

Sound and Space: Exploring the Relationship Between Music and Architecture

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## Introduction

Though invisible, the sound waves that create music often find visual expression in the objects that produce and encompass them. Instinctively, musical notation and instruments are associated with this visual and spatial dimension. Yet, architecture is also intricately tied to music. Sound waves interact with buildings to produce acoustic effects – each space has its own unique auditory character depending on spatial and material qualities. This relationship presents itself most directly in concert halls, where a building’s physical structure determines both aesthetic and acoustic qualities. Music can also be expressed conceptually in architecture through aesthetics and structure. In Ancient Greece, it has been suggested that musical proportions were used for temple designs;<sup>1</sup> In the Renaissance, mathematical ratios present in the harmony of the musical scale were used by architects to determine architectural proportion.<sup>2</sup> Concert halls and cathedrals are linked to music both as performance spaces and through their architectural qualities. Recently, music has served as aesthetic inspiration for architecture, and has inspired modern proportional systems. This catalogue explores such links between music and architecture, examining how individual circumstances and ideologies interact to influence these relationships, and how music and architecture continue to evolve today.

This survey examines key linkages between music and architecture, employing case studies in order to demonstrate relationships that might otherwise go unnoticed. While by no means all-encompassing, these examples offer a broad exploration of two seemingly disparate fields – culture and context come together to demonstrate unique approaches to music and architecture. While individual qualities may differ, each example provides insight into the link between sound and space, and the ways in which music and architecture have come together regardless of place and circumstance.

The catalogue is divided into three categories: “Proportion and Harmony in Classical Texts and Gothic/Renaissance Architecture”, “Music and Architecture, 20th Century-Present”, and “Concert Halls, 19th-21st Century”. By choosing this broad range of topics, this catalogue explores the following questions: How are music and architecture linked? How do typological, historical, acoustic and cultural factors influence the structure of buildings created with music as a central focus?

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<sup>1</sup> Daniel K.S. Walden, "Frozen Music: Music and Architecture in Vitruvius' De Architectura," *Greek and Roman Musical Studies* 2, no. 1 (2014): 129, <https://doi-org.myaccess.library.utoronto.ca/10.1163/22129758-12341255>.

<sup>2</sup> Robin Evans, *The Projective Cast: Architecture and Its Three Geometries* (Massachusetts: MIT Press, 2000), 241.

## Proportion and Harmony in Classical Texts and Gothic/Renaissance Architecture

Music and architecture are known to have been intertwined since classical antiquity. In Ancient Greece, Pythagoras devised a system of musical harmony, rooted in the discovery that the ratios between the lengths of two objects related directly to the sounds they produced. The Pythagorean scale relied on the numbers 1, 2, and 3, and expressed all harmonic relationships through powers of these numbers. These mathematical harmonic ratios were seen by Pythagoras not as simple musical properties. Instead, Pythagoras suggested that “the musical harmonies governed the movements of the planets”.<sup>3</sup> This reference to the architecture of the universe formed an important ideological bridge between musical harmony and the structure of the natural world, and attached a spiritual and religious dimension to the idea of the “music of the spheres” – these ideas would later be re-interpreted and absorbed by numerous scholars, leading to an overarching belief that musical, visual, and spatial harmony were all governed by the same proportional laws.<sup>4</sup>

This idea of music as a governing principle carried into Ancient Rome, where it appeared in Vitruvius’ treatise *De Architectura*, widely seen as the first preserved architectural text.<sup>5</sup> In this text Vitruvius emphasizes the importance of musical theory for architects, suggesting that a knowledge of music will bring architecture closer to nature, thereby rendering it “more beautiful, convenient, and useful”.<sup>6</sup> Vitruvius also uses musical terms to explain architectural ideas; these terms are linked to Pythagorean harmony.<sup>7</sup> Vitruvius emphasises the importance of a well-rounded education including music, as expressed for example in Book I:

“Music, also, the architect ought to understand so that he may have knowledge of the canonical and mathematical theory”<sup>8</sup>

“Astronomers likewise have a common ground for discussion with musicians in the harmony of the stars and musical concords in tetrads and triads of the fourth and the fifth, and with geometricians in the subject of vision”<sup>9</sup>

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<sup>3</sup> Angela Pintore, “Musical Symbolism in the Works of Leon Battista Alberti From *De re aedificatoria* to the Rucellai Sepulchre,” *Nexus Network Journal* 6, no. 2 (2004): 61, <https://doi-org.myaccess.library.utoronto.ca/10.1007/s00004-004-0018-3>.

<sup>4</sup> Ibid.

<sup>5</sup> Daniel K.S. Walden, “Frozen Music: Music and Architecture in Vitruvius’ *De Architectura*,” *Greek and Roman Musical Studies* 2, no. 1 (2014): 124, <https://doi-org.myaccess.library.utoronto.ca/10.1163/22129758-12341255>.

<sup>6</sup> Ibid, 126-127.

<sup>7</sup> Ibid., 128.

<sup>8</sup> Vitruvius, *The Ten Books on Architecture*, trans. Morris Morgan (Cambridge: Harvard University Press, 1914), 8.

<sup>9</sup> Ibid., 12.

