A SURVEY ON THE EMOTIONAL RESPONSES OF USERS TO BUILDING FORMS: FOCUSING ON DIGITALLY MANIPULATED CURVILINEARITY

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Naciye Kara

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We certify that we have read this thesis and that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.

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ABSTRACT

A SURVEY ON THE EMOTIONAL RESPONSES OF USERS TO BUILDING FORMS: FOCUSING ON DIGITALLY MANIPULATED CURVILINEARITY

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September 2021

In recent years, computer technologies in architecture have been chiefly changing the form of buildings, as it proposes a novel geometric language and different form-finding methods. It is widely known that computer technologies have enabled the design and construction of curvilinear forms to be more economical and faster than the pre-digitalization period for most cases and helped to design amorphous curvatures. Therefore, curvilinear forms have become more prevalent in architectural discourse and practice. This study approached the subject of digital curvilinearity from the perspective of the user. The aim of this thesis is to measure the emotional responses of the users to curvilinear building forms and compare them with the reactions to rectilinear ones. In order to measure peoples' responses to various building forms, 12 building cases were created, including rectilinear and digital curvilinear forms in this study. An online questionnaire is prepared with the visuals of these various building forms, and the answers are arranged according to Mehrabian and Russell's adjective pairs. 114 respondents voluntarily answered these questions, and the results were evaluated by using SPSS software. The responses of the respondents to rectilinear and curvilinear forms were compared. The results showed that participants' emotional responses were more positive for the digital curvilinear forms proposed compared to conventional rectilinear forms. In addition, there was no significant difference between the participants' emotional reactions to forms that are generated with different form manipulation methods.

Keywords: Digital building forms, Curvilinear forms, Emotion, Mehrabian and Russell's PAD model

ÖZET

KULLANICILARIN BİNA FORMLARINA DUYGUSAL YANITLARI ÜZERİNE BİR ARAŞTIRMA: DİJİTAL OLARAK MANİPÜLE EDİLMİŞ EĞRİLİKLERE ODAKLANMAK

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Son yıllarda mimaride bilgisayar teknolojilerinin kullanımı, yeni geometrik dil ve farklı form bulma yöntemleri önermesi nedeniyle binaların formunu büyük ölçüde değiştirmektedir. Bilgisayar teknolojilerinin, eğrisel formların tasarım ve yapımının çoğu durumda dijitalleşme öncesi dönemden daha ekonomik ve daha hızlı olmasını sağladığı ve amorf eğriliklerin tasarlanmasına yardımcı olduğu yaygın olarak bilinmektedir.. Bu nedenle, mimari söylem ve pratikte eğrisel formlar daha yaygın hale gelmiştir. Bu çalışma, dijital eğrisellik konusuna kullanıcı perspektifinden yaklaşmıştır. Bu tezin amacı, kullanıcıların eğrisel yapı formlarına karşı duygusal yanıtlarını ölçmek ve bunları doğrusal yapı formlarına verilen tepkilerle karşılaştırmaktır. İnsanların çeşitli yapı formlarına tepkilerini ölçmek için çalışma kapsamında doğrusal ve dijital eğrisel formlar olmak üzere 12 adet yapı örneği oluşturulmuştur. Bu çeşitli yapı formlarının görselleri ile çevrimiçi bir anket hazırlanmıştır ve cevaplar Mehrabian ve Russell'ın sıfat çiftlerine göre düzenlenmiştir. 114 katılımcı bu soruları gönüllü olarak yanıtlamıştır ve sonuçlar SPSS programı kullanılarak analiz edilmiştir. Katılımcıların doğrusal ve eğrisel formlara verdikleri yanıtlar karşılaştırılmıştır. Sonuçlar, katılımcıların duygusal tepkilerinin, geleneksel doğrusal formlara kıyasla önerilen dijital eğrisel formlar için daha olumlu olduğunu göstermiştir. Ayrıca, farklı form manipülasyon yöntemleri ile oluşturulan formlara katılımcıların duygusal tepkileri arasında anlamlı bir fark bulunmamıştır.

