

**DOI: 10.7596/taksad.v6i1.782**

**Citation:** Tavakoli, D., Bareshadat, N., & Tafrihi, M. (2017). The Understanding and Emotion Caused by an Architect-Built Space Using Music. *Journal of History Culture and Art Research*, 6(1), 791-803. doi:<http://dx.doi.org/10.7596/taksad.v6i1.782>

## **The Understanding and Emotion Caused by an Architect-Built Space Using Music**

**Davod Baradaran Tavakoli\*<sup>1</sup>, Negin Bareshadat<sup>2</sup>, Maryam Tafrihi<sup>3</sup>**

### **Abstract**

Music and architecture are two of the effective components of the lives of human beings which are especially important. However, the link between these two components and their impacts on the understanding of the audience are some of the issues which have not been focused on. This bond is caused by a mutual space. A space which can either be created by a work of architecture or a piece of music. Despite of the previous studies that focused on investigating the different aspects of these two forms of art that link them together, this paper aims to discover and understand the perceptual – emotional relationship between music and architecture further than the preliminary principles that link them. It also aims to find an answer to this question: how can a relationship be established between various linking aspects of these two arts that would be understandable for their audiences?

The present study is an analytical – descriptive research that relies on library studies and uses a logical argument in order to analyze, interpret and compare the relationship between music and architecture and its impact on the understanding of the audience.

Accordingly, after reviewing the research literature and stating the concept of space in architecture and music, the linking aspects of these two forms of art have been comparatively analyzed. According to the conclusion of results, by taking into consideration various frequencies and generation of a variety of geometrical orders in each frequency, the more intense music is the more complex its spatial impact will be on the feeling and understanding of the audience.

**Keywords:** Music, Emotion, Understanding, Form, Architecture.

---

<sup>1</sup> Corresponding Author, Ph.D. Student of Architecture, College of Art and Architecture, Mashhad Branch, Islamic Azad University, Mashhad, Iran.

<sup>2</sup> Ph.D. Student of Architecture, College of Art and Architecture, Mashhad Branch, Islamic Azad University, Mashhad, Iran.

<sup>3</sup> M.Sc. Student of Architecture, Department of Art and Architecture, Shiraz Branch, Islamic Azad University, Fars, Iran.

## **Introduction**

One of the main issues in the field of art has always been the investigation of the relationship between music and architecture. Music is considered as an inseparable part of our lives and it is prominent in culture. On one hand, the subject of music is associated with financial, spiritual and mental interactions of human beings and on the other one, an architect must integrate and multiply various components in a harmonious manner; just as it is in music. When the bass sound is triple and the tenor sound is in coordination with them both, an amazing and coordinated unity of proportions is created out of a variety of sounds which enchants us. The qualitative differences and similarities of music and architecture is caused by the thing that creates them both. Sound is the thing that creates music; a quality that is hidden and depends on time. On the other hand, the things that architecture is comprised of are tangible materials and the understanding of the audience of them depends on time.

The authors of this study argue that the similarities between music and architecture are not solely in aspects such as their mutual principles including rhythm, hierarchy, order, balance, equilibrium, etc.; these are the aspects that architecture has in common with many other forms of art. What has built the substrate for the comparative study of these two forms of art and has not been focused on much is that music includes human beings just like architecture and it forms a dominant space that is to some extent inclusive. Architecture creates such a space by emphasizing on visual sense (although other senses also play a role) and music creates such space with an emphasis on the sense of auditory (hearing).

The difference between these two forms of art in establishing a relationship is actually the thing that makes studying this matter more and more necessary. This is what has caused musicians and architects disagree and ignore the common beliefs that link these two arts together (both conceptual and structural). This study aims to find out about the feeling and understanding caused by music in an audience in an environment built by an architect by taking into account the aspects of these arts that link them together. Some music pieces intensify more internal feelings that can be associated with sadness and sorrow and others intensify more external emotions such as happiness in their audience. Similarly, in architecture, space is created and that leads to generation of some perceptions in the audience in a same way.

## **Research background**

Order is one of the main principles of aesthetics and although music is one of the purest arts and it is assumed that there would be less of a relationship between it and this criterion; but according to the researches and studies conducted by many students, musical pieces are delightful when there is a special order to them. In sciences, such as mathematics, geometry and physics, this order is recognized based on the mentality and senses of human beings; in such a way that the history of measurement and development of the principles associated with it can be traced back to more than two thousand years.

