Structuring Vertical Space: Relationship between Chants and Cathedral Naves in the Medieval Period

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Abstract
This paper presents a study on spatial construction in relation to chants and cathedrals in the medieval period. First, studies on musical space in relation to visual space are surveyed. The gestalt notions of figure and ground are then described. These are used as a basic tool for an analysis of how cathedral arches of the nave were assembled vertically with regard to musical sound. From a formal analysis it is found that the vertical spatial construction of chants and that of naves in medieval cathedrals display a similar pattern.

Keywords: Chant; church; nave; pitch; Gestalt; figure and ground

1. Introduction

The relationship between musical space and architectural forms is intimate, as exemplified by cathedrals in relation to chants, palazzos to madrigals and mascherata, and concert halls to symphonies and concertos. The physical environment of specific music forms is considered to be constructed as space, a concrete device that embodies diverse types of music. As such, sound can be imagined as an abstract construction that might be realized in architecture. In particular, chants and churches in the medieval period vividly showed such interaction. Accordingly, their relation may be verified with the principle of isomorphism (Arnheim, 1994) – i.e., if two different media have the same process of structural construction, the two structural constructions will be the same regardless of the difference in media.

This study mainly examines elevated naves in churches and the vertical spatial construction of chants sung in these churches based on the figure and ground theory. The period of has been limited to the medieval period, during which specialization in art had not yet occurred, and the church, as an institution with tremendous power over Western society, ruled all forms of art and culture. Nevertheless, the church, the main body of art production, could not produce various types of art genres that were independent from each other nor divorced from medieval thought, society, and culture. It is for this reason that the close interrelationship between music and architecture is worth examining. This study also limits its geographic scope to France. In the 7th century, France became a hub of European culture due to the obstruction of the international trading network by the Mediterranean Sea and the influence of abbeys. France is also the origin of the Gothic style in architecture and served as its center from the 12th century. In addition, in the mid-12th century, the leading role of European music was assumed by the Notre Dame School in Paris, which ruled Western European music for the next 150 years.

2. Musical Space

It is worthwhile to start with a survey of historic precedents with respect to musical space. Studies on musical space were led by W. James (1887), who compared the space experience of the eye and that of the ear; M. Palàgyi (1901), who studied flowing space; G. Révész (1952), who studied auditory space; Jakob von Uexküll (1928), who presented biological phenomena and defined musical space as the third factor and as a proof of spatial order transcending places; T. Clifton (1983), who defined musical space as space in motion; and V. Zuckermandl (1992), who argued that the space experience of the eye is a disjunctive experience whereas the space experience of the ear is a participative experience.

Clifton, James, Palàgyi, Révész, and Uexküll investigated the spatiality of music, while Clifton and Zuckermandl defined and investigated the spatiality of music. Zuckermandl's spatial concept to compare the relationship between architectural and musical space.
Zuckerkandl argued that despite the apparent evidence that musical space enters the ear as one vibration, many different sounds are heard at the same time, because space exists in the world of auditory consciousness. The external space that is seen is also present in our consciousness. However, the object seen—in other words, the object that exists in the consciousness—stays in the location outside the consciousness. It can be touched. It occupies a place, and thus appears to exist.

Unlike the visual, the musical space is a relational space with other tones, with the dimension of time as its progression. The tone used in music has two aspects: tone length and pitch. By slightly revising the tone length or pitch, the identity of a composition may be changed. It is difficult, however, to define rules on how much the tone length may be changed for its identity to begin to be transformed. This is because each tone has a different degree of importance, as the tones construct music. Although the changes in ornament marks may not transform the identity of music, even a slight change in the structural tones will change the music drastically. Among the musical elements, such as pitch, length, dynamics, and tone color, Western music has focused on pitch as a fundamental combinational principle. Therefore, this study considers only pitch, which is the relationship of the height between tones, the unit space of music.

3. Figure and Ground Theory

As an analogy to the study of the structure of cities, the figure and ground theory is an application of the relative relationship between a figure and the ground, as explained in Gestalt theory, to a cognitive logic for objects in space.