During the Medieval Period, architecture and music continued to be intertwined, particularly in the new “temple” – the Gothic cathedral. In the Gothic period, just as today, music played an important role in cathedral services. Aesthetically, some scholars have argued that the physical form of cathedrals may reflect their contemporary musical counterparts. Lee and Park, for example, use isomorphism to analyse medieval chants in relation to cathedral architecture, suggesting that “sound can be imagined as an abstract construction that might be realized in architecture”.<sup>10</sup>

Later, and more prominently, music became an important element of Renaissance architectural theory and practice. Following from Vitruvius’ *De Architectura*, Leon Battista Alberti’s *De Re Aedificatoria* is considered the second key Western architectural treatise. The text expresses a resurgence of classical ideals, referencing both Vitruvius and Pythagoras, among others.<sup>11</sup> Alberti states that “The same numbers, by means of which the agreement of sounds affects our ears with delight, are the very same which please our eyes and mind.”<sup>12</sup> In *De Re Aedificatoria* Alberti describes harmonic ratios in detail, providing a set of rules to determine architectural areas and volumes.<sup>13</sup> Inspired by classical ideals, harmonic proportions became a key element of Renaissance architecture, as for example in Alberti’s own design for the Rucellai Sepulchre.<sup>14</sup> Musical proportions have been observed in the work of many other Renaissance architects, for example Andrea Palladio and Filippo Brunelleschi.<sup>15</sup>

### Case Study: Notre Dame de Paris, Paris (1345)

“All at once the roll of the great organ was heard; but for me, the sound was the singing of the rose window before me. [...] my imagination led me to believe that such or such panes of glass emitted grave and solemn sounds, while others produced shriller and more piercing tones”<sup>16</sup>

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<sup>10</sup> Hong-Kyu Lee and Kin-Ho Park, "Structuring Vertical Space: Relationship between Chants and Cathedral Naves in the Medieval Period," *Journal of Asian Architecture and Building Engineering* 8, no.1 (May 2009): 25, <https://doi.org/10.3130/jaabe.8.25>.

<sup>11</sup> Angela Pintore, "Musical Symbolism in the Works of Leon Battista Alberti From De re aedificatoria to the Rucellai Sepulchre," *Nexus Network Journal* 6, no. 2 (2004): 60, <https://doi-org.myaccess.library.utoronto.ca/10.1007/s00004-004-0018-3>.

<sup>12</sup> Leon Battista Alberti, *Ten Books on Architecture*, trans. James Leoni (London: Alec Tiranti, 1955), 197.

<sup>13</sup> Angela Pintore, "Musical Symbolism in the Works of Leon Battista Alberti From De re aedificatoria to the Rucellai Sepulchre," *Nexus Network Journal* 6, no. 2 (2004): 62, <https://doi-org.myaccess.library.utoronto.ca/10.1007/s00004-004-0018-3>.

<sup>14</sup> *Ibid.*, 49.

<sup>15</sup> Rudolph Wittkower, *Architectural Principles in the Age of Humanism* (New York: W.W. Norton and Company, 1971), 136.

<sup>16</sup> Eugène-Emmanuel Viollet-le-Duc, *Lectures on Architecture*, vol. 1, trans. Benjamin Bucknall (New York: Dover Publications, 1987), 22.

The above quote describes a synesthetic experience in Notre Dame de Paris, as recounted by architect Viollet-le-Duc. Music is an important aspect of Notre Dame's function as a cathedral. Indeed, the formal aspects of its construction, like that of many similar cathedrals, can be linked to music through structure and ornamentation.

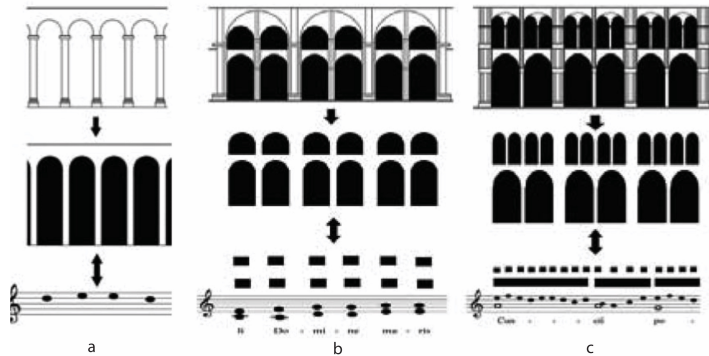


Figure 1: Cathedral elevations, translated by Lee and Park into musical harmony and rhythm. Shows a single-story elevation (a), a parallel elevation (b), and a melismatic elevation (c).

Diagrams: Hong-Kyu Lee and Kin-Ho Park, "Structuring Vertical Space: Relationship between Chants and Cathedral Naves in the Medieval Period," *Journal of Asian Architecture and Building Engineering* 8, no.1 (May 2009): 27-28, fig. 6, 11, <https://doi.org/10.3130/jaabe.8.25>.

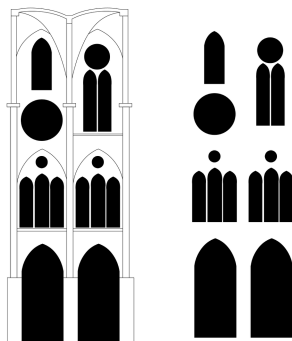


Figure 2: Figure-ground diagram showing a section of the nave interior elevation in the Notre Dame de Paris – these stacked arches can be interpreted as architectural harmony and rhythm, and translated into music.

Diagram by author

In particular, the architectural development of Gothic and medieval cathedrals has been linked to simultaneous developments in music, harmony, and chants. Lee and Park, for example, use Figure-Ground and Gestalt theory to link the structure of cathedral naves from the medieval period to that of chants being developed at the same time.