In this regard, Pythagoras and Plato were perhaps the first ones to prove the internal relationship between mathematics, geometry, music and ultimately, architecture. They founded some hypotheses and developed them (Anthoniades, 2007: 154).

As Morris (2005:12) point out “Pythagoras was inspired by the vibrations of lute strings, as he observed their successive modes of vibration produce notes whose frequencies have a simple mathematical relationship to one another. Each mode, or pattern of vibration, is composed of nodes (points on the string which remain stationary) and antinodes (points of maximum vibrational amplitude). Thus, sound is joined to a spatial pattern”.

By reviewing the next experiences in the field of discovering the nature of music and its relationship with form, it becomes clear that these preliminary experiences have been quite impressive and progressive.

“Albert Laviniak” wrote: “all of the natural phenomena have been made of waves and vibrations. Sound, just like light and heat, is made of vibrations between 32 and 73000 degrees (Falamaki, 1990: 41 and 42).

One of the considerable contemporary approaches is translation of sound to seeable form or shapes. One of the ways for this translation is using a method invented by the German physicist Ernst Chladni in 1787. Following Robert Hooke’s observations in the 17<sup>th</sup> century, Chladni found a simple method for observing sounds. At first, he poured fine sand on a glass surface, then made them swing through vibrations of violin (image 1). These frequencies caused the sand to be accumulated in some specific lines and spots and be formed quite symmetrically and vibration patterns were formed (Jormakka, 2009:21).

To see the sound



image 1. one of the important discoveries made by Chladni is a technique about the point that sound can be observed with the help of a string of violin and an even surface covered with sand. After Chladni, these shapes have been known as Chladni's images (sourcez 1; URL)

“One gateway into “nonlinear” pattern formation, a very active research topic today, was opened in the 1830’s by the great experimentalist Michael Faraday”; and after that “in the 1960’s and 70’s, Hans Jenny, a Swiss medical doctor, amateur scientist and artist, undertook a series of experiments on the visual characteristics of vibrational effects and wave phenomena. He includes references to Chladni and some of his experiments, such as the square patterns created in fluids spread on a plate, are similar to Faraday’s. Jenny also undertook and documented experiments with “writhing and leaping” cornstarch suspensions. This strange phenomenon was rediscovered only recently by physicists”. He called the theme of his research Cymatics. The most aesthetically beautiful images in Cymatics (1974), in both colour and black-and-white, are those created by animating a fluid drop with a simple audio frequency. (Morris, 2005:12) After Jenny, a cymatic specialist called John Stewart Reed repeated Chladni’s experiment and was able to create different kinds of shapes (image 2).

One of the most recent researches has been conducted by “Martin Wattenberg” (2009) (image 3). He has used arc-shaped diagrams in order to translate some of the most famous musical pieces of the work to diagrams. He proved that the relationships existing in pieces of work from the pre-modern age, unlike in those from the postmodern age, have many layers and compared them with the diagrams obtained from a few famous pieces (Watterberg, 2009: 120-140).

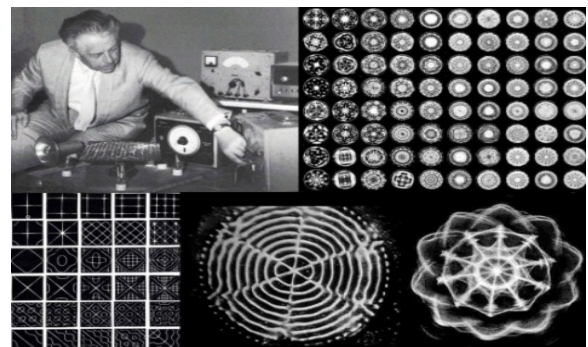


Image 2: formal pattern obtained from repeating Chladni’s experiment by StewRT Reed (source: URL2)