3.1 Gestalt Theory

Gestalt theory is a study of perception as a process of generalization. Gestalt, a German, did not differentiate form from abstract material, but defined it as an object that has its own structure or system. It refers to the shape or condition of things when they are unified, as opposed to a union of parts (Ehrenfels, 1890). Gestalt theory can be applied to sense as well as to vision, and of course, to music. Hanslick (1854), battling against the notion that music exists for the purpose of reproducing the feelings of the human mind, maintained instead that the content of music is "tönend bewegte Formen," i.e., "sounding forms in motion." In music, each tone is meaningless. Only when tones are recognized together as tone groups or phrases can music have meaning. That "a musical piece or its structural elements are one gestalt" means that musical perception forms a certain wholeness via the flow of tones (Goldstein, 1980).

Three important concepts of this theory are isomorphism, form, and field force. According to the principle of isomorphism, processes that take place in different media may nevertheless be similar in their structural organization. Form, i.e., its wholeness, is recognized as a gestalt against the background, and perceived according to factors such as proximity, similarity, closure, and continuation, in recognition of the specific relationship among the remaining elements, despite a certain degree of change in the foreground. The psychological force that works in the relationship among these factors yields dynamic properties. In the case of art or music, the stimuli received by the brain come from isolated pieces of colored matter or sound that constitute a painting or music as physical objects. In the brain field, however, these stimuli arouse patterns of forces that act as components of integrated whole-processes. The resulting field-processes consist of the impact exerted by everything upon everything, and the perceived picture or music is the result of this infinite and incausal interaction (Arnheim, 1995).

3.2 Figure and Ground Theory

A figure, which is a part of Gestalt theory, is placed spatially on the ground. Figure and ground refer to effects that are visually differentiated from each other due to the closure and the zone that surrounds them. The enclosed surface tends to be a figure, and the enclosing surface, the ground. Whether an object fades into the background or stands out as a segregated entity again depends on perceptual factors. The shape of contours, the contrast of brightness, and the structure of the overall pattern determine what is seen. The meaning of what is seen is influenced by this visible relationship of a figure and the ground. This study mainly investigates the contrast between brightness and darkness. This is because the core issue of church architecture in the medieval period was the development of brick vaults that could let light into the nave, at the center of the church (Klassen, 1980). Through the arch in the opening, the contrast of the elevating nave is articulated. This became an important spatial element that determined the form of the elevating nave. Therefore, this study schematizes each arch in the opening as an element of a figure (Fig.1.), and then examines how such arches were arranged vertically and how they were structured.

Fig.1. Schematization in the Opening as an Element of a Figure

Meyer argued that the principles of Gestalt theory for visual perception can be generally applied to hearing. Each structural element of music, which is a form of moving sound, is a gestalt. Music is not composed of tones that resonate randomly; with certain rules and specific patterns, it stimulates the human body (Meyer, 1956). How each and every tone in music is structured determines the form of music. It is believed that people simply listen to music. However, the music listened to is based on the ground, which is called silence. Music and silence have a close, functional relationship. When
a doctor places a stethoscope on a patient's chest, he/she blocks off other sounds and hears only the patient's heartbeat. The heartbeat is a figure on the ground called silence. In music, a figure is also heard as a sound and melody on silence, the ground.

The subject of this study is limited to the horizontal and vertical structures of pitch, the unit space of tones, so as to compare music to architecture (Fig.2.). Particularly, this study focuses on structuring tones vertically, so as to compare music with the elevating nave in the aforementioned churches. Comparing architecture and music using the figure and ground theory, pitch, which is recognized as the unit space of music, corresponds to each arch of the nave, and is analyzed accordingly (Fig.3.).

![Fig.2. The Horizontal and Vertical Structures of Pitch, the Unit Space of Tones](image)

![Fig.3. A Figure and Ground Diagram where the Unit Space of Music Corresponds to each Arch of the Nave](image)

4. Structuring Vertical Space

Architecture in the medieval period was directed more to the interior than to the exterior, and in particular aimed at verticality. The development of such a verticality-driven architectural style is not only a reflection of structural rationality in architecture, but also reveals various elevations of the nave. In music, soaring verticality is revealed through the organum and its vertical sonority. The naves in churches and chants in the medieval period show how the aspiration for verticality in this period structured space both in architecture.