Anahtar sözcükler: Dijital yapı formları, eğrisel formlar, duygu, Mehrabian ve Russell’ın PAD modeli

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ABBREVIATIONS

CAD- Computer-Aided Design

CAM - Computer-Aided Manufacturing

NURBS - Non-Uniform Rational B-Spline

SR- Square Plan- Rectilinear Form

SMC- Square Plan- Metamorphic Curvilinear Form

SPC - Square Plan- Parametric Curvilinear Form

LR- L Plan- Rectilinear Form

LMC- L Plan- Metamorphic Curvilinear Form

LPC- L Plan- Parametric Curvilinear Form

UR - U Plan- Rectilinear Form

UMC- U Plan- Metamorphic Curvilinear Form

UPC- U Plan- Parametric Curvilinear Form

B1- Buffer Setting 1

B2 -Buffer Setting 2

B3 -Buffer Setting 3

CHAPTER 1

INTRODUCTION

Architecture is a whole that is difficult to separate with its environment, zeitgeist, and user. It is well-known that technological, social, environmental factors and innovations influence architectural discourse and practice. In particular, the relationship between the discipline of architecture and technology is direct because architecture is not only concerned with designing but also with making (Dunn, 2012). Technology is effective in shortening, facilitating, or reducing the cost of building construction processes. For this reason, it is widely accepted that it influences designers’ decisions.

It is generally agreed today that innovations in material, construction, and design technologies mainly affect the form and appearance of the buildings. Examples of this impact are frequently encountered in the historical process. For instance, the change started with the effect of the industrial revolution in architecture in the 20th century. Mechanization technologies and mass production processes, which resulted from the Industrial Revolution, were reflected in architecture as modernism and new materials and construction techniques were used. For instance, in the 19th century, the use of materials such as glass, iron/steel, and concrete increased in design and construction. As a result, this situation has completely changed the appearance and form of the buildings. Joseph Paxton's Crystal Palace embodied the spirit of the era and pioneered the use of material technologies such as steel and glass in architecture. Then, Gustave Eiffel's Tower in Paris represented one of the tallest structures that can be reached with the latest construction technologies. Under the leadership of these structures, skylines of many cities have been filled with skyscrapers made from glass and steel. As a result, the modernism movement in architecture that has made the built environment filled with steel, glass, and concrete buildings of standard, rectilinear forms was triggered with the effect of mass production and standardization.

The significant changes in architecture with the industrial revolution are experienced with digitalization currently (Schumacher, 2008). Architecture depends on its medium, namely drawing, just as the economy depends on money and politics on power, and drawing defines the boundaries of architecture. Therefore, with the digitalization of drawing tools, the expression of architecture also changes (Schumacher, 2008). The design and construction facilities provided by new digital technologies find their expression in highly complex and curvilinear building forms (Kolarevic, 2003). Digitalization technologies may mainly help to construct and design curvilinear forms either more economically, faster and/or easier than before. This situation has triggered the transition from rigid, rectilinear forms and typological architecture to computational, digital architectures of topological, non-Euclidean geometric ones (Kolarevic, 2003). In summary, new design and construction techniques have emerged with digitalization, resulting in curvilinear digital forms' different and extensive design.

The relationship between the user and the architectural form is also inseparable, like architectural form and technology, because the form is a crucial factor in users' assessing environment. Form affects individuals' aesthetic experiences of the environment (Lang, 1987). Formal features such as shape, color, size, texture, etc., play a significant role in the assessment of the environment. At the end of these assessment processes, various emotional responses occur in people (Rafaeli and Vilnai-Yavetz, 2004). In addition, emotions affect the daily life of individuals. For this reason, it is vital to measure the effect of building forms on people's feelings. Designers need to know the impacts of building forms on users while making formal decisions to create better environments. In this context, users' evaluations of new curvilinear forms, which are the result of digitalization technologies, are worth studying.

1.1.Problem Statement

There are many studies in the literature on the impact of the use of digital technologies in architecture. Many researchers and designers have discussed and analyzed this topic theoretically, philosophically, methodologically, technically, professionally, and discursively. However, the concept of “architecture in the digital age” can still be regarded as an evolving and transforming subject (Oxman, 2005). The user’s response to resulting building forms of digitalization has not been much studied in the literature. The place consists of physical form, but user and time give it a meaning and identity (Norberg-Schulz, 1980).

On the other hand, many studies on various architecture scales focus on the effect of curvilinear architectural forms on individuals' emotional responses and assessments and compare this effect with rectilinearity (Lundholm, 1941; Küller, 1980;

Hesselgren, 1987; Dazkir and Read 2012; Örer, 2016). However, the curvatures mentioned in these studies are usually created by softening the corners of rectilinear objects or by tangent relations of primary shapes such as circles or ovals and their proportions. These classical architectural curvatures differ from digital curvatures today (Lynn, 1999). Currently, there are new form classifications for digital forms and curvatures (Terzidis, 2003; Kolarevic, 2000). Not much study has been encountered that measures the emotional responses of users to the digital curvatures. In addition, the subject of curvilinear form has been studied in the interior spaces and urban environment, but examples at the scale of building form have not been encountered very often (Dazkir and Read, 2012; Hesselgren, 1987; Küller, 1980; Örer, 2016). Since there are few studies in these areas, it would be helpful to approach digitalization and curvature at the scale of the building form and from the user's perspective.