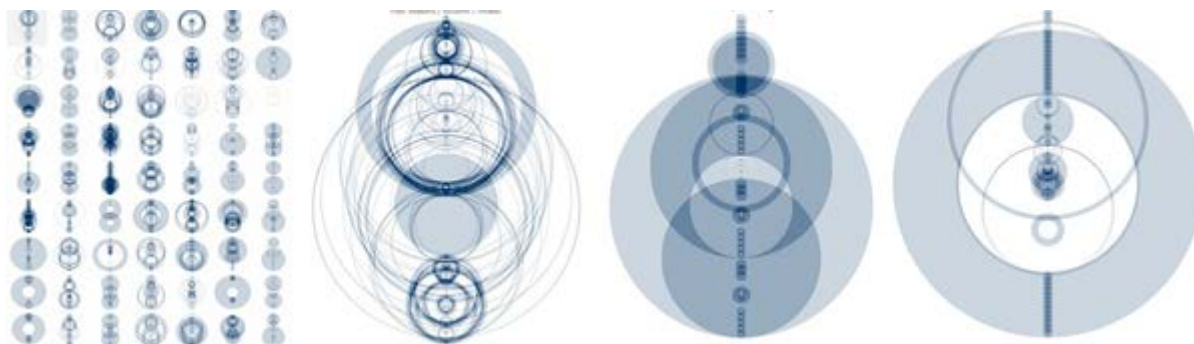
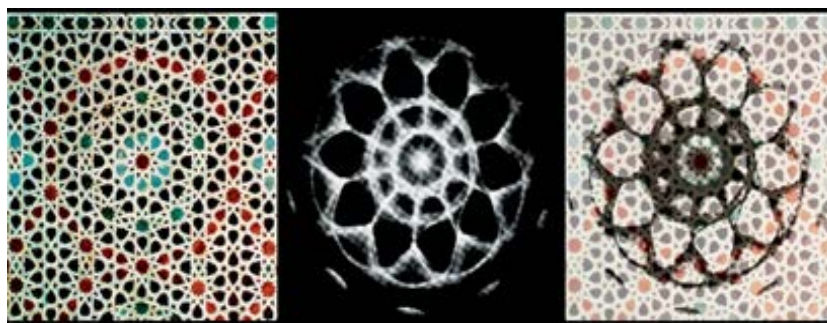


Image 3: in this figure, we see diagrams presented by Martin Wattenberg (2009) in order for showing the musical structure while playing a few different musical pieces. Here, three of the pieces have been zoomed (source: URL:3)

Stephen Morris and Lydia Sharmen (2005), in a study called “sound images”, considered Chladni’s method as the basis but created new formal patterns (Morris, 2005: 12) (image 4).

Image 4: inspired by the experiments of Hans Jenny and medieval Moroccan mosaics, Lydia Sharman uses small icons in the form of a silver pendant, an intaglio plate or a silk screen image based on these fundamental geometries, and then connects and expands them over the surface in closed or open repeating forms(morris,2005)



Many studies have focused on the direct relationship between music and architecture, mostly dispersed studies and sometimes purposeful ones. “Iyanis Xenakis” used her experiences in the field of relations and geometry in architecture from her time with Licorbozie and mentioned the role of geometry in creating a compliance and coordination between these arts in her book called “music and architecture”. She reviewed some examples of converting music to architecture in her own works and in the works of other architects. Ultimately, in the final chapter of her book, she states that “the relationship between music and architecture is a mental and virtual relationship not a real one” (Xenakis, 2008: 150). She also argues that “just like a musical piece is affected by “photosphere” or an audio space, a mental space full of spiritual and divine attractions, building a mosque using the sky-tall components and elongation of the sides of a church as if they want to reach excellence; they are all able to create a space full of religious and divine attractions in those who have faith.

Thus, the aforementioned studies show that not only music and architecture affect the perception of human beings, but they can have similar effects as well.

### Research method

The present study is an analytical – descriptive research that relies on library studies and uses a logical argument in order to analyze, interpret and compare the discussions of the study.

According to Groot’s viewpoint, there is no doubt that any research program o theory must have a logical coherence. Most of the previous studies, with a logical argument, have a

tendency towards a hierarchy of existing dispersed findings, the unknown or factors that haven't been focused on yet and make them coherent by putting them in special frameworks that have great, and sometimes new expression ability. In other words, preliminary logical systems have a tendency to innovation, to the extent that it leads to a conversation at the level of mental patterns (Groot Linda, Wang David, 2012: 309).