Monophonic chants (those with a single melodic line) are compared to single-story elevations, and polyphonic chants (those with multiple melodic lines) are compared to multi-story elevations –

stacked architectural elements are linked to stacked notes in a musical score. Lee and Park also compare musical and architectural structure through two types of compositions: parallel, where rhythms are identical in all vocal parts or architectural layers, and melismatic, where rhythms differ across parts (see figure 1).<sup>17</sup>

Charles Jencks uses a similar analysis to describe the structure of Notre Dame de Paris, linking architectural aspects of the cathedral to music being developed at Notre Dame by Pérotin. According to Jencks, Pérotin's rhythmic notation system is tied to the alternate bay "rhythms" in the cathedral. Pérotin's novel harmonies and stacked chords are linked to architectural "chords", created through the stacking of arcade, triforium, gallery, and clerestory.<sup>18</sup> Figure 2 demonstrates these relationships, using Lee and Park's figure-ground system.

<sup>17</sup> Hong-Kyu Lee and Kin-Ho Park, "Structuring Vertical Space: Relationship between Chants and Cathedral Naves in the Medieval Period," *Journal of Asian Architecture and Building Engineering* 8, no.1 (May 2009): 26-28, <https://doi.org/10.3130/jaabe.8.25>.

<sup>18</sup> Charles Jencks, "Architecture Becomes Music," *The Architectural Review*, May 6, 2013, <https://www.architectural-review.com/essays/architecture-becomes-music/8647050.article>.

### Case Study: Santa Maria del Fiore, Florence (1436)

Brunelleschi's dome, long known for its feats of engineering, became a subject of musical debate in 1973 when musicologist Charles Warren proposed possible links between the proportions of the cathedral and *Nuper rosarum flores*, a motet composed by Guillaume Dufay for the dome's dedication ceremony. Warren argues that the dome and motet are also linked mathematically, and suggests that both feature the harmonic proportions 6:4:2:3. He provides an analysis of both dome and motet in order to demonstrate this relationship (see figures 3 and 4).<sup>19</sup>

According to Warren, the plan and elevation of the cathedral contain this 6:4:2:3 relationship when measured using modular squares (see figure 4), as does the motet through the meters of its isorhythmic sections.<sup>20</sup> Warren draws several further parallels, linking structural and proportional elements of the cathedral to musical qualities of Dufay's motet. He suggests that "the first section of the motet relates proportionally to the nave, the second to the transept, the third to the apse, and the fourth to the dome."<sup>21</sup>

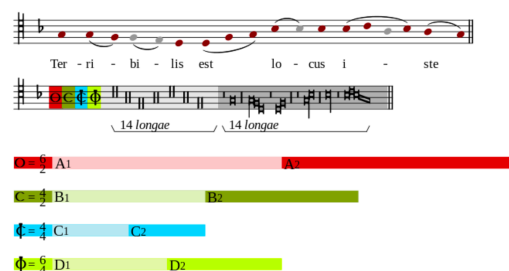


Figure 3: "Diagram illustrating the isorhythmic sections of *Nuper rosarum flores* with their respective meters" – visually demonstrates how the metres associated with each section of the motet demonstrate the 6:4:2:3 relationship.

Diagram and caption quote: Jacy Stahlhut, "Nuper rosarum flores: The Cathedral Conundrum," *Musical Offerings* 11, no. 1 (2020): 34, fig. 3, <https://digitalcommons.cedarville.edu/musicalofferings/vol11/iss1/3>.

Debate ensued following the publication of Warren's theory. Warren's ideas have been criticized on multiple levels, including that many correspondences between the dome and the motet arise from invisible architectural qualities, only observable through official documents.<sup>22</sup> Subsequent scholars have presented alternate theories. Craig Wright, for example, criticized Warren's observations and suggested instead that the motet's proportions are biblical, reflecting the description of King Solomon's Temple. Subsequently, Marvin Trachtenberg proposed that both the cathedral and motet may relate proportionally to King Solomon's temple, thereby preserving the relationship between cathedral and motet, and the proportional bridge between architecture and music.<sup>23</sup>

<sup>19</sup> Charles Warren, "Brunelleschi's Dome and Dufay's Motet," *The Musical Quarterly* 59, no. 1 (January 1973): 92-96, <https://www.jstor.org/stable/741461>.

<sup>20</sup> *Ibid.*, 94-96.

<sup>21</sup> *Ibid.*, 103.

<sup>22</sup> Robin Evans, *The Projective Cast: Architecture and Its Three Geometries* (Cambridge: MIT Press, 2000), 245.

<sup>23</sup> Jacy Stahlhut, "Nuper rosarum flores: The Cathedral Conundrum," *Musical Offerings* 11, no. 1 (2020): 30, <https://digitalcommons.cedarville.edu/musicalofferings/vol11/iss1/3>.

The source of this debate emphasises a more fundamental point: this is an example of architecture that merited a musical commission. *Nuper rosarum flores* was written with the intention of celebrating architecture, and harmonising with an incredible civic space – this simple and fundamental connection between music and architecture is perhaps the most important.

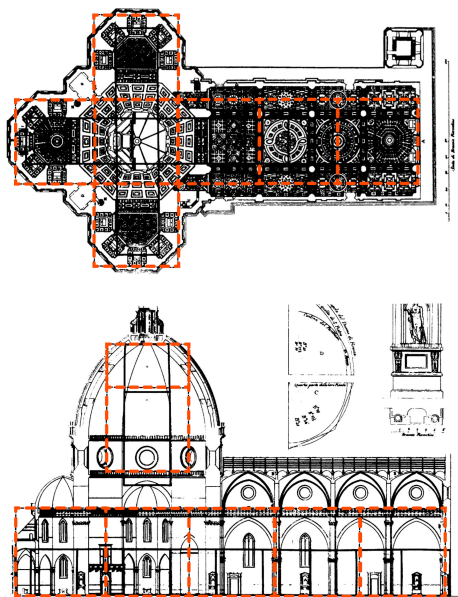


Figure 4: "Warren's diagram indicating (with dotted lines) three 50.8-braccia units in the nave, two in the transept, one in the apse, and one and one-half in the dome." These numbers, multiplied by two, demonstrate the 6:4:2:3 relationship – diagram annotated by author.