1.2.Aim and Scope of the Thesis

This thesis aims to measure the emotional responses of individuals to digital curvilinear building forms and compare them with conventional, rectilinear forms. In addition, there are various ways of derivation and generating curvatures; some of these methods are relatively new, while some of them are older. Therefore, it is also essential to investigate whether the curvatures resulting from different digital ways impact individuals' emotional evaluations. The generation method of curvilinearity is not the main focus in this thesis, as the user did not answer the questions being aware of these methods, but various methods result with associative or amorphous forms. This thesis aims to observe the effect of these differences on the responses of the users. It is anticipated that considering these effects may help designers in their formal decision-making processes.

It is a known fact that the relationship between architecture and user is not all about the users' emotional evaluations of the building forms because experiencing architecture is multidimensional. Many people have explored the nature of this relationship from various perspectives. For instance, the relation can also be more concretely approached as a body experiencing architecture or mental processes. Many personal and environmental factors affect these processes. Also, it is a multi-sensory experience (Pallasma, 1996) and emotional reactions occur due to all these senses (Rafaeli and Vilnai-Yavetz, 2004). However, this study only focuses on people's emotional and verbal assessments of building forms. Within the scope of this study, it is difficult to make a general judgment or inference about the relations of users with digitalized building forms because this thesis focuses on a very small part of the architectural form experience of the users. In this study, participants were asked only what they felt when they saw the building forms. Other sensory experiences, the background of the participants, or why they gave positive or negative responses were not considered. Many factors, such as backgrounds, early experiences of users, etc., may differentiate their evaluations. Nevertheless, it is meaningful to measure the users' evaluations about the changing building forms because the building forms affect the emotional state of the users and this emotional state affects the daily lives of the individuals.

Moreover, being in a building or looking at it from the outside may evoke different emotions. However, users can have some idea about the experience gained in these spaces with the available information and cues provided, even without being in it (Gosling et al., 2002). When a space is observed from outside, some predictions about the users inside and service level of the place and how they interact and experience the space could be made by individuals (Gosling et al., 2002). In this thesis, the spatial experience and the emotional reactions of the users associated with it are discussed only in the context of the building form. It is questioned what kind of emotions the building forms evoke when viewed from the outside and whether they arouse the desire to be inside. Accordingly, a survey has been conducted within the scope of this thesis to measure and compare users' emotional responses to different building forms. Twelve building cases were created with digital curvilinear and rectilinear architectural forms. These cases were presented online to the individuals, and their emotional responses related to the form of the buildings were measured via Mehrabian and Russel's PAD adjective pairs and compared for this thesis.

In more detail, this thesis mainly aims at answering the questions of;

- Are there any differences between the emotional responses of individuals to curvilinear building forms and conventional, rectilinear ones?
- Are there any differences in the emotional responses of individuals to the curvilinear building forms with the changing methods of form generation (Metamorphic curvilinear- Parametric curvilinear)?
- Do people desire to be in digital curvilinear form buildings when they encounter from outside? Does this desire differ for rectilinear forms?

1.3. Structure Of The Thesis

This study consists of six chapters. The chapters are listed as follows;

The first chapter of the thesis reveals the problem, aim, and structure of the thesis. This chapter briefly mentions the relationship between emotional response and architectural form and the digitalization processes that result in curvature in architecture. With this information, the purpose of the research has been revealed, and briefly, the method and importance of the thesis study are explained. This chapter also includes the research questions to be answered in the study.

In Chapter 2, firstly, the definition and processes of digitalization in architecture are mentioned. Also, in this chapter, digitalization processes are divided into different periods, namely the Utopian Computational Design Period, Computer-aided Drawing and Manipulation Period, and Computer-aided Computational Design Period. Sample studies and projects of these periods are included and investigated chronologically.

Secondly, it was focused on digitalization and curvature mainly. This section is divided into three. In the first part, the subject of architectural form was examined in the geometric context. This section focused on changing geometric relations in the form before and after digitalization, focusing on curvature. In the second part, the situation of curvature before and after digitalization is discussed. In the last part, methods for generating and deriving digital curvatures are presented.

In chapter 3, primarily the environment and the assessment of the environment by individuals are mentioned. This chapter is divided into two parts. The first part mentions how much the concept of environment and its evaluation have been reduced for this study. The factors that are effective in environmental evaluation and the place of architectural form among these factors are explained. Also, studies on curvilinear forms and the evaluation of individuals are presented in the literature. The second part presents the definition of emotion, its relation with the environment, and its measurement methods. In addition, Mehrabian and Russell's (1974) model used in the questionnaire is presented in detail.