### **Music and architecture**

Presence of a common and consistent process in the approach to the artistic lives of human beings creates similar qualities in it; one of the most important of which is the investigation of concepts that occupy the minds of human beings and the concepts us as humans try to express. If one can say that the main goal of music composers when creating a musical piece is presenting a certain concept that should be tangible and have sociocultural efficiency; it cannot easily be said that architects are also after the same goal. Architects deal with works that put them in another land for two reasons. The first one is that the essence of their raw materials forces them to consider a wider range of formal features. The second one is the applicable aspect of architecture which usually does not accept a frank and direct conceptual and spiritual meaning. Although the complexity and contrast seem to disagree with these two phenomena, what is prominent in these two aspects is the presence of a concept seen in it; and it is the frankness in expressing a concept itself is a major difference and limits this relationship. Different expression tools on one hand and the common mental structure on the other one, have created some links and disconnections between these two issues and one must be aware of this difference while reviewing them. The art of architecture and music in the mind of the user is a perception caused by cultural assets and experiences and an understanding of the point that how the emotions are evoked and how the musical and architectural shapes and outcomes can be known only by experience. In general, these shapes in architecture and/or music are the feeling of happiness, humility, a sense of relief and dignity, a sense of excitement and attraction, a feeling of sorrow and monotony, a sense of greatness and glory, etc. (Falamaki, 1990: 311).

### **Musical and architectural space**

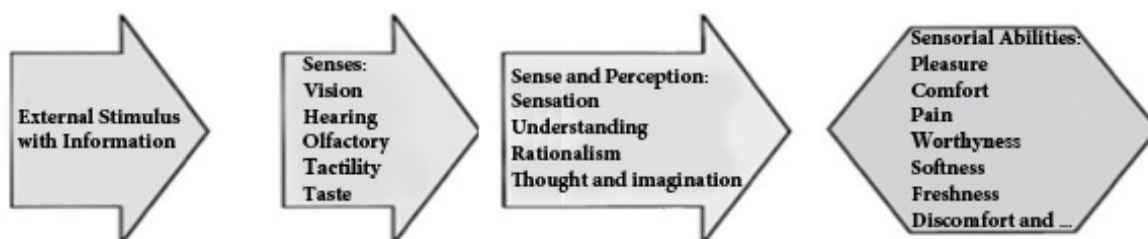
A lot has been said regarding the nature of space and what it is. However, we strongly believe that in expressing, understanding and perceiving it, human beings are at the first stages of recognition. Space is manifested and embodied with a variety of relationships between objects and elements and it is a complex set of these relations that makes perceiving the space more difficult (Rezvani, 2013: 4). Therefore, there is always a relationship between the observer and the space and an ordered relation relates these two together (Grooter, 2003: 169). According to Hans Jentzen's theory, the art historians, analysis of the formalistic space, which describes the space in works of art as an independent formal style, must embody its conceptual dimension in the works of art (NorbergSchulz, 1971: 1240-1252). On the other hand, despite the fact that the art of music must be heard and the art of architecture is tangible

and objective, both include the concept of space in themselves; because both can be experienced over time and are essentially perceivable in the temporal and spatial space.

According to Zuckerkand's theory, a variety of relationships in the musical space is also especially considered and space is not only the thing one encounters, but it is a place in which the things one encounters have an interaction with one another. The main assumption of this theory is that music belongs to the outside world and its space is fluid. According to this theory, since the space is a place for the phenomena to interact with each other, music has the ability to create a physical space (Zuckerkand, 1957: 302). On the other hand, Bowman believes that the musical space is not an objective space that can only be perceived using physical, intuitive and geometrical tools. The musical space is apparent. It is a space that moves without going anywhere and without changing. However, in all cases, all of these spatial features are perceived by our conscious mind, all of our senses and not only by our sense of hearing (Bowman, 1998: 273-275).