Caption quote: Jacy Stahlhut, "Nuper rosarum flores: The Cathedral Conundrum," *Musical Offerings* 11, no. 1 (2020): 32, fig. 3, <https://digitalcommons.cedarville.edu/musicalofferings/vol11/iss1/3>.

Diagram: Charles Warren, "Brunelleschi's Dome and Dufay's Motet," *The Musical Quarterly* 59, no. 1 (January 1973): 95, fig. 2-3, <https://www.jstor.org/stable/741461>.

## Concert Halls, 19<sup>th</sup> Century – Present

Although ideas of harmonic proportion in architecture began to fade in the seventeenth and eighteenth centuries, the link between architecture and music was preserved, resurfacing in the form of the modern concert hall.<sup>24</sup> In the following examples, both music and architecture have power to evoke an emotional response – sound and space work together to “perform”. Within the concert hall, music and architecture have a bi-directional influence. Musical style influences architectural form through the acoustic and structural qualities necessary to optimize a musical performance, as well as the seating and other accommodations necessary for a live audience. Likewise, composers have often composed music with a specific architecture in mind, and in such cases have created a musical style that will feature favourably in the specific acoustics of the venue. In certain instances, architecture itself can be played as a musical instrument; In the world premiere of Judith Bingham’s *Hidden City*, St. Paul’s Cathedral acted as an enormous musical instrument, transforming and performing a musical piece inspired by the cathedral itself. Music and architecture can also interact to produce spatial musical performances, for example where choirs encircle an audience to produce a “surround-sound” effect. Music moves and sound encompasses the audience from all directions, playing with spatial awareness as choral parts shift.<sup>25</sup>

Throughout history, architectural and musical styles have changed alongside one another, and musical halls are no exception. During the Baroque Period (1600-1750), the contrapuntal style evolved alongside two separate acoustic types: dry and reverberant. Secular music was often performed in dry spaces, such as ballrooms, while sacred music occupied a wide range of acoustics, from dry to reverberant. The less reverberant acoustics of Lutheran churches appeared during this time, and influenced Bach’s use of counterpoint. During the Classical Period (1750-1820) secular music gained popularity, leading to the development of melodic classical symphonies and sonatas. The construction of designated concert halls, however, did not occur until the late 18<sup>th</sup> Century. Only in the 19<sup>th</sup> Century were larger concert halls constructed, featuring reverberant acoustics and an overall rectangular “shoebox” form. During the Romantic Period (1820-1900), ideal acoustic environments were those with “high fullness of tone and low definition”.<sup>26</sup> Pieces during this period were often composed for a specific music hall, and many halls built towards 1900 reflected the specific acoustic desires of composers. In European opera houses in particular, composers could write for a specific acoustic environment – the consistent horseshoe-shaped hall with short reverberation times. Moving into the 20<sup>th</sup>

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<sup>24</sup> Rudolph Wittkower, *Architectural Principles in the Age of Humanism* (New York: W.W. Norton and Company, 1971), 143,154.

<sup>25</sup> John Wheatley, “The Sound of Architecture,” *Tempo* 61, no. 242 (October 1, 2007): 12, 14, doi:10.1017/S0040298200000267.

<sup>26</sup> Leo Beranek, *Concert Halls and Opera Houses: Music, Acoustics, and Architecture* (New York: Springer-Verlag, 2004), 12.

and 21<sup>st</sup> Centuries, concert halls have become extremely innovative and adaptive architecturally – able to accommodate a wide range of musical styles.<sup>27</sup>

### Case Study: Bayreuth Festspielhaus (1876)

The Bayreuth Festspielhaus is an example of a concert hall designed for the music of a single composer. Designed by Richard Wagner, it showcases his operas and does not respond well to others' compositions.<sup>28</sup> This unusual hall was born out of Wagner's dissatisfaction with traditional theatres. He wished to have audience members by invitation only, and designed the hall in order to capture the audience's attention on the stage, while heightening the illusions of stage performance and the dramatic effects of the music.<sup>29</sup> Wagner's hall features a covered orchestra pit in order to increase the dramatic power of the orchestra and maintain an element of mystery (see figure 5). The hall has a long reverberation time, and responds best to Wagner's operas *Der Ring Des Nibelungen*, and *Parsifal*.<sup>30</sup> This hall is a rare example of architecture created for the music of a specific composer, and shows a strong connection between musical compositions and their respective performance space, as well as the importance of an appropriate hall for any given type of music.

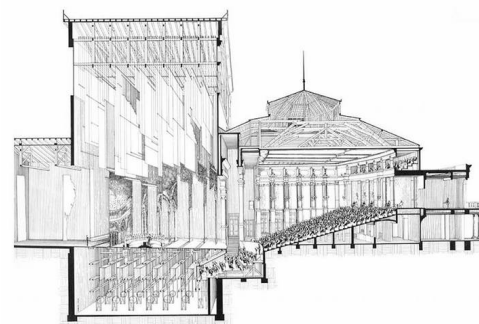


Figure 5: Perspectival Section, Bayreuth Festspielhaus, showing seating, stage, and sunken covered orchestra pit.

Diagram: Perspectival Section, digital image, Wagner & Heavy Metal, accessed September 5, 2020, <https://www.wagner-heavymetal.com/ein-hollaumlander-in-bayreuth-2017-meistersinger.html>.

