As previously discussed the initial condition of the site was predominantly fixated with water and this is the effect that Holl was trying to recreate in the interior of the Stretto House (Figure 14). The damns and streams already present on the site were left, leaving the original state unaltered, and the atmosphere created by them was translated into the building. The external damns are mirrored by the orthogonal elements of the exterior design creating “spatial dams”, with

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146 ibid p 8
147 BENEDIKT, M., op.cit., p 61
the curved roofs flowing above (Figure 15). These roof “shells never overlap, and their energy never surmounts the ‘dams’”; instead they appear to be flowing between the dams, containing the spaces below. This aqueous theme is then developed in the main house; “floor plans pull the level of one space through to the next, roof planes pull space over walls, and an arched wall pulls light down from a skylight”. Although the idea of aqueous space is only a product of Holl’s imagination and thought process, it aids to reinforce the initial design concept of strepoto and the links to Music for Strings, Percussion and Celeste. The aqueous spaces produce a sense of perpetual motion, overlapping and progression, which are all common within a musical piece containing strepoto. The idea of aqueous space is used throughout the house making the musical sense felt within the spaces tangible. This was usually to its best effect in smaller details such as cast glass “melting ice” fountain in the entry area to the house (Figure 16), which gives the perception of the masonry dams restraining water within the house. This helps to achieve a sense that if the masonry spatial dams were somehow removed, and then just like an actual damn, water would escape and the building would lose its sense of aqueous space. This concept is then taken to its extreme at the flooded room, which lies at the north edge of the house. This room, as its name suggests, is completely flooded by an existing pond on site, doubling its space in

148 HOLL, S., One House Series: Stretto House, p 7
149 BARNA, J.W., ‘Stream and Consciousness’, Progressive Architecture, p 63
150 MARTIN, E. (Ed), op.cit., p 57
151 HOLL, S., One House Series: Stretto House, p 33
reflection.\textsuperscript{152} With balconies facing the flooded room, and bridges over head it becomes a tranquil space to relax in.

The Stretto House can be seen to have a multitude of different influences and ideas, all emanating from one design concept: *stretto*. To complete his design, Holl infused every aspect of the house with these ideas, from the large aspects of the home, down to every last detail. The window design produces a glance into the Golden Section which the house is based on, as they are often segmented into a perfect Golden rectangle. There are many references to the spatial concepts such as liquid terrazzo, fluid shapes, curved glass window pieces, light fixtures and glossy surfaces.\textsuperscript{153} This is not just confined to the details of the building but can also be found in much of the furniture contained within the house. This furniture has been designed as a parallel to the musical theme, with quarter-note (Figure 17), counterpoint (Figure 18) and half note tables (Figure 19); kitchen cabinet handles based on the heavy/light and orthogonal/curved concepts (Figure 20); carpets with musical score designs (Figure 21) and many other furniture pieces. This only helps to increase the sense of music throughout the house, although some would argue this detracts from the architecture, instead it clearly complements it, further emphasizing an extraordinary concept.

The musical piece *Music for Strings, Percussion and Celestra*, by Bartok is known for its use of *stretto*, in this case it has helped to define the music’s

\textsuperscript{152} GAROFALO, F., *Steven Holl (Architecture/Design S.)*, p 73
\textsuperscript{153} HOLL, S., *One House Series: Stretto House*, p 7
character, tempo and composition. These qualities have been translated, untouched, from the musical score into a piece of contemporary architecture. Steven Holl has used many architectural and musical techniques to almost perfectly transform all the predominant features of the music into his building. The music aids to define the architecture; its use as a concept has given order, strength and continuity to its design. Not only has Steven Holl been successful with the design of the Stretto House, but if other architects are to be truly influenced by music, then this is how it must be done. Holl refers to this as enmeshed experience, where all parts of the design merge, creating a singular experience within the architecture. The intertwining of space, light, colour, geometry, detail and material complement each other and the building and its musical concept to be experienced as a whole. Holl uses concepts such as aqueous space and stretto, in an attempt to engage the occupant, through bodily experience of the music created by the architecture. This building can be remembered as a seminal piece of architecture and its dedication to concept, but it can also aid to highlight the sometimes blurred links that are present between music and architecture and how these can be used to have a beneficial effect on architectural design. Through the design techniques and concepts used, Holl allows the occupant to view music, through architectural representation. It can be seen that even though there are strong bonds between the two along the lines of geometry and mathematics, similarly strong bonds can be created when trying to connect the fundamental nature of the music and the architecture, through techniques, experience and ideas.
METAPHOR OF MUSIC

The metaphor of music recurs throughout the ages. Yet, it is more commonly used comparatively, rather than in the actual practice of design. Goethe spoke of architecture as frozen music and this represents how the use of music is commonly considered by most architects and theorists. However, this study differs from that trail of thought, rather it attempts to seek and investigate themes, techniques and examples, which have actually used music to inform and improve architectural design, rather than merely comparing the two. In Copland’s *Music and Imagination*, the author states “a single musical moment immobilized makes audible only one chord, which in itself is meaningless”. This would imply, unlike other art forms, when music is taken out of context, and frozen it loses its coherency and meaning. Therefore, the famous quote that architecture is frozen music becomes redundant for this study. If music is frozen it will become restricted, losing what it is and be without reason and meaning. By describing architecture as frozen music it portrays it as a lesser art form. The negative connotations implied by this famous analogy are undesirable. Furthermore, the statement *architecture is frozen music* tends to suggest a “relationship without influence, likeness without connection”. Rather, this paper has found a bond between them and encourages the use of music in architectural design metaphorically and describing the two as parallel disciplines, occupying the same essence thus able to inform each