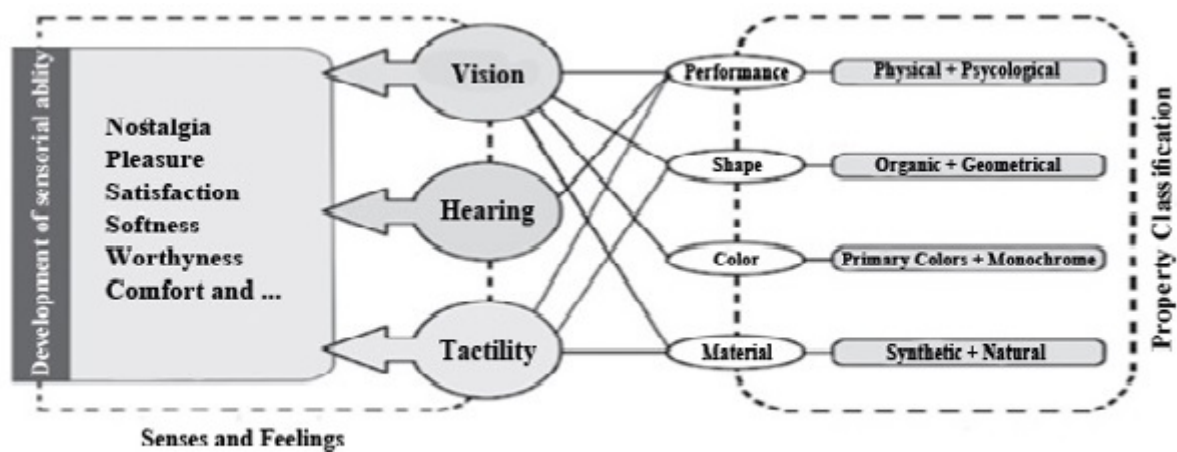
Perceiving the musical space plays a crucial role in Clifton's philosophy. Clifton argues that space belongs to four key elements: music, time, execution and emotions. In Clifton's theory, the musical space is not just a visual one, nor it is just a physical space; but it also includes lines, flat screens and surfaces which show different degrees of delicacy and softness or masses that reveal different degrees of rigidity (Clifton, 1983: 137-204). Thus, by taking into account Robinson's theory, it can be concluded that there are two approaches in defining the musical space. Some think that music is an art of absolute audit design and don't believe that there is space in music and others believe that it is an integrated art that expresses some concepts and meanings through mental images and words (Robinson, 1977: 57). It is necessary to emphasize that although the main substrate of the link between architecture and music is completed with space which has a 3-dimensional or multiple-dimensional interpretation; but most researches, just like the present study state that translating music to two-dimensional forms provide an opportunity for developing an understanding of a three-dimensional space. Nonetheless, as Xenakis states, "whether we like it or not there is a link between architecture and music and this is based on our mental structures which is one in the both of these arts" (Falamaki, 1990: 40-41).

### The process of evoking an emotion in the audience



Graph 1: the process of evoking an emotion in the users (cited by Bagheri, Ebrahim, 2011)

Each product or space establishes a close relationship with the audience through its function and appearance; in such a way that it shows itself through its shape or form and reveals its capabilities to them through its function. However, these two alone cannot transfer all of the emotions bottled up in a product or space to the audience; because the product must contain meaning and emotions too and have the ability to transfer them to the audience so that no confusing and inaccurate emotions would be evoked in them. On the other hand, if some spaces have a similar order or similar forms, using different materials causes some differences in their specifications. For this purpose, other basic factors, such as material and color, that have a visual or audit relationship with the audience and have common messages with the form and function shall also be considered as important criteria. For instance, the type of material in two completely similar spaces is a criterion that makes the audience translate the emotions and perceptions differently using different senses and personal experiences over the course of their lives.



Graph 2: analytical criteria in a sensibility design (cited by Bagheri, Ebrahim, 2011)

Form of any musical or architectural creation won't make that piece more efficient and evoke emotions in people's minds unless its subject is considered in the process of transferring the concept from creator to user. Although eyes and ears are the paths for the concepts in the outside world to enter the inside world, but any relationship between these two worlds is established through the forms and elements that they are comprised of. On the other hand, form can play the role of a deceiver in addition to the role it plays in delivering messages and establishing a relationship between the user and the work of art and associating meanings in the minds of users. It can attract the audience through devices such as metaphor, historical references, humor, novelty and so on and create a unique feeling. Moreover, in sensibility design, a combination of geometrical, soft, curved and organic forms are used; however, the application of curved and organic forms in this approach is quite different than that of those in the previous approaches. A combination of curved forms can add to the softness of the final design and establish a relationship with the audience by creating potential cognitive signs and implying different meanings. The design center of Tooshiba company argues: "form shall not

solely create a sense of responsiveness and an aesthetic satisfaction, it shall focus on the function as well” (Sapper, 1999).

Since architects use nature as the source for the material and texture of their products and are compatible with the nature and the surrounding environment, architecture is considered as an art that deals with nature; therefore, nature is an inspiration for the artist. The artist shall always have in mind the natural conditions and requirements of their own work; in such a way that even the sky and the earth are a part of their creation. Musical thinking and liveliness, consistency and mobility of the selected tunes with the purpose of embodying thoughts, the created harmony for reinforcing and implying these thoughts and various rhythms created by the composers are the things that make music colorful. Color adds something to music which will enable the musician to embody the scene or the space he/she is thinking of. For instance, for a Spanish dance to have local colors, it must have a local rhythm and some specific moves that are some of the unique features of this type of dancing.