### Case Study: Berliner Philharmonie, Berlin (1963)

The Berlin Philharmonie opened in 1963, two years after the construction of the Berlin Wall. Situated near the wall and visible from East Berlin, the concert hall was seen by many as “a beacon of democracy”.<sup>31</sup> Architecturally, the hall was intended to be democratic, involving the audience members as participants in each performance, with visitors facing other audience members in addition to the orchestra.<sup>32</sup> Hans Scharoun's unusual design for the hall puts music at the center quite literally, by positioning the stage centrally and arranging the audience

<sup>27</sup> Leo Beranek, *Concert Halls and Opera Houses: Music, Acoustics, and Architecture* (New York: Springer-Verlag, 2004), 8-15.

<sup>28</sup> *Ibid.*, 283.

<sup>29</sup> Simon Williams, “Bayreuth Festspielhaus: Enchaining the Audience,” *Theatre Survey* 33, no. 1 (1992): 69, 73, doi:10.1017/S0040557400009613.

<sup>30</sup> Leo Beranek, *Concert Halls and Opera Houses: Music, Acoustics, and Architecture* (New York: Springer-Verlag, 2004), 283, 287-288.

<sup>31</sup> Hugh Campbell, “‘The Bright Edifice of Community’: Politics and Performance in Hans Scharoun's Berlin Philharmonie,” *Architectural Research Quarterly* 11, no. 2 (June 1, 2007): 160, 159–66. doi:10.1017/S1359135507000632.

<sup>32</sup> *Ibid.*, 160.

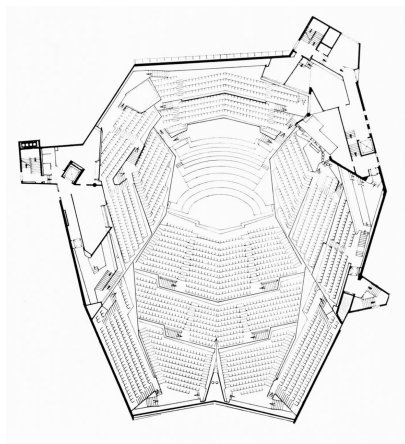


Figure 6: Plan view showing radial “vineyard” audience arrangement, Berlin Philharmonie.

Image: Berlin Philharmonie Plan, digital image, Archive of Affinities, accessed September 4, 2020, <https://archiveofaffinities.tumblr.com/post/12222284077/hans-scharoun-berlin-philharmonic-hall-floor>.

around it (see figure 6). This unusual arrangement has proved to be influential in the further development of non-rectangular concert halls.<sup>33</sup> The audience is arranged in a “vineyard” configuration, with rows of spectators divided into blocks arranged radially around the stage.<sup>34</sup> This connected both architecture and music with ideas of culture, community, and democracy, at a unique moment in history. In this example, music is the central element that provides a focal point within a democratic structure – this egalitarian cultural gathering is facilitated by architecture. Externally, the hall features unusual swooping forms – these could be interpreted aesthetically as visual expressions of music melodies, crescendos or decrescendos (see figure 7).



Figure 7: Exterior view, Berlin Philharmonie.

Image: A. Savin, *Philharmonie (concert hall) in Berlin*, May 14, 2018, Wikimedia Commons, accessed September 4, 2020, [https://commons.wikimedia.org/wiki/File:Berlin\\_Philharmonie\\_asv2018-05\\_img1.jpg](https://commons.wikimedia.org/wiki/File:Berlin_Philharmonie_asv2018-05_img1.jpg)

<sup>33</sup> Leo Beranek, *Concert Halls and Opera Houses: Music, Acoustics, and Architecture* (New York: Springer-Verlag, 2004), 3.

<sup>34</sup> *Ibid.*, 297.

### Case Study: Norwegian National Opera and Ballet, Oslo (2008)

The Norwegian National Opera and Ballet, designed by Snøhetta, is an interactive public landmark that functions as an outdoor civic space as much as an indoor musical hall. The sculpted angular exterior and smooth interior spaces give the impression of a new opera house typology. However, the interior performance space is traditional in form, maintaining the horseshoe shape seen in the majority of European opera houses (see figure 9).<sup>35</sup> This mixture of traditional and contemporary styles is striking.

The Oslo Opera and Ballet was intended as a “flagship for opera and culture”, with aims of creating cultural identity, regenerating the local area, and reconnecting the city to the sea.<sup>36</sup> The exterior is designed as a continuous series of ramps from the neighboring fjord to the top of the hall, open year-round to the public (see figure 10). This creates a tie to Norway’s natural landscape, increasing its effect as a marker of cultural identity. Conceived as both a musical performance space and a civic space, the interior and exterior of the hall function dually to provide unique experiences. This shift from a traditional interior to an untraditional exterior shows how modern civic culture and traditional opera come together through architecture, linking music, cultural identity, and the surrounding natural features in a single building.



Figure 8: Norwegian National Opera and Ballet, viewed from the water.

Image: Exterior View, digital image, Snøhetta, accessed September 5, 2020, <https://snohetta.com/projects/42-norwegian-national-opera-and-ballet#>.

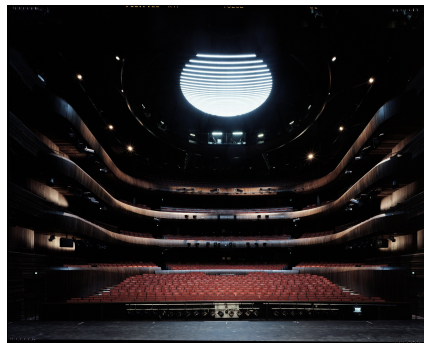


Figure 9: Horseshoe interior, Norwegian National Opera and Ballet.