The methodology of the study is included in chapter 4. This chapter describes the process of creating the questionnaire, the methods of creating visual stimuli and building cases, sample group, and questionnaire.

Chapter 5 is initially split into two. Firstly, the data collected by the questionnaire and their analysis are mentioned under the title of results. The second part is gathered under the title of the discussion, and inferences are made according to the analysis of the collected data. The results section is divided into seven parts. In the first part, normality and reliability tests performed in SPSS are presented. In the second part, pleasure and arousal scores of rectilinear and parametric-metamorphic curvilinear forms are compared. In the third part, the desire of respondents to be in various building forms is compared. In the fourth part, the effects of the subjects of the education that the participants studied on the pleasure and arousal scores are investigated. The fifth section compares the emotional response differences between the various layouts prepared for the survey. In the sixth part, the relationships between the adjective pairs used for the pleasure and arousal scales and the correlation between the pleasure, arousal scores, and the desire to be in a building are tested. In the seventh part, pleasure and arousal scores are placed on Russell and Pratt's (1980) bipolar dimension plane, and total emotional states are examined. In the last part, all the discussions about analysis are done.

In the conclusion part of the study, the questionnaire results are interpreted, and recommendations for future studies are made. In addition, the limitations of the study are mentioned. Finally, references and appendices are included.

CHAPTER 2

DIGITALIZATION AND CURVILINEARITY

Curvilinear forms can be created with analog methods, as well as it is possible to design and built rectilinear forms with digital design tools most of the time. Still, the digitization process is often associated with curvilinearity in architecture. There are various reasons for this, but one of the most important is that computers are versatile machines that enable complex calculations and greatly simplify design and manufacturing processes of these complexities. Therefore, digitalization processes remove some barriers and boundaries for designers and end the sharp distinction between construction and design with the “file to factory” era (Kolarevic, 2003). It provides more unrestrained design opportunities to designers, letting them to focus on more avant-garde designs and forms (Hagan, 2008). For this reason, different and more unlimited curvatures can now be designed and produced with these technologies. Nevertheless, according to Carpo (2013), there is a more complex understanding behind curvilinear forms than just the possibilities of computers. Today's situation cannot be summarized as "we make blobs because we can."

Curvilinear forms are the result of many digitalization theories and philosophies (Carpo, 2013).

Within the scope of this thesis, it is hard to address the causes of curvature in architecture exactly and fully, but in general, it is widely known that some theories and ideologies have mainly influenced architectural form with digitalization. For example, Darwin's (1859) and Thompson's (1997) study of the relationships between species' morphological features and environmental factors and Thompson's (1997) presentation of form as a “diagram of environmental forces” triggered designers’ use of curvature (Figure 2.1).

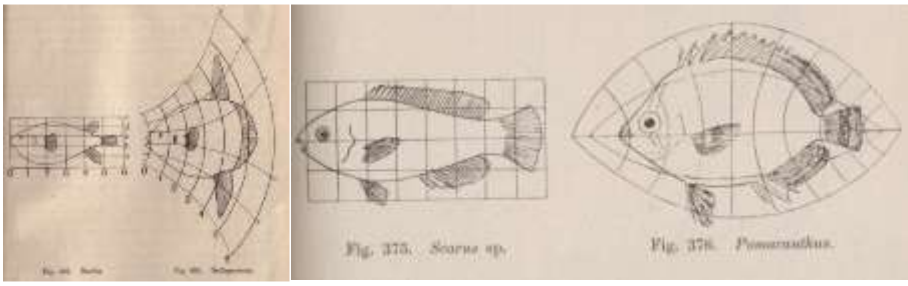

Figure 2.1: Deformation of fish species under forces, D'arcy Thompson
(https://www.ongrowthandform.org/on-growth-and-form-gallery/)

Greg Lynn (1999), one of the most influential names in digitalization and the changing of architectural form, claimed that it is possible to produce a more dynamic architecture that is based on the nature theories of Darwin and Thompson and with the convenience of computers. He asserted that nature's system of controlling and organizing these forces and forms could be an architecture model. According to him, modern architecture made the space fixed, clear, static, and rectilinear, which are only related in terms of gravitational forces, and he proposed using curvilinear forms in order to respond to various environmental forces and to design more dynamic, anexact, smooth and differentiated architecture, like in airplane, naval, and car industries (Lynn, 1999). On the other hand, the curvature can be accepted as a form that can respond to various environmental factors; it is a form that contains indefinite relationships of more than two variables mathematically (Jencks, 1997). For this reason, spatial problems with multiple inputs often result in curvature with the help of computers. The relationship between environmental factors and form can only result in curvature because it can respond to multi-element problems and can therefore be used to solve contextual problems in architecture (Lynn, 1999). In addition, Leibniz and Deleuze's theory that the universe and nature use fold and curvature to regulate complexity, provide transitions between dimensions, and remove boundaries between them has been influential in digitalization processes (Figure 2.2) (Kolarevic, 2003).

