

Empirical Study on Perception of Musically Inspired Architectural Façades - Music and Architecture

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Abstract Inspiration plays an essential role in architectural design process that compels architects to bring their ideas into final product by engaging in creative thinking. The relation in between architecture and music has been one of combination throughout architectural history used as inspirations for façade's forms and shapes, space configurations and arrangements, and etc. Applying music in architecture produces creative and scientific design methods, provides attractions for visitors, and reflects the social and cultural identities and changes of the particular period. This research aims to analyze the correlations between architecture and music in depth, and examine the perception of musically inspired architecture by empirical study. Five buildings that applied musical rhythms were chosen for survey questionnaires in order to observe how people majoring in architecture, music, and other fields perceive musically inspired architecture differently by matching the music with the building that correlate to each other. By examining the reasons that the respondents have selected such music with a building from the questionnaires, the keywords are extracted and interpreted. The results showed that it is possible for people to perceive music from architecture, and that it is suitable to use music as a source of inspiration in architectural designs.

Keywords: Architectural expression, design inspiration, creative design, music and architecture, design thinking

1. INTRODUCTION

Generally, people tend to depend on their sight before hearing. It is common to immediately take in the visual information when perceiving a matter. On the other hand, if auditory information approaches first, the method of how to visualize the information should be examined as well. Just as many thinkers and architects have noted the relationship between the senses of seeing and hearing in the past, music and architecture also have an intimate relationship in the same context.

At least from the 6th century B.C., many believed that music and architecture are connected with the universe, which was understood by mathematics and geometry, and many Greek temples were designed with the principles of proportions. The

Greek thinkers have attempted to find the order of law from the proportion of human body and the proportion of musical scale (Yoon, 2005). Johann Wolfgang von Goethe, a German writer and politician, stated that, "Music is liquid architecture; architecture is frozen music." With the knowledge of proportion system in architecture with the music background, the Greeks believed that the perfect proportion has started from the harmony of music. Yoon (2005) also have asserted that through the numerical values and proportional system, the structural relationship of music can be substitute as a visual understanding of architecture. Even after Greek's numerous explorations of music and architecture, the architects who are fascinated by this method continued to use this approach by applying to the new designs to this day.

According to the Concise Oxford Dictionary, music is defined as the art of combining sounds and silences by time, in a way that creates harmony and usually transmits emotion. Architecture is the art of designing through space, and complex organization and coordination of heterogeneous composite. Since music relies on auditory system and architecture relies on visual system, architecture has the benefit of converting music into visible and tangible object. The application of musical characteristics in architecture may produce creative and scientific method, provide enjoyable attraction for visitors, and reflect social and cultural properties of the particular period.

The purpose of this study is to thoroughly examine the relationship between music and architecture, and experi-

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ence of rhythmically inspired architecture by three groups of participants – architecture majors, music majors, and other majors. This research only deals with façades because a large number of cases on musically inspired architecture were focused on façades, and façades are easier and definite for the respondents to recognize the expression of music on buildings. As Daemei & Safari (2018) have mentioned, the enhancement of creativity in architecture education is vital for various reasons, and it is a universal objective. Therefore, this research focuses on what people perceived from music and architecture, and attempts to give ideas on how to apply musical features in architecture more effectively.

2. THEORETICAL STUDY

(1) History of Music and Architecture

Music and architecture have a long history of attempting to introduce music into the form or space of architecture in various ways. The ancient Greek philosophers have started to combine music, architecture, mathematics, and geometry. There some studies that attempt to prove that the Greek temples were built on the basis of the proportions of music. Then the Medieval and Renaissance architects shared the world view that was derived from the Greeks. They have considered that the universe and the proportion of musical scale are able to control the harmony of universe and the movements of planets (Yi, 1991). Furthermore, in the Medieval time, music was based on mathematics, including algebra and geometry. The Roman architect, Marcus Vitruvius Polio (80 B.C.~70 B.C.) asserted that just as music is the proportion of science, architecture is also science that relies on order and proportion, which leads to the statement that architects are able to understand music through the principles of proportion (Moon, 2010). Moreover, Vitruvius stated that in order for architecture to become an art, norms need to be created, and appropriate proportions must be made according to these norms (Heo, 2010).

In the section of ‘Education of the Architect’ in *The Ten Books on Architecture*, Vitruvius also has mentioned that “Music, also the architect ought to understand so that he may have knowledge of the canonical and mathematical theory...” Based on this writing, Leon Battista Alberti (1404~1472) commented that beauty exists when the harmony is inherent in the building, and can be detected by rational means. In other words, the beauty of architecture is the proportion of each parts are combined to form a harmonious whole. Its chief characteristic is the classical idea of maintaining a uniform system of proportion throughout all parts of a building (Wittokower, 1940).