Image: Interior View, digital image, Snøhetta, accessed September 5, 2020, <https://snohetta.com/projects/42-norwegian-national-opera-and-ballet#>.



Figure 10: Public roof space, Norwegian National Opera and Ballet.

Image: Exterior View, digital image, Snøhetta, accessed September 5, 2020, <https://snohetta.com/projects/42-norwegian-national-opera-and-ballet#>.

<sup>35</sup> Leo Beranek, *Concert Halls and Opera Houses: Music, Acoustics, and Architecture* (New York: Springer-Verlag, 2004), 14.

<sup>36</sup> Andrew Smith and Ingvild von Krogh Strand, “Oslo’s New Opera House: Cultural Flagship, Regeneration Tool or Destination Icon?” *European Urban and Regional Studies* 18, no. 1 (January 2011): 106-107, doi:10.1177/0969776410382595.

## Music and Architecture, 20th Century – Present

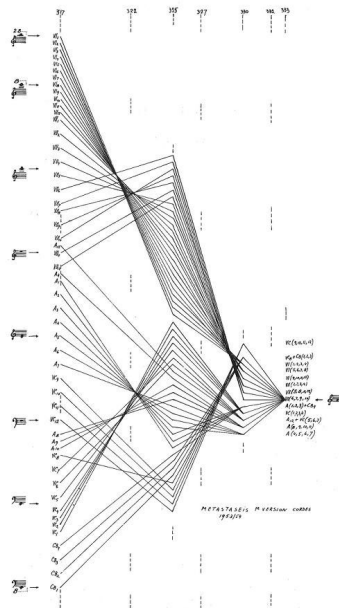


Figure 11: Graphic Score for *Metastasis*, composed by Iannis Xenakis.

Diagram: Iannis Xenakis, *Musique. Architecture* (Tournai: Casterman, 1976), 8.

Beyond concert halls, music and architecture have remained linked in contemporary architecture through aesthetic interpretations of music, as well as new uses of musically inspired proportions. In the 20<sup>th</sup> Century, architect Le Corbusier devised the Modulor, a proportional system based on the proportions of a man with his arm raised, the golden section, and the Fibonacci series.<sup>37</sup> However, it also had strong musical ties. Le Corbusier was fascinated by Pythagorean ideas and considered himself both a musician and mathematician, with music as a starting point for his mathematical explorations.<sup>38</sup> While the Modulor's ratios do not exactly follow those of harmonic proportion, Le Corbusier described his system as equivalent to a musical scale, and frequently used musical terms and metaphors in describing it.<sup>39</sup> More recently, the Modulor has been re-interpreted by scholar Radoslav Zuk in order to create multiple "Musical Modulors" that follow harmonic ratios more exactly.<sup>40</sup>

Le Corbusier's musical involvement was furthered by his twelve-year collaboration with engineer and composer Iannis Xenakis. Xenakis employed the Modulor to create architecture that both mimicked and housed music. The Modulor was also influential in Xenakis' musical compositions, notably in *Metastasis* (1954), where he employed the Modulor's proportional relationships in order to create mathematical unity across the orchestral piece. Thus, this interdisciplinary collaboration moved in both directions, with architecture influencing music, and music influencing architecture.<sup>41</sup>

<sup>37</sup> Robin Evans, *The Projective Cast: Architecture and Its Three Geometries* (Cambridge: MIT Press, 2000), 275.

<sup>38</sup> Clara Germana Gonçalves and María João Soares, 2015, "Le Corbusier: Architecture, Music, Mathematics: Longing for Classicism?" (paper presented at Le Corbusier, 50 Years Later: International Congress, Valencia, Spain, November 18-20), 3, <http://dx.doi.org/10.4995/LC2015.2015.791>.

<sup>39</sup> Radoslav Zuk, "Three Musical Interpretations of Le Corbusier's Modulor," *Nexus Network Journal* 15, no. 1 (March 20, 2013): 155, doi:10.1007/s00004-013-0143-y.

<sup>40</sup> *Ibid.*, 165-167.

<sup>41</sup> Robin Evans, *The Projective Cast: Architecture and Its Three Geometries* (Cambridge: MIT Press, 2000), 295-296.





Figure 13: Exterior view of the Philips Pavilion, constructed using ruled surfaces in a similar way to Xenakis's musical glissandi.

Image: Iannis Xenakis and Le Corbusier, "Philips Pavilion," *ANY: Architecture New York*, no. 5 (1994): 34, <http://www.jstor.org/stable/41845639>.

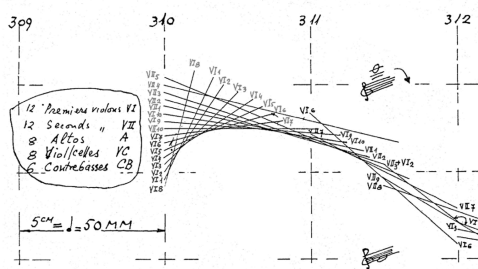


Figure 14: Portion of the preliminary visual score for Xenakis' *Metastasis*, showing a glissando represented using ruled surfaces.

Diagram: Anne-Sylvie Barthel-Calvet, "De l'ubiquité poétique dans l'œuvre de Iannis Xenakis – espace, temps, musique, architecture," *Intersections* 29, no. 2 (2009): 46, fig. 15a, <http://myaccess.library.utoronto.ca/login?url=https://www.proquest.com/docview/341213%3Faccountid%3D14771>.