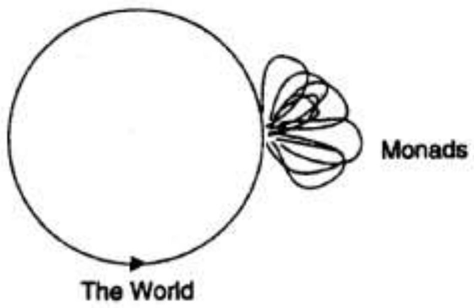

Figure 2.2: An entire universe exists in a “folded state” within each monad, and inside the folds, there are limitless folds, organization of universe (Deleuze, 2006)

According to these models, everything in nature folds. Everything in the universe is open-ended, comprehensive, and in a state of constant diversification and development, and this generative system is provided by fold and curvilinearity. For example, proteins fold to build larger structures. In order to slide and move, snakes and fishes fold and unfold. Eyelids, knees, fingers, and jaws move on the base of the fold (Terzidis, 2003). That is why most architects and theorists perceived the Deleuzian fold model as a theoretical background for the literal folding of the façade and the curvilinearity of the skin (Vidler, 2000). Many architects focused their designs on non-Euclidean, topologic geometries for these reasons.

It is difficult to relate the prevalence of curvilinear forms both in practice and discourse, only to digitalization processes, as can be seen. There are many theoretical backgrounds behind curvilinear forms. However, this thesis focuses on the relationship between curvature and digitalization as architects drew what they could build and built what they could draw (Mitchell, 2001). This chapter examines both the digitalization processes in architectural form and its relationship with curvature. The first part of this chapter will discuss the digitalization processes in architecture and the effects in discourse and practice. The second part will focus more on curvature and form. The construction and design of curvature before and after digitalization will be discussed. Finally, the methods used to generate and derive digital curvilinear forms will be explained.

2.1. Digitalization Processes in Architecture

Digitalization is defined as converting information into a digital form that can be stored and read by computers or using digital technologies such as computers or the internet for an operation (Cambridge University Press, n.d.). Although the invention and utilization of the computer and the digitalization processes date back to earlier times in most professions, computers in architecture have become widespread after the 1990s (Dunn, 2012). The inclusion of digital design tools in architecture results from a long development process since the emergence of the primary approaches.

Digitalization in architecture is the transition from sketches, 3D models, and drawings to digital tools, software, computer usage, and coding methods. On the other hand, "the medium is the message," that is, the content and product change with the transformation of the tools used (McLuhan, 1967). Therefore, the digitalization of drawing tools introduced new design concepts, form-finding techniques, and more frequent uses of curvilinear building forms in architecture with its eases (Kolarevic, 2000). Since the emphasis is on digitization in architecture, building forms, and the user's emotion in this study, it is essential to explain digitalization processes in architecture.

In this study, the digitalization process in architecture is divided into three stages. This distinction is based on the level of computer usage and computational characteristics utilized in the projects. To better explain this classification, the difference between computational and computer-aided design should be understood well.

Computational design is often confused with computer-aided design in today's architectural discourse, although the two terms have different definitions. Information is stored or organized as symbolic representations based on specific geometries and objects in the computer-aided design approach. Forms or entities that are already conceptualized in the designer's mind are transferred, manipulated, or stored into a computer system (Coates,2010; Terzidis,2016). On the other hand, the computational approach accepts values and actions as a set of algorithmic codes and computes their abstract relationship with numbers and representations (Coates, 2010). The computational process generates more sophisticated information separate from the input data rather than simply storing and organizing it (Menges & Ahlquist, 2011).

The period when digitalization first entered architecture has been accepted as the "Utopian Computational Design Period" because it was a period when computers were not used extensively. Still, some experimental, computational methods and algorithmic approaches were utilized in design. In the second stage, computers were widely used in the design processes, but computers' coding and algorithmic features were not profited. For this reason, this period has been accepted as the “Computer-aided Drawing and Manipulation Period.” Finally, more projects were designed using computers' computational and algorithmic capacities in the third stage. Thus, this period is named as the “Computer-aided Computational Design Period” (Table 2.1).