Even in modern and contemporary periods, the exchanges between the two arts have been continued by a small number of people. However, the theories on music and architecture rarely mentioned, and even if it is, it obtains only an ambiguous concept. The studies that attempt to describe about music and architecture only show the tendency of mysticism (Heo, 2010). Even with this hardship, some architects and musicians make efforts to produce creative work by using the two arts as the

source of inspiration. Frank Lloyd Wright’s (1889~1998) father taught him that the symphony was an edifice of sound. (*The Baltimore Sun*, 1998). This leads Wright to similarly view the way music was composed and the way buildings were designed. Fleming & Reynolds also mention about Louis Khan applying music in the design for Kimbell Art Museum by having the concept of seeing buildings like a harmony of spaces in light, just like how music sheet is seen from what the musician hears. A Hungarian musician, Béla Bartók (1881~1945) uses golden ratio in his music by dividing bars, and locating the climax of the music on the point of the golden section according to the Fibonacci numerical sequence¹. Iannis Xenakis (1928~2001) also asserts that music is moving architecture. Xenakis composes music by using computer and probability system of mathematics, and then expresses the music into architecture (Heo, 2010).

It is seen that similar to the numbers in music that please our ears with sound, the numbers in architecture please our eyes and hearts. Both musicians and architects have been mutually interacted between the two arts, which proves that music and architecture have a strong relationship. Thus, discussions about music and architecture have been established with the long history.

(2) Relationship between Music and Architecture

Music and architecture are arts that express emotions, and consist of logical and systematic form of law. Since music is an art of time, and architecture is an art of space, they both trigger to feel the aesthetic emotions from the composition. In translating music to architecture, Jung, S. & Lee, H. (1998) have mentioned that the components of music, rhythm, melody, harmony, timbre, and tone color may be defined in the components of architecture, point, line, surface, material, and color (table 1). Moreover, proportion exists both in music and architecture. In music, the harmony is created through the speed of rhythm or chords of notes, and the beauty of architecture is presented with proportion by controlling sizes.

Table 1. Similarities between Music and Architecture

Music	Architecture
Rhythm	Point
Melody	Line
Harmony	Surface
Timbre	Material
Tone Color	Color

Lee (2002) claims that there are three ways of describing the relationship between music and architecture. First, the correlation is expressed in the aspect of form. Since music is systematically composed in the flow of time, it is an art based on time that gives the aesthetical emotion from the sound in the composition. Music consists of rhythm, melody, and harmony

¹ Fibonacci numerical sequence is a series of numbers in which each succeeding number (after the second) is the sum of the previous two.

by using the tone of music, dynamics, speed and changes of the notes. Architecture on the other hand, is a spatial art that expresses the form by the proportion, balance, contrast, repetition and unity using point, line, form, material and color. The primary similarity between music and architecture is that they both do not bring the form from the existing elements, but they both establish the art mentally. Second, the relationship may be explained in the aspect of creative expression. Different from natural science where it seeks for objective accuracy, art emphasizes to give the freedom of human thoughts and emotions. In EBS documentary, a neurobiologist, Eric Kandel asserts that a work of art is created by an artist, but the work is only completed when someone sees it. People interpret art in various ways, and recreate the image drawn on the work in their brains. This shows that they are communicating with the artists because the artists also expressed their interpretations in the art work. Lastly, the relationship may be seen in the aspect of method of transmitting the concept. In order to convey the completed music and architecture, a concept or motif should be formed.

On the other hand, Kim (2018) refers to Goethe's thought that he did not solely compare the two arts externally by stating that the mood that occurs in architecture is similar to the effect that music gives to the listeners. Goethe has emphasized on the 'tone of mind' rather than the form. Kim then criticizes that the precedent studies on music and architecture also only focus on morphological similarities.

Thus, it may be said that architecture creates space by physical materials, and music creates space by sounds. Even though music and architecture are arts that have different ways of expressing emotions, generating the art that provides the sense of seeing and hearing all at once by using the similarities between the two will offer new and innovative experiences to the visitors. Furthermore, this study will make an attempt to explore the relationship between music and architecture in depth from the empirical studies.

3. RESEARCH METHOD

(1) Purpose of Survey and Method

All the methods of architectural research regarding on the application of musical qualities in the past were theoretical and superficial. There were no empirical studies that study about the perceptions of the visitors in details. Empirical study was proceeded in this study in order to analyze more in depth on the relationship between music and architecture, and to have a conclusive evidence in the research through observation and actual experience. Since this study attempts to describe accurately on the interaction between the human senses and musically inspired buildings, empirical research is the valid method for this study. It will also help to demonstrate more realistically on how people actually recognize music from the

musically inspired buildings. This research observes statistically on how people perceive the musically inspired architecture through survey questionnaires.

The target of this survey is the people who have or are currently majoring in architecture, music or any other fields in order to see if architecture majors or music majors are able to identify the musical properties from the musically inspired buildings more than the other majors in Korea. The general information includes age, gender, major, final education, average duration of listening to music per day, music genre preferences and music experiences (figure 1). In the experiment section of the survey, the images of five musically inspired buildings including elevation views and perspective views are shown all at once to the respondents (figure 2), and five songs are played on at a time in different orders. Each of the songs is cut to two minutes and thirty seconds for the consistency of the survey. The respondents were allowed to listen to the music more than once as they desire. The respondents were asked to match the music with the building that they think they correlate to each other, and write the reasons on their selections. They were not allowed to select more than one building person. Then, all the responses from the respondents were analyzed statistically.