4.1 One-story Compositions

Cathedrals in which vaults have naves and aisles exhibit no clearstory, because the vaults on the aisles directly support the barrel vault on the nave, and thus, yield no difference in height between the nave and the aisles (Fig.4.). A church without a clearstory on the nave due to the nave being of the same height as the side aisles is called a Hallenkirche or Hall-church. Such a church has a nave arcade with only one story. Continuity is created between the supporting and the supported members, as the arch of the nave is on top of the column, and a sense of regular movement is formed inside the church as the row of arcades creates a uniform space. A colonnade gave a spectator a sense of movement towards a certain direction, and this attracted people toward the inner side of the church. As such, internal space stresses the horizontal relationship more than the vertical. This articulates the space of the church, directing to the sole destination, the altar (Klassen, 1980).

![Fig.4. A Typical One-story Cathedral Composition (St. Révérien, France, ca. 1130–1140, Redrawn by authors from Bony 1983)](image)

Gregorian chants, which were sung during the medieval period in churches, are musical recitations for religious ceremonies, and were less for listening than for serving liturgies (Georgiades, 1974). In other words, chants were born as prose was sounded and resonated. According to the regulations of Benediktiner dictating that all tones inside a church shall have identical durations, Gregorian chants, which were mostly monophonic, were sung at a regular rhythm. Shown in Fig.5. is the expression of such musical sounds based on the figure and ground theory.

![Fig.5. Monophony that is Made up of a Single Melodic Line](image)

It is argued that musical space, which consists of this unit space of tones, is the relational space with other tones to which time, the progressive direction, is added. Therefore, the vertical accumulation of space in music can be thought of as a space with different pitches resonating at the same time. In this sense, Gregorian chants, which are monophonic, can be thought of as one-story elevations. Shown in Fig.6. is a comparison of Gregorian chants as one-story elevations and elevated naves in early basilicas. This can be termed "single composition."

4.2 Two-story Compositions

In church architecture, a one-story elevation is followed by the installation of a barrel vault, divided in half, on the aisles. Thus, the thrust of the nave is
moved to the aisles and, at the same time, the thrust is delivered to the buttress, which is located at a lower level (Fig.8a and 8b). This method allows natural light to penetrate into the nave indirectly through the windows of the aisles; and if the barrel vault is installed on the aisles, the windows also become smaller. Thus, the aisles are lowered by making a clearstory on the nave in order to introduce direct lighting (Fig.8c). These two methods of building an elevated internal nave in a church result in the arcade and the tribune, a two-story elevation that consists of the arcade and a clearstory.

Monophonic music evolved with vertical structures, creating polyphonic music called an organum in the late 9th century. An organum is a method of singing different parts simultaneously, accumulating tones vertically. This corresponds to the vertical structures in the elevated nave. The earliest form of polyphony, first clearly described in the late 9th century, consisted of two voices that moved in parallel motion. This is a parallel organum. The two parts have a 1:1 relationship, or a so-called "punctus contra punctus," which can be analyzed using the figure and ground theory (Fig.9.) (Miller, 1972). In the early 12th century, a new type of organum emerged. This is referred to variously as melismatic organum, sustained-tone organum, or St. Martial organum. It was assigned to one voice in long, sustained notes to which were added a higher voice with faster-moving note values. An organum that is composed in a two-part texture is called an organum duplum, whereas a melismatic organum duplum has one part with a sustained voice and another part that moves freely (Fig.10.).

4.3 Three- and Four-story Compositions

Following the one- and two-story nave constructions is a basilica with a nave and two aisles and covered with a cross vault. From the perspective of lighting, a cross vault is more desirable than a barrel vault. The problem with the cross vault, however, is that it exhibits a huge thrust, with which its whole weight is pressed on its four corners. At this point in time, the flying buttress had not yet been developed, and thus the vault's thrust was supported by an arch installed on the upper story of the aisles to prevent the wall of the vault from being pushed forward. By building the second story on the aisles, the wall of the nave and that of the aisles could support the vault's thrust. This structure, termed a tribune, was often used as a dynamic device, disappearing with the spread of the flying buttress later in the Gothic era.