Another interesting point is that it is an architect’s or a constructor’s job to create a coordination between stability and instability, heaviness and lightness, roughness and smoothness. Professor “Loop” states: “in architecture, there can be coordination between colors, texture, shape, softness, roughness and reflection altogether. In general, architecture must be peaceful and harmonious. It is true that in music, what is meant by coordination is the compliance between the sounds; but in a broader sense, it is the relations between sounds, musical sentences, colors and the resonance of instruments with one another. The sound of a plectrum instrument is different from that of bowed instruments; but when they are used in a certain way they will be delicate and coordinated”.

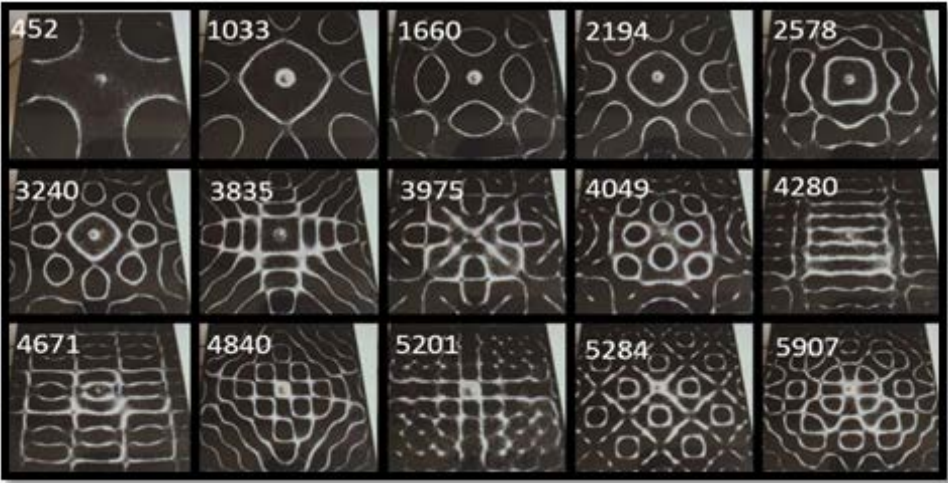
### **Analysis**

In order to explain the issue more, we review the geometrical systems dominating various generated frequencies; because in sensibility design, a combination of geometrical, soft, curved and organic forms are used; however, the application of curved and organic forms in this approach is quite different than that of those in the previous approaches. Nevertheless, in designing emotional spaces and products, geometrical forms are one of the basic components of the design that can deliver strong formal messages; but a combination of curved forms can add to the softness of the final design and establish a relationship with the audience by creating potential cognitive signs and implying different meanings.

In architecture and music, geometry is a set of regulating principles that lead all components towards beauty and aesthetics. Naturally, a building and a musical piece are both comprised of various and integrated components. Musical rhythms have arisen from mathematics. Music, as an art, is rooted in mathematics and mathematical relations and it is manifested through geometry. In architecture, geometrical volume is a three-dimensional element that can be solid (filled with areas) or hollow (limitation of space by areas). Further, acoustic is one of the common mathematical grounds of music and architecture which has been created in the past century. It is the science of converting architecture to a proper substrate with a proper



condition for music. Designing an amphitheater, concerts and opera are issues that require mastery of physics of sound (Seyedian, Seyed Ali; Samipoor, Timan; 2016: 8).



Examples of Chladni patterns on vibrated square plates, created by Stephen Morris (source: authors)