Music-Architecture Survey Questionnaire

1. General Information

1.1 Gender ① Male ② Female

1.2 Age _____

1.3 Major ① Architecture ② Music
③ Other (_____)

1.4 Final Education (For students select the current status)
① Bachelor's ② Master's ③ Ph.D ④ Other

1.5 On average, how much do you listen to music on a daily basis?
① I don't listen to music ② Less than 1 hr
③ 1~2 hrs ④ 2~5 hrs ⑤ 5~8 hrs
⑥ More than 8 hrs

1.6 What kind of music are you interested in? (Select all that apply)
① Rock/Metal ② Pop ③ Classical ④ Jazz
⑤ Indie ⑥ Hip-hop/R&B ⑦ Country
⑧ Electronic ⑨ Ballad ⑩ Dance ⑪ Trot
⑫ Others (_____)

1.7 Are you currently involved in any activities that are related to music or have any music experiences in the past? If so, what is it and for how long? (ex: piano, 5 years)

Figure 1. Example of Survey Questionnaires - Part 1

2. Experiment

※ After listening to each song (2min 30sec each), select a building that might be related to the music in your opinion, and explain why you selected such building. You may listen to the music more than once if needed. (The building may NOT be selected more than once)

Music	Building	Reason
1		
2		
3		
4		
5		

Figure 2 Survey Questionnaire - Part 2

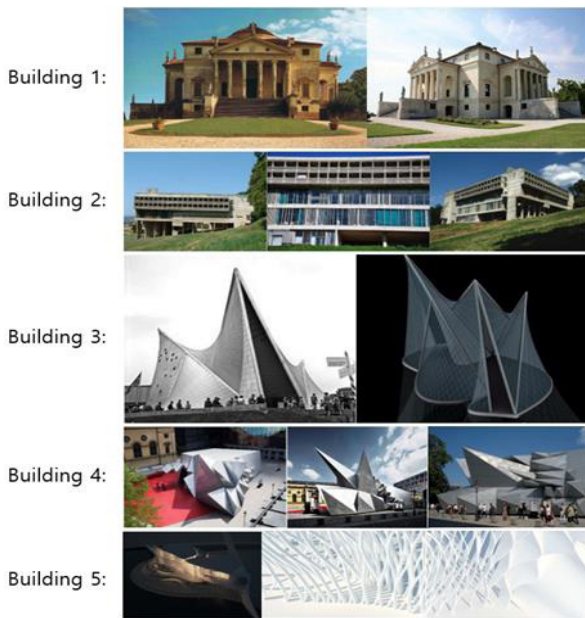


Figure 3. Images of Building 1~5 in Survey Questionnaire

(2) Survey Contents

For the survey, five different buildings were selected from cases that are inspired by the musical rhythms based on the text description provided by the architects on their web site or architectural websites such as “Archdaily”(table 2). Rhythm has a close relationship with architecture because they both have proportions and ratios. In addition, rhythm has a systematical order as it is in architecture. Many case studies have shown that rhythm was frequently used by the architects in the past. As many Greek architects have used proportions and ratios in the past, rhythm was commonly applied on buildings, and it was also one of the first techniques that was used in incorporating music to architecture. Thus, it was predicted that the respondents will be able to easily recognize rhythm more than any other musical elements from the buildings.

Table 2. Survey Contents

No.	Name	Architect	Year	Composer	Title
1	Villa La Rotonda	Andrea Palladio	1570	Karl Jenkins (Music 4)	Palladio
2	Monastery of La Tourette	Le Corbusier, Iannis Xenakis	1957	Iannis Xenakis (Music 5)	Metastasis
3	Philips Pavilion	Iannis Xenakis	1958	Edgar Varese (Music 1)	Poeme Electronique
4	Pavilion 21 MINI Opera Space	Coop Himmelbl(l) au	2013	Jimi Hendrix (Music 2)	Purple Haze
5	Busan Opera House	Orproject	2014	Karlheinz Stockhausen (Music 3)	Klavierstück I

Unlike the other four buildings, building 1, Villa La Rotonda was built first, and then composer, Karl Jenkins wrote the piece, Palladio inspired by the building’s Renaissance style. This building was added in this survey in order to investigate on the possibility of perceiving the music from architecture, and compare the results with Jenkins’ interpretation of the building. Before Andrea Palladio designed this building, Europe was all about music, humankind, and nature in the result of following the rules of music that includes harmonious proportions and mathematics, which is built from the cultures of ancient Greece and Rome. As mentioned in the description of his album, the title of the work was in reverence of Palladio. Jenkins desired to show the validity of the continuing relevance of music on the philosophies and principles established by the ancient Greeks that had been passed down by Vitruvius, Mozart, and Palladio. He has reinterpreted this tenet by translating the proportion of the music into harmonious chords, repetitive patterns like the rhythm and composition (The Culture Concept Circle, 2014).

For building 2, Monastery of La Tourette, Iannis Xenakis has worked on the placement of vertical elements for the strip windows on the western façade of the building, which he called the ‘undulatory glass surfaces.’ The idea of decreasing and increasing of intervals of the vertical strip windows came from the composition, *Metastasis*, an orchestral work for 61 musicians. The motif of the façade and the composition design is the glissando, the sliding movement within the tonal scale on string instruments. The increase-decrease of the façade spacing is set equal to the increase-decrease of notes according to the tonal scale. The largest distance becomes the lowest note, and the smallest distance equals the highest note (Xenakis-emulator).