Table 2.1: Classification of digitalization processes in architecture

Period	Computer Usage	Computational Characteristic
Utopian Computational Design Period		✓
Computer-aided Drawing and Manipulation Period	✓	
Computer-aided Computational Design Period	✓	✓

2.1.1. Utopian Computational Design Period

Computer use was not much common in this period. However, it is considered the era of digitalization because of computational logic in the design processes. Studies in this period can be mainly divided into two groups. While one group of researchers explored ways to use and improve computer technologies in architecture, another group of architects and theorists produced many utopian and experimental projects without using these technologies. However, in general, projects often remained in a utopian stage and could not be realized concretely. Architects were only interested in the abstract relations of design elements in theory and could not work with computers in practice. Although they did not have much access to computers, they tried to apply the computational thinking system to the design. Therefore, Frazer (2005) claims this period 1970s and 1980s as "computing without computers."

Before the 1970s and 1980s, namely before the use of computers in architecture, the idea of automating the tedious and time-consuming tasks of information management through machines was studied by mathematicians such as Alan Turing and John Von Neumann as a field of research, and these machines were used in military departments in 1920s. However, these machines were different from today's computers; they could not perform various directives of the users, and they did not have hardware or interfaces to communicate with them. Therefore, they were used only for calculation and automation. The idea that these tools could also be used in design and architecture first emerged with increased number of studies on human-computer relation. For example, Yershov's model of director-agent interaction between human and machine, a system in which the human director commands a machine agent to execute a directive, was a step in human-computer relations (Figure 2.3) (Yershov, 1965).

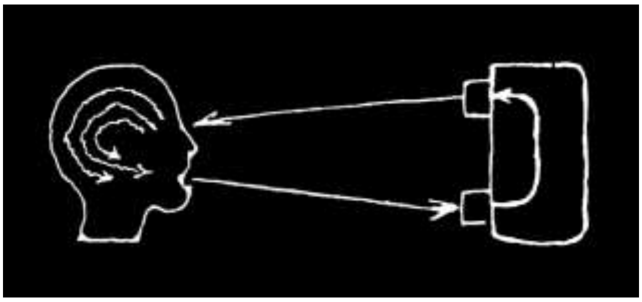

Figure 2.3: Yershov’s human-machine interaction model (http://www.madlab.cc/after-50-years-of-computer-aided-design)

Another human-computer relation study was SketchPad, a computer interface capable of recording drawings made with the help of an optical pencil invented by Ivan Sutherland (1963). A designer could draw what he had in mind to a computer screen with this method, and this approach used the computer as a representation tool for the human intellect. In addition, this methodology offered a system for sustaining rule-based geometric associations (Figure 2.4).

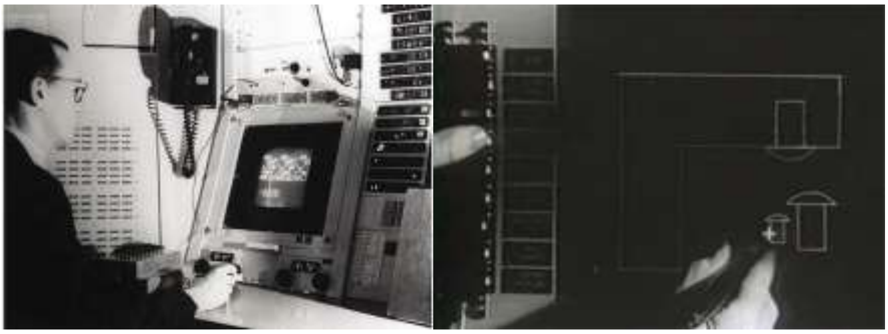

Figure 2.4: Ivan Sutherland using SketchPad(https://www.designworldonline.com/50-years-of-cad/)

The interaction with all computer-aided programs used today works with the model of Yershov, and the command line, mouse, and codes provide communication with the computers (Gannon, 2013). Thus, with these studies and inventions on human-computer relations, the boundaries between the human and the computer/machine interface were primarily negotiated (Dunn, 2012).

In the 1960s, computers stopped to be closed devices that only programmers could use. With human-computer breakthroughs in the 1970s and 1980s, the idea that everyone could use computers expanded, and this circumstance increased the belief that computers might be employed in design and architecture. Pask (1969) asserted that the computer could also be used in architecture one step further in that era. In his article, Pask (1969) argued that computers could be useful tools to go beyond the mere functionality of modernism and create a more dynamic and ever-changing architecture concerning the needs of the user because Pask (1969) perceived architecture as a dynamic output that is designed with inputs such as environmental factors, weather conditions, and human needs. Thus, Pask (1969) proposed that an architecture like that can be realized with computers and, hence, be programmable.