154 ANTONIADES, A. C., op.cit., p 265
155 COPLAND, A., *Music and Imagination*, p12
other. The architecture discussed throughout this study can all be united under a common statement; “that music, the most divine and free of arts, become the teacher of worldly and material-bound architecture”.157

This connection between music and architecture provided Plato with reasons for the natural occurrences in the cosmos. When Alberti discussed theories on harmony it allowed him to translate Plato’s ideas of the perfect cosmos into his architecture, which was experienced by anyone connected to the architecture. Similarly, the Baroque attempted to represent a progressive state in its architecture, through its use of musical harmony and dissonance. Furthermore, the bond between Baroque musical and architectural temperance shows a desire to control and change the world around them. Serialist thinkers Schoenberg attempted to step away from the use of harmony in their work, attacking its use in the creation of aesthetics. Their designs attempted to remove standardised musical and architectural elements, critiquing their age. All of the above discussions present the thoughts of their age, however, as time progressed, ideas became unique to each person. This is clear in the work of Xenakis and Holl, who utilized many of past connections between music and architecture within their work.

In conclusion, it is clear from this investigation that there are real and tangible bonds present between music and architecture. Throughout history they have often been considered one and the same, only their context separates them.

From the examples presented throughout this paper, it is clear that in some instances this statement is true, as both the theories and concepts defining both architecture and music have often been the same, only their context in creation differs. To expand on this, both architecture and music can be related through their creation, harmony, proportion, composition and cultural expression. Although some may doubt these links, from this study it is clear that there are many examples of the bond between music and architecture and little evidence to doubt it.

This investigation has almost exclusively focused on the use of musical theories within architectural theory and practise, metaphorically. It is true that these theories often required translation into the visual form before becoming available to architecture, yet their essence is still the same. Furthermore, when beneficial, examples have also been given where the influence has been reversed; architecture inspiring music. From their initial conception, this mutual influence has been crucial to the development of both architecture and music. The original discovery of harmony paved the way for their collaboration, and allowed the two art forms to be linked in every aspect. Although this study has been narrowed by the discussion of westernized theories of harmony, I feel there is still much more that can be discussed as to the collaboration of music and architecture. Even though the scope of this study has been limited, it has sought to understand the use of the metaphor of music in architectural theory and practice, such as in musically designed buildings like the Stretto House, by Steven Holl. In addition, this paper does
not attempt to be the finite source for the discussion of music and architecture, rather it is a starting point, representing a selection of the countless areas in which music and architecture are collectively bound. Finally, this investigation has attempted, and hopefully succeeded in highlighting historical examples with new meaning behind their design, and showed the collaboration of architecture and music. If music and architecture are truly to evolve, they must continue to question and influence each other, for problems in architecture are the same as in music.\textsuperscript{158} Future architecture will be influenced by new music and this beneficial partnership can only result in creativity, innovation and ingenuity.\textsuperscript{159} For music and architecture are identical; negating their medium of expression, they are equal and admirable.\textsuperscript{160}

This paper has presented a cross section of musical and architectural ideas (harmony). As discussed in the introduction, melody and rhythm are not as important in this study, as there is no direct translation. It is clear that harmony has been the overriding structure in the metaphor of music in architecture. Furthermore, is has become clear that both music and architecture are metaphysical forms of expression. Through historical examples, this study has determined that their correlation has been beneficial in their mutual development. Moreover, due to their metaphysical nature, the relationship between them cannot be exhausted. The term architect is

\textsuperscript{158} INTERVIEW WITH XENAKIS, 1997, cited in MATOSSIAN, N., op.cit., p 69
\textsuperscript{159} MARTIN, E. (ed), op.cit., p 80
\textsuperscript{160} WATERHOUSE, P., ‘Music and Architecture’, \textit{Music and Letters}, p 331
constantly being utilised in other fields, however, the term musician is not.\textsuperscript{161} This is the result of the lived experience of music being missed. To experience music through architecture, one must be aware of it and believe in its existence. The belief of the representation of music within architecture results in an unforeseen beauty – long may it continue.

\textsuperscript{161} Software developers are often being referred to as software architects etc.
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ILLUSTRATIONS

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<table>
<thead>
<tr>
<th>SHORT AREAS</th>
<th>MEDIUM AREAS</th>
<th>LONG AREAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 : 1 (square)</td>
<td>1 : 2 (double)</td>
<td>1 : 3 (1 : 2 : 3)</td>
</tr>
<tr>
<td>3 : 4 (sesquitercia)</td>
<td>9 : 16 (9 : 12 : 16)</td>
<td>1 : 4 (1 : 2 : 4)</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Interval</th>
<th>Octave</th>
<th>Minor Third</th>
<th>Major Third</th>
<th>Fourth</th>
<th>Fifth</th>
<th>Minor Sixth</th>
<th>Major Sixth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Union</td>
<td>1</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>5</td>
</tr>
</tbody>
</table>

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