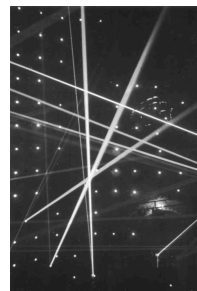


Figure 15: Polytope de Cluny. Light projections and grids of light form a unique, ever-changing spatial experience, and are combined with music and sound.

Image: Philipp Oswald, "Iannis Xenakis' Polytopes," *Contemporary Music Review* 21, no. 2–3 (June 1, 2002): 42, fig. 6, doi:10.1080/07494460216658.

The Philips Pavilion was designed to relate to the "electronic poem" in its unusual formal and stylistic aspects.<sup>46</sup> Xenakis was tasked with developing the form of the pavilion, and employed a system of ruled surfaces and hyperbolic paraboloids in order to achieve the final shape (see figure 13). These ideas were not unique to the Philips Pavilion and had been used previously in Xenakis' musical compositions, in particular for the graphic score of *Metastasis* (see figure 14).<sup>47</sup> Already tied to architecture through its use of the Modulor system, *Metastasis* also became part of the inspiration for an architectural construction. The Philips Pavilion not only housed music, but was itself inspired by musical form and notation.

Xenakis' experiments with Le Corbusier likely inspired the creation of later independent works that Xenakis called Polytopes. These immersive installations were created using "abstract compositions of light" (see figure 15).<sup>48</sup> Xenakis used music from his own compositions in these

installations, along with grids of light and light projections. Spatial and temporal auditory effects were created by changing elements such as tempo and time signature, and using speakers to represent orchestras or ensembles.<sup>49</sup> In these installations, architecture and music came together to produce an immersive sensory experience for viewers within an architectural space.

<sup>46</sup> Iannis Xenakis and Le Corbusier, "Philips Pavilion," *ANY: Architecture New York*, no. 5 (1994): 34, <http://www.jstor.org/stable/41845639>.

<sup>47</sup> Alessandra Capanna, "Iannis Xenakis: Architect of Light and Sound," *Nexus Network Journal* 3, no. 1 (April 1, 2001): 20, 25, doi:10.1007/s00004-000-0003-4.

<sup>48</sup> Philipp Oswald, "Iannis Xenakis' Polytopes," *Contemporary Music Review* 21, no. 2–3 (June 1, 2002): 37, doi:10.1080/07494460216658.

<sup>49</sup> *Ibid.*, 37–40.

## Case Study: Monastery of La Tourette, Éveux (1961)



Figure 16: West Façade of the Couvent de La Tourette, showing Xenakis' Stacked Undulating Glass Panels.

Image: Fernando Schapo, *Façade, La Tourette*, digital image, Dezeen, accessed September 5, 2020, <https://www.dezeen.com/2016/07/22/le-corbusier-la-tourette-monastery-grass-roof-france-unesco-world-heritage/>.

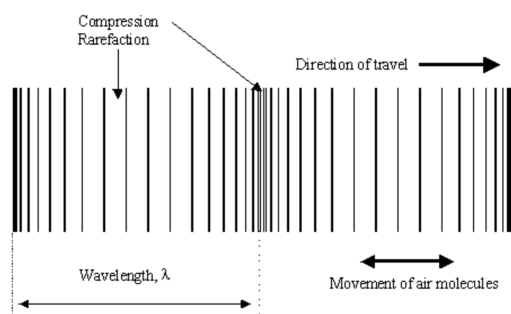


Figure 17: Diagram showing the compression and rarefaction patterns in a sound wave.

Diagram: Longitudinal Wave, digital image, The Sinequanon, accessed September 5, 2020, <http://www.sinequanonthebook.com/AetherHistory.html>.

Le Corbusier's collaboration with Iannis Xenakis led to another example of musical architecture at Monastery of La Tourette in France. Xenakis is responsible for a series of undulatory glazed panels along the façade of the monastery, which have been interpreted musically in various ways (See figure 16).<sup>50</sup> Again, his design was influenced by his score for *Metastasis*.<sup>51</sup> Here, Xenakis translated musical rhythm into architectural rhythm in the design of the glass panes, creating a unique aesthetic quality while moderating light and ventilation. Xenakis related musical qualities such as pitch, tempo, and sound to the shifting density of panels along the façade. Additionally, Xenakis suggested that the stacked rows of glass panels were equivalent to musical counterpoint, creating architectural polyphony.<sup>52</sup>

Two additional interpretations of the façade pattern have been suggested by Anja Kostanjšak and Marko Slaviček. Kostanjšak and Slaviček relate the varied horizontal density of panels to the physical form of sound waves, which feature repeated areas of compression and rarefaction as they move through air (see figure 17).<sup>53</sup> As an engineer, Xenakis certainly would have been aware of this pattern, and may have used it as a source of aesthetic inspiration.

In a different interpretation, Slaviček and Kostanjšak translate the physical form of the undulating panes directly into a musical score, using vertical grid lines to measure time and horizontal grid lines as indicators of pitch (see figure 18).<sup>54</sup> In this interpretation, the glass panes create exactly the type of musical and architectural

<sup>50</sup> Robin Evans, *The Projective Cast: Architecture and Its Three Geometries* (Cambridge: MIT Press, 2000), 296.

<sup>51</sup> Clara Germana Gonçalves and Maria João Soares, 2015, "Le Corbusier: Architecture, Music, Mathematics: Longing for Classicism?" (paper presented at Le Corbusier, 50 Years Later: International Congress, Valencia, Spain, November 18-20), 9, <http://dx.doi.org/10.4995/LC2015.2015.791>.