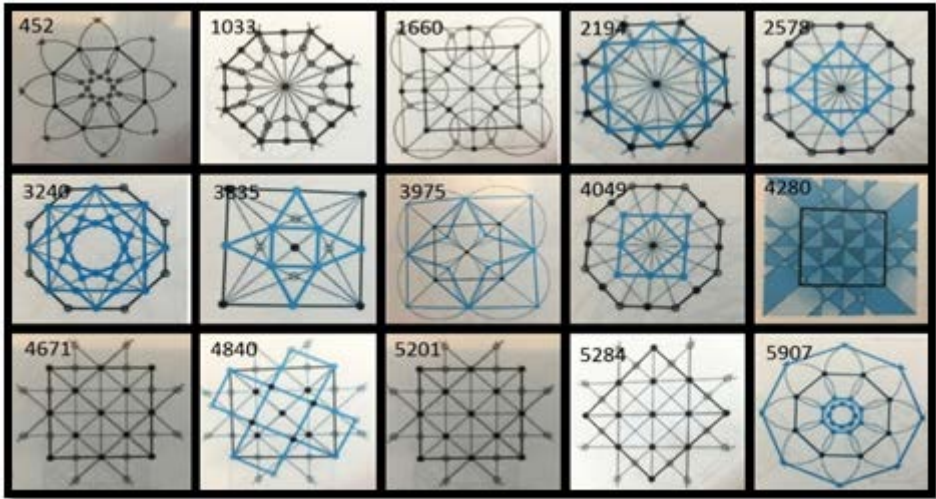


Image 8: internal and external relations of geometrical shapes given the patterns generated by different frequencies (source: Rezvani, Alireza, 2015)

The criteria for drawing internal relations, vertices, centers of edges and other main spots that are obtained from the connection of these spots together are indicative of the developed and dominant organization of geometrical shapes on their inside and outside space. These provide the applicable and functional fields for designers to understand the essence of geometrical shapes and their capabilities (Rezvani, Alireza, 2015; 196).

By comparatively reviewing the obtained images, it becomes clear that the higher the applied frequency is, the more complex the obtained shapes will be and the higher their number in the geometrical structures will be. In such a case, they will be more extroverted to lower frequencies. Just like the sound of music in a joyful or sad musical piece, the louder the sound is, the more the emotions and perception of the audience will be evoked and complicated regarding themselves, their surrounding environment. On the other hand, by comparing the

geometrical systems of the shapes obtained from different frequencies and translating geometrical patterns, it can be understood that all of the shapes obtained from various frequencies have a regulated geometrical system which show their own specific features and characteristics in addition to valuable concepts based on the users' emotions. The latter is because they are able to deliver strong formal messages.

To sum it up, the relationship between the audience and the product is established by emotions, sight, design, sound and touch. Moreover, all of the preliminary factors of design (function, form, color and material) create a sense of physical piece and mental satisfaction in the user or the audience through senses and by translating their unique features which will be briefly presented in table number 1.

Elements	Descriptions
Function	Visible, simple. Supports a mixture of manifestoes. Possesses semiotic potential: satisfaction, convenience, amenity, comfort, etc.
Form	Organic / geometric. Expresses higher meanings. Based on the feelings of consumers. Displays characteristics (semantic expression): nostalgia, richness, pleasantness, etc
Color	Mixture of monochrome and primary, complementary, transparency. Stimulus to form / a part of the structure. Possesses a sense of high quality: strong vitality, nostalgia, pleasantness, etc.
Material	Blends natural and artificial. Possesses tactile qualities (elastomers, new synthetic plastics). Highlights the contrast or composite of different surfaces. Generates satisfaction, richness, comfort, etc.

Table 1: translation of sensibility design factors (source: Dongha Kim and Prasad Boradkar, 2006)

As it was mentioned earlier in the article, function, form, color and material are the criteria used for evaluating and analyzing a product. According to Kim and Boradkar, these evoke different emotions through human being's sensuous media and through certain physical and psychological features and so on.

### Conclusion

After expressing the background of the subject in the frame of formal studies, the present study reviews the literature on space in architecture and music and uses logical argument and inferential research method to comparatively review the shapes obtained from musical frequencies and spatial organization models obtained from internal and external relations of geometrical elements. Then, a new hypothesis is mentioned based on the internal relations of music and its impact on the emotion and perception of the audience in a space created by an architect. In this research, in addition to converting and translating the forms obtained from

different frequencies to regulated geometrical patterns, the deep connection between these two forms of art is reviewed. This connection is indicative of functionalism of forms obtained from different frequencies. Accordingly, each form is separately reviewed and translated to regulated geometrical ones. The statement of the design center of Tooshiba company regarding the point that in designing emotional forms, function is more valuable than the aesthetic satisfaction has also been taken into consideration. Further, given that geometrical forms have been considered as the main component of design and the previous comparative observations show that there is a relation in regular quadrilateral and octagonal shapes in all of the generated forms, it can be concluded that there is a direct relationship between the intensity of the frequency and the number of generated elements and when the frequency is more intense, they are more extroverted. Therefore, there is a deep conceptual – perceptive bond between these two arts that intensifies the emotions of their audiences.