As with music, the two-story elevation in architecture can be divided into two styles: one in which one arch of the nave story corresponds to one arch of the clearstory, and another in which one arch of the nave story corresponds to more than one arch of the clearstory. Just as with music, the former can be termed a "parallel structure" and the latter a "melismatic structure." Therefore, the two-story compositions can be divided into "parallel composition duplum" (Fig.11a) and "melismatic composition duplum" (Fig.11b). The following is an analysis of such styles in comparison to chants, using the figure and ground theory.

Fig.7. Typical Two-story Elevations of the Nave (Left. S. Ambrogio, Italy, ca. 1080, Redrawn by Authors from Klassen 1980; Right. Champeaux, France, ca. 1190–1205, Redrawn by Authors from Bony 1983)

Fig.8. Different Perspective Sections of Two-story Cathedral Composition (Left. St. Paul, France; Middle. St. Sernin, France, ca. 1078–1150; Right. Paray le Monial France, ca. 1110, Redrawn by Authors from Bony 1983)

Fig.9. An Example of Parallel Organum Duplum

Fig.10. An Example of Melismatic Organum Duplum

Fig.11. Two-story Cathedral Elevations in Relation to a) Parallel Composition Duplum: b) Melismatic Composition Duplum (a. S. Ambrogio, Italy, ca. 1080; b. Santiago de Compostella, Spain, ca.1075, Both Redrawn by Authors from Klassen 1980)

Fig.12. Cathedral Elevations: a) Four-story, b) Three-story (Left. Laon Cathedral, France, ca.1165–1175; Right. Mont-Saint-Michel, ca. 1062, Redrawn by Authors from Bony 1983)
Therefore, the elevated nave structure in the churches first saw the four-story arcade, the tribune, the triforium, and the clearstory, which appeared in the transition period from the Romanesque style to the Gothic style, followed by the three-story arcade, the triforium, and the clearstory, which appeared in the Gothic period. Polyphonic music in two parts began to see polyphony in three or four parts by Perotin and the Notre Dame School in Paris in the early 13th century.

As with music, the four-story or three-story structure can generally be divided into two classes: one in which an arch of the arcade corresponds to an arch of another story; and another in which one arch of the arcade corresponds to more than one arch of another story. The three-and four-story compositions can be divided into "parallel composition triplum" and "melismatic composition triplum" and "parallel composition quadraplum" and "melismatic composition quadraplum" (Fig.13.).

Shown in Fig.14. are the results of the analysis using the figure and ground theory, and a comparison of these results to chants. As noted in Table 1., the melismatic structure is stronger than the parallel structure in the three-story compositions. In addition, there is no parallel composition quadraplum in the four-story compositions. This is due to the development of traceries in the Gothic period. A tracery plays an important role in expanding the size and structuring the overall shape of windows. Plate traceries, which comprise certain patterns on the surfaces of walls, developed into bar traceries in the 13th century, where the thrust was distributed not along the surface of the walls but through the lines of the patterns (Pevsner, 1981). A bar tracery breaks every arch into several arches, resulting in a structure that is more melismatic than parallel compared to the previous period.

Table 1. shows that chants emerged slightly later than the spatial construction of church naves. This may be because the spatial verticality of churches influenced the appearance and development of the organum in music. According to E. Zwicker (Hall, 1991), the basilar membrane in the human ear has a region for frequency detection. When two different sounds are heard the frequencies of which are close enough to each other, they are heard as softer than when their frequencies are far apart. When the frequency of one sound is changed while that of the other sound is fixed, the perceived difference between the two frequencies shows a so-called plateau phenomenon. However, when the two frequencies become larger, the sounds become much louder than they were before. This range of difference in frequencies is called the critical bandwidth: the point at which the sound becomes louder is where the frequency of one sound moves far enough from the frequency of the other sound, leaving the critical bandwidth (Fig.15.). Once the basilar membrane begins resonating at a certain frequency, it is sensed that the sound becomes louder when its intensity becomes considerably stronger. An increase of only 3 dB results from doubling the amplitude of the sound at 70 dB. However, when a certain part of the basilar membrane vibrates, not all the other parts outside the critical bandwidth become unrecognized. Thus, two sounds whose frequencies are so far apart as to cause the vibration of different parts of the basilar membrane sound louder than when their frequencies are closer (Hall 1991). This is why a string quartet sounds louder than four violins, and a choir with different voices sounds louder than one with the same voices. Moreover, this is how music corresponded to the vertically expanded church spaces.