By the 1970s and 1980s, it is widely known that designers' interest in these technologies increased. The minority group that had access to computers worked on software and some experiments that could interact with the user. For instance, in 1973, at M.I.T, Nicholas Negroponte designed software called URBAN5 that could assist architects in the design process and contribute to project development. URBAN5 received text commands from the user and interpreted them as geometric and spatial constraints, and the program would then calculate a response based on user inputs (Figure 2.5).

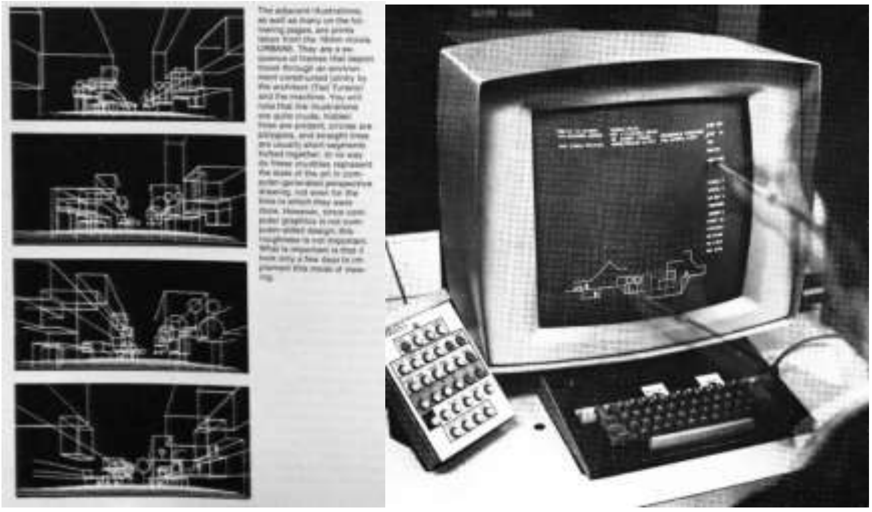

Figure 2.5: Software for the URBAN 5 project, developed by the "Architecture Machine Group", MIT, 1969. Negroponte, 1973 (https://medium.com/designscience/1973-a1b835e87d1c)

In addition, Negroponte with the Architecture Machine Group at M.I.T. designed a robotic arm, “SEEK” which continuously changed the positions of the small blocks according to patterns of behaviors that mimicked the gerbils’ behavior (Figure 2.6) or Souder and Clark designed a space planning software called COPLANNER (Mitchell, 1977).

Figure 2.6: Cover of the Software exhibition that SEEK was exhibited in
(http://cyberneticzoo.com/robots-in-art/1969-70-seek-nicholas-negroponte-american/)

On the other hand, despite the great importance of digitalization, it is widely known that most architects still did not have enough technical knowledge and equipment on computers (Frazer, 2005). For this reason, most designer groups considered computers as a machine that could realize and compute all kinds of utopian thinking when there was sufficient technical equipment, and they made some designs as if they could reach computers in this process. Although most designers could not realize concrete projects in practice, computing and its application became common in architectural theory (Frazer, 2005). During the 1970s and 1980s, most architects began to see the design process as a result of a set of inputs, parameters, associations, and outputs. They designed some utopian, imaginary projects according to this ideology (Frazer, 2005).

One of the essential suggestions was Price and Pask's "Fun Palace" project. “Fun Palace" is a theater and a cultural center project designed as an adaptable and changing structure. Pask and Price proposed a backstage computer that facilitates a system of continuous interaction to provide a feedback loop between audiences, artists and the stage can be arranged in different forms (Dunn, 2012) (Figure 2.7).