Building 3, Philips Pavilion from Expo 1958 in Brussel, Belgium is designed by the office of Le Corbusier. The design of the pavilion consists of nine hyperbolic paraboloids made of reinforced concrete with precast panels hung in tension from wire cables in which the music, *Poeme Electronique* has created the space by sound projectionists using 425 megaphones. The complex and connected form of the pavilion were created from the glissando with lines and curves. Xenakis, a member of Le Corbusier’s architectural firm, has transformed the glissando by the ascending glissando line and the line of descending glissando becoming the form of conoid based on the density of the changes (Lee et al., 2009).

Building 4, Pavilion 21 MINI Opera Space, is a temporary mobile performance space for Bavarian State Opera. The shape of the pavilion was driven by the concept of materializing music into architecture. Selected sequences of the songs become the forces that transform and create spatial form. The sequence of Jimi Hendrix’s *Purple Haze*, “Scuse me while I kiss the sky” was used by analyzing the frequencies of the sound file and linking it to the computer generated 3D model, and then parametrically transforming the shell into pyramid shapes like spikes (Arch-Daily).

Building 5 is Orproject’s proposal of Busan Opera House competition in Busan, Korea. According to the scheme of the opera house, Orproject describes that the design for Busan

Opera House is based on simple strip morphology, which creates the façade, structure and rhythm itself with the patterns that shift and alter create complex architectural rhythms. They began with the idea that Busan Opera House becomes the physical expression of Klavierstück I, like a frozen music. This piece uses a twelve tone row, which converts into the strip morphology. After the first cycle, the row repeats, but moves up by half a tone. In the next iteration, this move continues, but the range also gets reduced in size (Orproject).

(3) Analysis Method

General information is statistically analyzed by displaying data in tables and graphs in order to see at a glance. The data is organized by the number of people or percentage by majors or number of correct answers. Here, correct answer means matching with the architects and composer's intentions. This is to make several comparisons such as if gender affects the result, if there are any differences in studying in different fields, if average number of hours of listening to music per day influence the result, if there are any other effects with the people who have made more correct answers, or if the duration of musical experience helps in selecting the correct answers. Figure 4 shows the steps of analyzing with all the information collected from the survey responses on selection reasons (part 2 of the survey). First, each of the responses on each selection the respondent has made are simplified into one keyword. For example, a respondent wrote "The strong and upbeat tempo seems on par with the strong 'statement' that the building is making", it is simplified to rhythm in music and mood in architecture as the keyword. Then all the keywords of the responses are categorized into similar keywords by grouping.

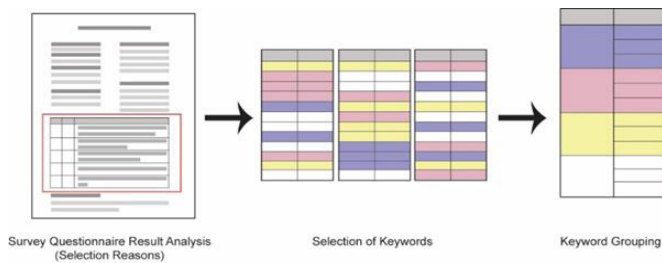


Figure 4. Process of Keyword Extraction

Then, examining the reasons that the respondents have matched particular songs with a building will help to draw primary keywords on musical elements and architectural elements that have frequently appeared. From these information, words, phrases, and expressions that were frequently mentioned are organized by the frequency. Then, the similar ones were groups into a keyword, which came out to be four keywords in music, such as genre, mood, rhythm, and sound, and five keywords in architecture, such as style, mood, pattern, form, and material as shown in the next section (table 5).

4. RESULT OF SURVEY ANALYSIS

(1) Survey Results and Analysis

For three months, 50 architecture majors, 50 music majors, and 50 other majors, a total of 150 people have responded to the survey questionnaire. There were total of 57 males and 93 females. The average final education level of the respondents was undergraduate. However, the gender and academic years were irrelevant to the results because there were no specific trends on the responses and the reasons that participants have written did not correspond in accordance with the academic year. For architecture major, the respondents were mostly students from department of architecture in Seoul National University, and others are employees who are working in architectural design firms in Seoul. For music major, the respondents are students in department of music in Seoul National University, and rest are working as professional musicians. For other majors, some are students who are majoring other than architecture and music, and some are workers who are irrelevant to architecture and music. The survey was taken directly and electronically such as email. The responses were al statistically organized in order to easily analyze and view the results.