5. Conclusion

Through an investigation of the music played in cathedrals in the medieval period, which aspired towards verticality, based on the principle of isomorphism, this study discussed and analyzed the relationship and interplay between architecture and music.

Table 2. shows that even before the 9th century, architecture developed parallel structures in three-story structures, wherein one arch of the arcade corresponded to one arch of another story. It was not until the 9th century, however, that music saw the two-
story parallel organum, in which one part corresponded to the other part (1:1). Further, it was not until the 12th century that music saw the melismatic organum, in which many more notes corresponded to one note. The melismatic form in the two-story structure emerged in the same period both in architecture and music. By the 12th century, architecture even developed a four-story structure whereas music, having seen the melismatic organum in the 12th century, developed three- and four-part compositions in the 13th century. The vertical
structures of the three- and four-story compositions, either with parallel or melismatic structures, appeared in architecture earlier than they did in music. In terms of vertical spatial construction and structural form based on the figure and ground theory, architecture and music showed internal similarity. Compared to architectural space, however, musical space underwent development of the aforementioned construction relatively later.

The results of the analysis of the vertical spatial structure of naves in cathedrals and chants show that the organum, i.e., the vertical spatial construction of chants, appeared later than the vertical spatial construction of naves in cathedrals in the medieval period. This may be because the soaring verticality of the churches, a practical device for realizing chants, influenced the styles of the organum, the expansion of music's vertical space, by layering other notes whose frequencies are different from each other so as to make chants louder. However, it should be pointed out that the result may be coincident because the influence between architectural works and musical ones is possible but not concretely proved in this stage.

In addition, the formal construction of the space examined using the figure and ground theory shows that the formal construction in architecture and music appeared in a similar pattern. Although there were differences in priority between the three- and four-story structures due to differences between architecture and music, their internal similarity based on isomorphism can be found in the naves of the cathedrals and the vertical musical space. This is a reflection of the dependency of the arts on the experiential world perceived by human beings as well as on society, culture, and the environment.

Table 2. Comparison of the Vertical Spatial Structure according to Time Period

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<tr>
<th>Vertical spatial structure</th>
<th>genre</th>
<th>before the 10th century</th>
<th>11th century</th>
<th>12th century</th>
<th>13th century</th>
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<tr>
<td>Single Composition</td>
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<tr>
<td>Parallel composition duplum</td>
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<td>Melismatic composition quadruplum</td>
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<td>music</td>
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Table 3. A Flow of the Vertical Spatial Structure Relationship between Architecture and Music

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<th>architecture</th>
<th>Single Composition</th>
<th>Parallel composition duplum</th>
<th>Melismatic composition duplum</th>
<th>Parallel composition triplum</th>
<th>Melismatic composition triplum</th>
<th>Melismatic composition quadruplum</th>
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<tbody>
<tr>
<td>music</td>
<td>Single Composition</td>
<td>Parallel composition duplum</td>
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<td>Melismatic composition quadruplum</td>
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A form explains its environment. The perceptive experience of form is influenced by what is "seen" and "heard" in architecture and music. The eyes and ears of the observer open what s/he perceives directly, and thus offer more expressive experiences in diverse genres. Such an analysis explains the interaction between architecture and music and provides a foundation on which understanding of space can be expanded.

References

Notes
1 In Greek, Monos is one and phonos is sound.
2 In psychology, plateau is a period of little or no apparent progress in an individual's learning, marked by an inability to increase speed, reduce number of errors, etc.