Finally, authors believe that music, in its essence, is comprised of natural sounds and the closer it gets to nature, the closer it actually gets to its own essence. Because sounds are nothing but the spirit of nature. The geometrical system and its elements are also inspired by nature and many scientists and researchers believe that existence and nature are comprised of geometrical networks and systems. On the other hand, in designing emotional spaces, geometrical forms are parts of the main component that can deliver strong formal messages. In addition, adjacency of geometry with reinforcement of logical and rational abilities, design process, formation of ideas and concepts and expressing architecture is a necessity which makes the creations of the designers emotional, in addition to the aforementioned features.

## References

Anthoniades, Anthony, C. (2007). *Architectural Poetry (Creation in Architecture)*. Translated by Ahmadreza Ay, 3<sup>rd</sup> Edition, Tehran: Soroosh, 154.

Robinson, J. B. (1983). *Foundations of Music, History*, Translated from German, Cambridge: Cambridge University Press, 57.

Seyedian, Seyed Ali, Samipoor, Timan (2016). “Interpretation of Musical and Architectural Elements with a Common Language: Case Study of Iran’s Traditional Architecture and Music”. *Comparative Art Studies*. 6<sup>th</sup> Year, 11<sup>th</sup> Issue, 8: 2016.

- Bagheri, Ebrahim (2011). Applicable Concepts in Sensibility Design. *Journal of Fine Arts–Visual Arts*. 50<sup>th</sup> Issue, 2012.
- Bowman, W. D. (1998). *Philosophical Perspectives on Music*. New York: Oxford University Press, 273-175.
- Clifton, Thomas (1983). *Music as Heard: A Study In Applied Phenomenology*. New Haven, Conn: Yale University Press. (137-204).
- Falamaki, Mohammad Mansoor et al. (1990). *Architecture and Music*. 1<sup>st</sup> Edition, Tehran: Faza Publications, 40-42, 285.
- Gibson, J. J. (1966). *The Senses Considered as Perceptual Systems*, Houghton Mifflin Co, Boston & New York.
- Groot, Linda & Wang, Davi (2012). *Research Methods in Architecture*. Translated by Alireza Eynifar, 6<sup>th</sup> Edition, Tehran: Tehran University, 283.
- Grooter, Yorg Court (2003). *Aesthetics in Architecture*. Jahanshah Pakzad and Abdolreza Homayoon, 5<sup>th</sup> Edition, Tehran: Shahid Beheshti University, 252.
- Jormakka, K. (2009). *Basics Design Methods*. Berlin: Birkhauser Press, 21.
- Kim, Dongha & Boradkar, Prasad (2006). *Sensibility Design*, retrieved from [www.Citeseerx.Ist.Psu.Edu](http://www.Citeseerx.Ist.Psu.Edu) (2010-07-24).
- Morris, Stephen & Sharman, Lydia (2005). *Images of Sound Symmetry Hidden and Manifest in Physics and Art*. Faculty of Arts & Science, University of Toronto, *Idea&S*, 2(2), 12.
- Norberg Schulz, Ch. (1971). *Existence, Space and Architecture*. London: Oslo Press, 138.
- Rezvani, Alireza (2013). *The Spirit of the City, A Redefinition of the City, Space, Urban Space and Determination of Refreshing Indexes*. National Conference on Urban Management, Culture and Architecture, Karaj, Applicable and Scientific Education Center of Karaj's Municipality, Did Architectural Office, 4.
- Rezvani, Alireza (2015). *Spatial Networks and Geometrical Volumes*, 1<sup>st</sup> Edition, Misagh Publications, 196.
- Sapper, R. (ed.). (1999). *The International Design Yearbook 13*, New York & London: Abbeville Press.

Starck, P. (ed.). (1995). *The International Design Yearbook 1997*, New York & London: Abbeville Press.

Wattenberg, M. (2009). *Arc Diagrams: Visualizing Structure in Strings*. London: Cambridge University Press, 120-140.

Xenakis, I. (2008). *Music and Architecture*. New York: Pendragon University Press, 150.

## **URL**

URL1: [Http://www.Thescienceofcreativity.Com/](http://www.Thescienceofcreativity.Com/)(Access Date: 2016/03/20).

URL2: [Http://cymatics.Blogsky.Com/1389/01/10/Post-1](http://cymatics.Blogsky.Com/1389/01/10/Post-1)(Access Date: 2016/03/10).

URL3: [Http://www.Bewitched.Com/Song.Html](http://www.Bewitched.Com/Song.Html)(Access Date: 2016/02/28).