The results of the average time of listening to music per day by each majors, the average time of listening to music per day by the number of correct answers, the number of experience in music by the number of correct answers, the duration of experience in music by the number of correct answers, and interested music genre by the correct answers, however, showed that this information does not correlate with the result of this research. Furthermore, the number of the correct answers and the field of study were not related to the results. Then the expected value is calculated in order to see the probability of randomly matching the correct buildings and music. This value was calculated with combination and derangement, which combination is the selection of items from collection, and derangement is a permutation of the elements of a set, such that no element appears in its original position. The expected value is calculated by multiplying combination and derangement. Permutation is also calculated in order to get the percentage. For example, to calculate the probability of choosing 3 correct answers out of 5 choices randomly, the formula would be:

$$\binom{5}{3} \times \frac{!2}{5!} = \frac{1}{12} = 0.08333$$

To calculate the probability of choosing 1 correct answer randomly, the formula would be:

$$\binom{5}{1} \times \frac{!4}{5!} = \frac{3}{8} = 0.375$$

However, since it is impossible to choose 4 correct answers, it is eliminated from table 3. Contrary to the expected value in table 3 that only 0.8% of the respondents were supposed to match all the five buildings correctly, 36.7% of the respondents were supposed to make all incorrect matches. The expected value increased as the number of correct answers decreased. The actual results showed that the respondents gave more

correct answers than the expected value. When expected value was 0.8% for matching all five of the buildings correctly with the music, 15% of the respondents made correct answers. In addition, 36.7% of respondents are expected to answers all answers incorrectly, with the actual result being only 7% of the respondents. The results may vary slightly depending on the number of the respondents, but this reveals that people actually perceive the musical qualities from musically inspired buildings.

Table 3. Number of Correct Answers by Majors

Major	# of Answers						Total
	5	4	3	2	1	0	
Architecture	5	-	14	13	12	6	50
Music	9	-	13	13	12	3	50
Others	8	-	14	14	12	2	50
Total # of respondents	22	-	41	40	36	11	150
Total % of	14.6%	-	27.3%	26.7%	24.0%	7.3%	100%
Expected Value (%)	0.8%	-	8.3%	16.7%	37.5%	36.7%	100%

Out of the five buildings, the results have shown that the respondents have correctly matched the building 1, Villa La Rotonda, the most with 113 respondents (75.3%) out of 150 respondents (table 4). Less than half of the respondents have matched the rest of the buildings correctly. According to the respondents' reasons on why they have chosen building 1, most of the respondents have mentioned that, "The music has a classical feel to it like the building." This may be because building 1 has a definite building style and genre of music. Moreover, a large number of the respondents have associated the music and the building with the period of time. Unlike this building, the rest of the buildings had more variety of reasons as will be explained in section 3. Furthermore, figure 5 shows that all the majors have similar trends of making correct answers, which means that it is valid to use this analysis method in this study.

Table 4. Correct Answers in Each Building

	Building 1		Building 2		Building 3		Building 4		Building 5	
Architecture	34	68%	13	26%	22	44%	26	52%	12	24%
Music	41	82%	16	32%	22	44%	25	50%	18	36%
Others	38	76%	21	42%	22	44%	22	44%	19	38%
Total	113	75.3%	50	33.3%	66	44%	73	48.7%	49	32.7%

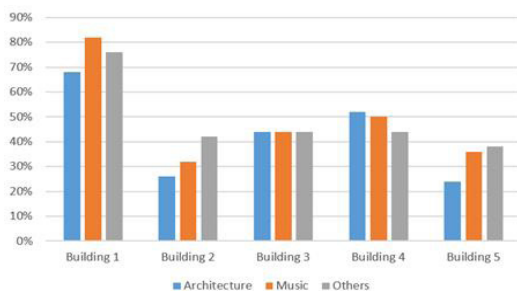


Figure 5. Graph of Correct answers in Each Building

(2) Keyword Definition

As mentioned earlier, the keywords were extracted directly from the responses from the second part of the survey questionnaire on the reasons why they have selected such buildings and songs. Table 5 shows the definition of the keywords for music and architecture.

Table 5. Definition of Keywords

Category	Keyword	Definition
Music	Genre	Genre, Period
	Mood	Emotions, Feelings, Symbolization, Imagery
	Rhythm	Regularity, Sequence, Repetition, Speed, Composition, Structure
	Sound	Sound description (instrument), Volume, Pitch, Notes, Harmony
	Style	Style, Period
Architecture	Mood	Emotions, Conception, Feelings, Program, Function
	Pattern	Regularity, Repetition, Composition, Structure, Size, Proportion
	Form	Shape
	Material	Material, Technique

First, genre in music is the genre or type of music and music that was created or played in the certain period of time that respondents have mentioned such as rock music, electronic music, religious music, classical music, and etc. Mood in music is the emotions and feelings that the respondents have received while listening to the song. For instance, the respondents were terrified by listening to the song, felt the coldness, felt peaceful, and etc. Moreover, respondents have symbolized and made imageries such as linear music, a music that might be played in a concert hall, a music feeling like the universe, and etc. Rhythm includes the regularity, sequence, speed, composition, and structure. This is when music has constant beat, repetitive rhythm, irregular beats, strong beats, fast rhythm, the flow of the whole music and etc. Sound in music is the description of sound such as instrument, volume, pitch, and harmony of notes. This is when the respondents had described the song as sharp sound, ascending notes, sound of bells, electric guitar and piano, and etc.