<sup>52</sup> Michelle Morimoto, "Music and Architecture: Notes on Experiencing the Convergence of Music and the Built Environment" (PhD diss., University of Hawai'i at Manoa, 2017), 16-18.

<sup>53</sup> Anja Kostanjšak and Marko Slaviček, 2016, "The Musicality of Undulating Glass Panes in the Convent of La Tourette" (paper presented at Places and Technologies, Belgrade, Serbia, April 14-15), 4.

<sup>54</sup> *Ibid.*, 5-6.

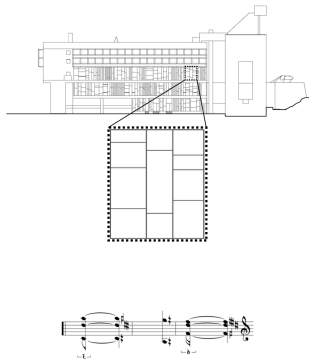


Figure 18: “Musical analogy of La Tourette's west elevation sample.”

Diagram and caption quote: Anja Kostanjšak and Marko Slaviček, 2016, “The Musicality of Undulating Glass Panes in the Convent of La Tourette” (paper presented at Places and Technologies, Belgrade, Serbia, April 14–15), 6, fig. 3.

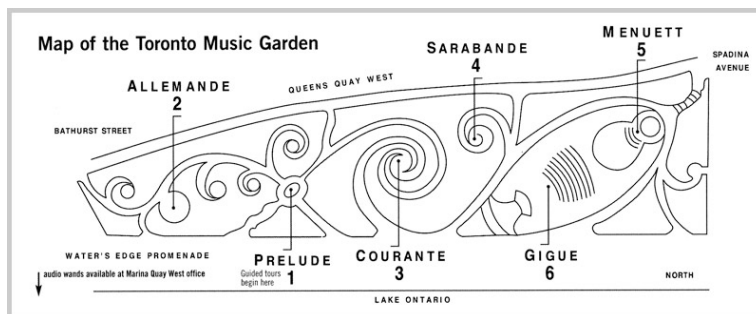


Figure 19: Plan drawing of the Toronto Music Garden showing the different sections of the garden, each inspired and informed by a movement of Bach's *Cello Suite No. 1*.

Diagram: Plan View, digital image, Cherish Toronto, accessed September 5, 2020, <http://cherishtoronto.blogspot.com/2009/08/visit-to-toronto-music-garden.html>.

and the aesthetic and formal aspects of the garden are informed by both metaphorical and concrete interpretations of the cello suites (See figure 19).<sup>55</sup>

The Prelude section is designed to suggest an official entrance to the garden, with stones and tree trunks mimicking notes and measures in a musical score. The Allemande section suggests a flowing dance traditionally associated with that musical movement, while the spiralling Courante is far more energetic, inspired by Baroque dance patterns (see figure 20). The slower, introverted Sarabande is far more solemn, marked by towering trees and subdued perennials,

polyphony that Xenakis suggested might appear in the façade. Slaviček and Kostanjšak's theories are speculative, and may not align directly with Xenakis' original intentions. The idea of using undulating windows as a musical score, however, is directly linked to Xenakis' architectural and musical composition strategies, and perfectly demonstrates the aesthetic musical quality of the façade design.

### Case Study: Toronto Music Garden, Toronto (1999)

The Toronto Music Garden, designed by Landscape architect Julie Moir Messervy in collaboration with world-renowned cellist Yo-Yo Ma, is an example of landscape architecture inspired directly by music. Located on Toronto's harbourfront, the garden was inspired by J.S. Bach's *Cello Suite No. 1*. Each section represents a different movement of the suite,

<sup>55</sup> Julie Messervy, *The Toronto Music Garden* (Saxtons River: Julie Moir Messervy Design Studio Inc., 2009), 3, 16.

while the stately Minuet holds a pavilion for formal concerts. Finally, the Gigue, shaped like a lyre, features stepped seating to imitate the fast jumping melody while simultaneously providing public seating.<sup>56</sup> Each of these movements flows into the next, forming a cohesive architectural whole that encompasses the cello suite.

Music in this public garden is not confined to its visual features. Each summer the garden turns into a public performance space, featuring a series of free concerts.<sup>57</sup> This unique example of landscape architecture thus performs music both formally and functionally.



Figure 20: Aerial view of the “Courante” section of the Toronto Music Garden in Summer.

Image: Julie Messervy, *The Toronto Music Garden* (Saxtons River: Julie Moir Messervy Design Studio Inc., 2009), 36.

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<sup>56</sup> Julie Messervy, *The Toronto Music Garden* (Saxtons River: Julie Moir Messervy Design Studio Inc., 2009), 28-51.

<sup>57</sup> *Ibid.*, 54.

## Conclusion

The case studies featured in this catalogue demonstrate only a few of the many moments in history where music and architecture have come together. Music and architecture have developed in parallel throughout history; some of the most innovative buildings both today and in the past contain explicit and even structural links between the two.

Proportional harmonic relationships have influenced architecture since antiquity, and continue to feature in architectural texts and thought. Performance spaces transform communities and bring music to life – in these examples architecture houses music, but both music and architecture influence one another. Aesthetic interpretations of music continue to shape architecture, whether in landscape or concert hall design. The interchangeable use of terms such as counterpoint, texture, harmony, rhythm, tempo, proportion, and articulation to describe music and architecture is revealing, and demonstrates a fundamental link between the two fields.

Music and architecture's continued relationship highlights the versatility and experiential nature of both mediums, and how in particular examples they shape each other. Together, each expresses and communicates in reference to the other, transforming and adapting to an ever-shifting cultural space.

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