In architecture, style is the type of architectural style that represents certain period of time such as Renaissance, Classical and contemporary architecture, and etc. Mood in architecture emerges from emotions, making conception, feelings, and imagining and associating with the building's function and program. This is when a building gives intimidating feeling, a building looking like a concert hall, school or church, a building looking like it is going to rend the skies, and etc. The pattern of architecture is the regularity, repetition, composition, structure, size and proportion of the buildings such as mentioning about the intervals of the windows, irregular pattern of the structure, and etc. The form of the architecture simply means the shape of the building or parts of the building. The respondents have described the building as sharp, linear, rectangular, a shape of a bell, cylinder and etc. The material of the architecture is

describing the material and technique that was used to build the building such as concrete, metal, steel, the building’s detailed technique and etc.

(3) Keyword Frequency

Instead of analyzing right or wrong answers separately, the responses were analyzed as a whole by each major to see which elements are perceived by the majors. This is due to reasons of the respondents, who have correctly matched the buildings and songs, did not match up with the architects’ intentions. Moreover, even when the respondents have matched incorrectly, the reasons for selection were very similar to the architects’ intentions. The top four keywords from the responses of all the majors are listed in the order of frequencies from the highest to lowest.

Architecture majors have associated the mood of music with the mood of architecture the most, stating that frightening music (music 5) matches with scary looking building (building 2) [table 6]. Secondly, the number of the association of musical sound and architectural form were similar. When the respondents have interpreted the rhythm to the pattern, they mentioned that the rhythm of music 5 was related to the proportions of the windows in building 2. For sound and form, the sound of the electric guitar in music 2 connected to the sharp shape in building 4. Then the following pair was linking with the genre of music to architectural style such as classical music (music 4) reminding them of classical building (building 1).

Table 6. Keywords from the Responses of Architecture Majors

No.	Music - Architecture	Count
1	Mood – Mood	46
2	Rhythm – Pattern	38
3	Sound – Form	36
4	Genre – Style	30

Music majors have interpreted the mood of music to the mood of architecture the most as well [table 7]. One of the reasons that these two elements were paired is that music 3 was untuneful to listen, which also led to choose the building that was uncomfortable to see (building 5). The second highest pair was the sound of music and the form of architecture by associating the crescendo of the notes in music 1 to the building that is shaped like it is rising with the shape of a cone in building 3. When the genre of music and the architectural style were linked together, the oriental style of music (music 1) was relevant to the oriental style building (building 5). Then the rhythm of music and the pattern of architecture were matched. Since the rhythm was regular in music 4, a symmetrical building (building 1) was selected.

Table 7. Keywords from the Responses of Music Majors

No.	Music - Architecture	Count
1	Mood – Mood	59
2	Sound – Form	37
3	Genre – Style	34
4	Rhythm – Pattern	34

The other majors have associated the mood of the music and the mood of architecture the most as both architecture and music majors have selected [table 8]. Music 1 gives a sense of freedom which led to select the building 4 that also gave the sense of freedom. Secondly, the genre of music is interpreted as the style of architecture. Since music 5 is a contemporary music, building 2 that looked like contemporary architecture was chosen. Thirdly, the rhythm from music and architectural pattern were paired by responding that since music 3 has irregular rhythms, it is matched with building 3 that has irregular patterns. Then the sound of music is connected to the form of architecture. The sound of bells in music 1 reminded the respondents of the shape of a bell in building 3.

Table 8. Keywords from the Responses of Other Majors

No.	Music - Architecture	Count
1	Mood – Mood	67
2	Genre – Style	42
3	Rhythm – Pattern	28
4	Sound – Form	22

Although the order was slightly different, the pairs of musical and architectural elements were same up to the top four of the keyword frequency, meaning that the field of study did not affect the way people perceive musically inspired architecture. Table 9 lists the overall keywords in the order from the highest to lowest, and it indicates that people perceived by associating the mood of music with the mood of architecture the most. Then the following order is the genre of music to style of architecture, the rhythm from music to the pattern of architecture, and the sound of music to form of architecture. After listing and grouping by the musical element, each musical element appears to have a representative architectural element.

Table 9. Overall Keyword Frequency

Music	Architecture	Count	Music	Architecture	Count
Genre	Style	99	Rhythm	Pattern	99
	Mood	23		Form	29
	Form	19		Mood	11
	Material	5		Material	3
	Pattern	2		Style	1
Mood	Mood	172	Sound	Form	96
	Form	45		Pattern	26
	Material	8		Mood	13
	Pattern	7		Material	8
	Style	3		Style	3

(4) Interpretation

The following analysis is on the interpretation of each building to investigate more in depth about how the respondents have perceived the musical and architectural elements. The diagrams [figures 6~10] of the keyword frequency in each building are expressed by the pairs of the keywords between music and architecture with graphs and tables. The keywords are abbreviated in graphs such as the following: genre(G),

mood(MM), rhythm(R), sound(S) in music, and style(ST), mood(MA), pattern(P), form(F), material(MT) in architecture. The blue bar in the graph refers to the pair of musical element and architectural element that the respondents have selected the most. The red bar refers to the architect's or the composer's intentions.

The composer's intention for building 1 was to demonstrate musical rhythm to architectural pattern by expressing the building's harmony of proportion and order by the repetitive rhythms. However, most of the respondents have interpreted musical genre as the architectural style because classical music reminds them of classical style architecture. This reveals that the respondents have connected the music that represents the period to the architectural style that represents the same period [figure 6].

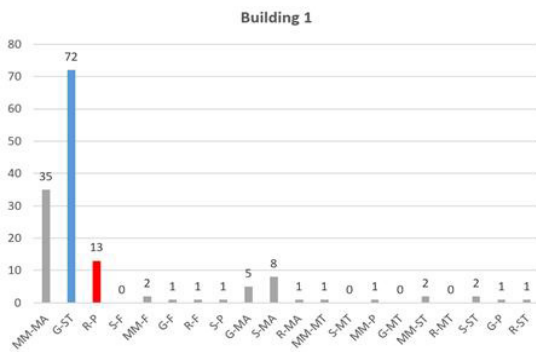


Figure 6. Interpretation of Building 1

The architect of building 2 has translated musical rhythm into architectural pattern. Despite the architect's intention, most of the respondents have perceived the mood of the song as the mood of the building. The respondents thought that the scary song goes with the scary looking building, and the music that gives cold feelings goes with the hospital-like buildings. This shows that the respondents have examined the whole mood of the song and the building instead of observing the small detailed elements [figure 5].

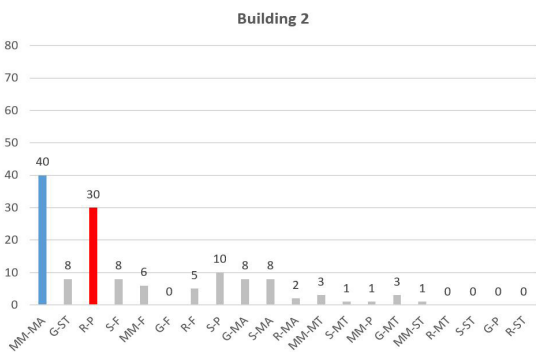


Figure 7. Interpretation of Building 2

Figure 6 shows that although the architect's intention was to connect the musical rhythm to architectural form, most of the respondents have responded that the sound of music connects

to the architectural form. The respondents have felt that the sharp sound of the song reminded them of sharp shape, and the sound of a bell reminded them of the shape of a bell. This presents that people have associated the overall mood of the song to overall mood of the building, and the instruments used in the music were associated with the morphology of the instrument.

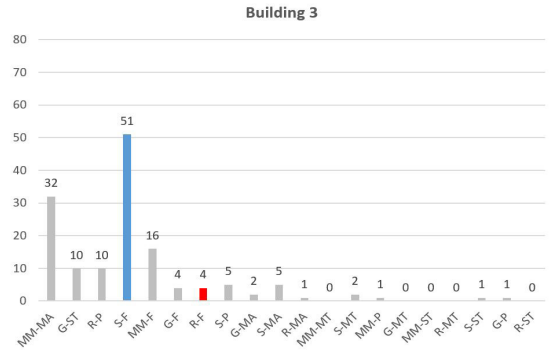


Figure 8. Interpretation of Building 3

In building 4, the architect has planned to depict the rhythm from the music with the form of the building. There was only a slight difference between the architect's intention and the result stating that the strong beats connect with the pointy shaped skin of the building. However, the result shows that the respondents have associated the mood of the song and the mood of the building the most. The respondents have felt the freedom from the song, so they have selected the building that gave the sense of freedom. This is another case of the respondents perceiving the overall mood of the song and building [figure 7].

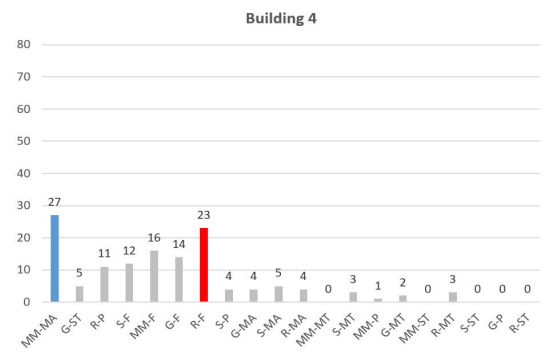


Figure 9. Interpretation of Building 4

The architect of building 5 has attempted to express the complex rhythms by utilizing the pattern of the building with strip morphology. Even though some respondents have associated the rhythm with the building patterns, many respondents have connected the mood of the music and the mood of the building as well. They have felt that the music gave the feeling of tension, which led them to match with the building that also gave the feeling of tension. Respondents have concentrated more on the overall feeling than the individual elements [figure 8].

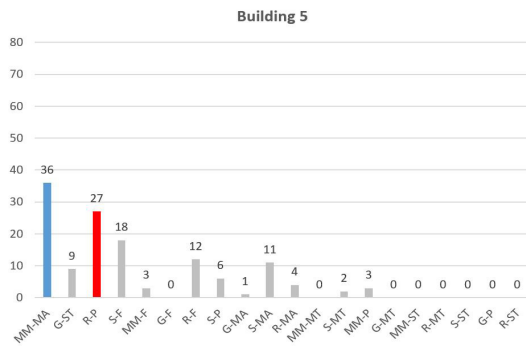


Figure 10. Interpretation of Building 5

This analysis provides a message that each respondent's emotions had a significant impact on the results. However, although all the respondents had different experiences from the buildings, they were all looking at the similar musical and architectural elements. In addition, even though the respondents were not able to accurately grasp the architects and composers' purposes, they were all able to identify some kind of musical qualities from architecture. As long as the intentions were not too complex or the music genre and architectural style were not too definite, the respondents were able to determine the intentions to a certain extent.

5. CONCLUSION

The significance of this research is to prove that it is appropriate to use music as a source of inspiration in architectural designs. This is the first empirical study to investigate the perceptions of visitors when experiencing the musically inspired architecture. Respondents' feedback on why such music and buildings fit together were more important and helpful in identifying people's perceptions on musically inspired architecture. In addition, the expected values and the actual research results present that people have the ability to understand musical characteristics through architecture. People were able to identify and match with similar musical and architectural elements such as genre, mood, rhythm and sound of music, and style, mood, pattern, form and material in architecture. As a result, most people perceived the overall mood and environment of the music and architecture rather than looking at the specific elements when they first came across the musically inspired buildings just as Goethe has mentioned about focusing on the mood of music and architecture rather than the forms in Kim (2018)'s research. This also reveals that most of the relationship between music and architecture by elements in the past has changed. Furthermore, by looking at the respondents' responses of the survey questionnaire in the section of matching the building with music, and comprehending the reasons for the selections, people's emotions greatly influenced on the result. A large number of respondents have translated the overall mood of the music to the overall mood of the architecture by interpreting the music and architecture with the emotions they have received directly from what they have heard and seen. Generally, the

reasons for selection of the respondents were generated by the association that they have made after hearing the music and seeing the buildings with their own understandings about music and architecture.

In order to make creative, systematical and logical designs in architecture, the concept should be formed not just for the function, but it should also be developed from another field of study such as music. Thus, the results of this study will help in suggesting the ideas of design for architects who are seeking to express the musical qualities through architecture. Moreover, through further studies, more effective directions in architectural planning are to be provided for the architects with interests in other forms of arts as well.

REFERENCES

- Archdaily. <http://www.archdaily.com/41319/pavillion-21-coop-himmelblau>. Accessed on May 2016.
- Boosey & Hawks. http://www.boosey.com/pages/cr/catalogue/cat_detail.asp?site-lang=en&musicid=761&langid=1. Accessed on June 2016.
- EBS Documentary, 2020. *Docu-Prime – Observing Human with Brain: Art*. <https://www.ebs.co.kr/tv/show?prodId=348&lectId=20254134>. Accessed on May 2020.
- Fleming, S. & Reynolds, M. (2006). Timely Timelessness: Traditional Proportions and Modern Practice in Kahn's Kimbell Museum. *Nexus Network Journal*, 8(1), 33-52.
- Heo, Y. (2010). *A Song of Architecture*. Kimoondang.
- Jung, S., & Lee, H. (1998). A Study on the Relationship of Architecture and Music by Aesthetical Constituent Factor – Focused on the Recent and the Present Age. *Journal of Architectural Institute of Korea*, 18(1), 259-266.
- Kim, J. (2018). Analogical Relationship and Heterogeneous Characteristics of Architectural and Musical Experience Found in Stretto House Designed by Steven Holl. *Journal of the Korean Institute of Culture Architecture*, 61, 203-210.
- Lee, H. et al. (2009). A Study on the Form of His Philips-pavilion based on Xenakis's the Musical Thought. *Journal of Architectural Institute of Korea*, 25(3), 151-158.
- Moon, S. (2010). Architecture and Music. *Journal of Architectural Institute of Korea*, 54(8), 55-57.
- Orproject. <http://orproject.com/busanoperahouse/>. Accessed on November 2015.
- Pollio, V. et al. (2008). *Vitruvius: The Ten Books on Architecture*. Charleston, SC: BiblioBazaar.
- The Baltimore Sun. (1998). An Ego, a Talent as Big as All Outdoors Preview: Ken Burns Tackles Another American Icon in His Biography of the Architect 'Frank Lloyd Wright'. <https://www.baltimoresun.com/news/bs-xpm-1998-11-10-1998314101-story.html>. Accessed on May 2021.
- The Culture Concept Circle. (2014). Music – Harmony from Apollo to Palladio & Mozart to Jenkins. <https://www.thecultureconcept.com/music-harmony-from-apollo-to-palladio-mozart-to-jenkins>. Accessed on September, 2015.
- Wittokower, R. (1940). *Alberti's Approach to Antiquity in*

- Architecture*. London: The Warburg Institute.
- Xenakis-emulator. http://nexialist.com/XENAKIS/NEX_XENAKIS.htm. Accessed on September 2015.
- Yi, D. (1991). *Music Analogy in Gothic and Renaissance Architecture – A Study of Rational Proportion in Architecture*. Ph.D Dissertation, University of Sydney.
- Yoon, H. (2005). *Dialogues between Contemporary Architecture and Music*. Spacetime-Shigongmunhwasa.
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