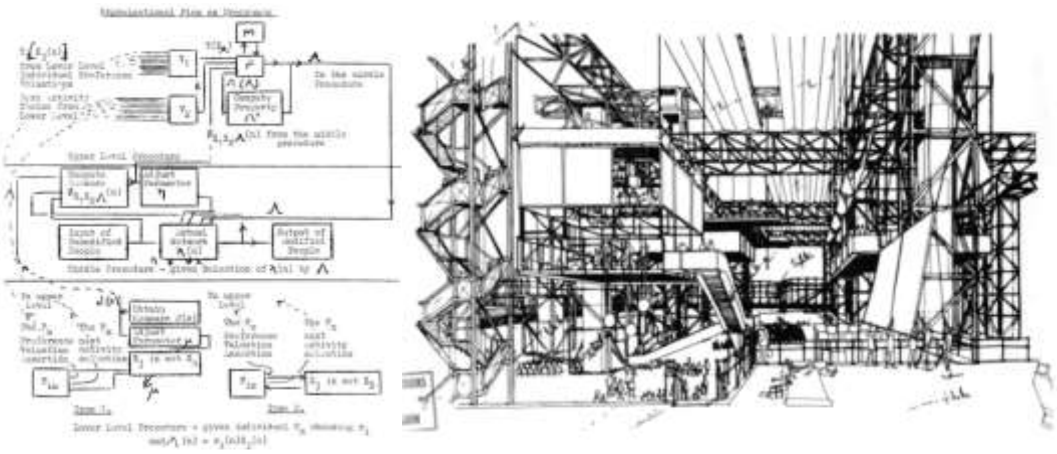

Figure 2.7: (Left) Computing diagram for the Fun Palace, (Right) Drawing of Fun Palace (https://www.arkitektuel.com/fun-palace-cedric-price/)

Further, many fictional software projects such as "Flatwriter," 1960, "Computer City," 1963 and "Plug-in City" of Archigram, 1964 (Figure 2.8) have been developed, which can be programmed and shaped according to the needs and preferences of the users (Arteta,2017). This situation was reflected in Archigram, metabolism movement, and Hi-Tech architecture projects.

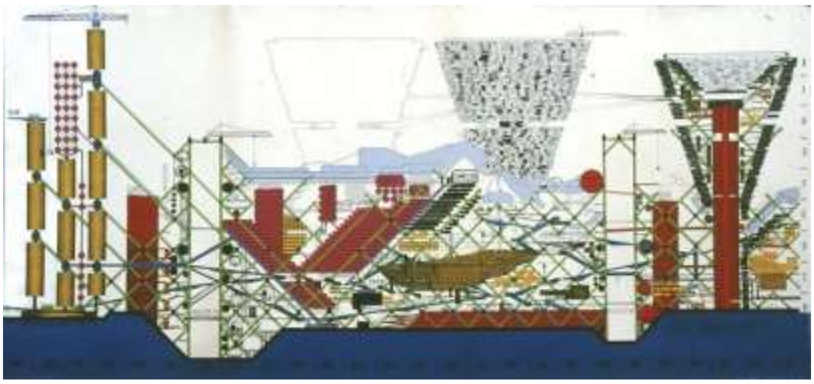

Figure 2.8: The Plug-In City / Peter Cook, Archigram, 1964 (https://www.archdaily.com/399329/ad-classics-the-plug-in-city-peter-cook-archigram)

It can be asserted that new design concepts have entered the architectural discourse in this period, although the use of computers in this era has not become widespread.

However, as can be seen from the examples, digitalization entered architecture in theory in this period.

2.1.2. Computer-aided Drawing and Manipulation Period

The 1970s and the 1980s involved many experimental works and efforts to integrate computers into the world of design. Although integration took place in theory and ideology, it was challenging to incorporate it concretely into architectural practice because computers were difficult for eveyone to reach. However, the computer usage situation in the 1990s was the opposite (Frazer, 2005). In the late 1980s and 1990s, personal computers in daily life and in architecture have become quite ubiquitous. As a result of easier access to computer equipment, computers were no longer perceived as a new technology but a casual fact during the 1990s by most architects (Dunn, 2012).

Terzidis (2016) claimed that in the 1990s, the benefits from computers were generally limited to the type of computer-aided design rather than the computational approach and said that designers did not make enough use of the computational power of the computers. For this reason, in the 1990s, computers were often used as a representation tool to speed up the drawing process, and CAD technologies only replaced with the conventional methods like sketching, drawing, and physical model-making and the design ideology that changed in the 1970s and 1980s were generally not implemented in the 1990s (Dunn, 2012).

In 1982, Autodesk, which develops software for computer-aided design, was founded, and the first versions of Autocad were presented to designers. In 1985, Autodesk introduced a primitive version of its 3D modeling programs, and thus the 3D design processes in the digital environment began, and 3D Studio DOS was introduced to the market in 1990. As a consequence of this period, although drawing was constantly shifting from analog to digital, the designers rejected to leave conventional drawing methods. 2D representations, such as plan, section, elevation, were drawn and manipulated on the computer screen, and the design of most buildings did not reflect the change. Previous architectural forms were chiefly designed with traditional methods but with new tools (Iwamoto, 2009).

In this sense, Gehry & Associates prioritized the advanced use and exploration of digital technologies. They encouraged the CATIA program in architecture, which was developed for the French aviation industry (Dassault Systems) and was first used in the automotive, ship, and aircraft design and manufacturing sectors. Thus, the period called "from file to factory" began and where the boundaries between design and construction were disappeared (Kolarevic, 2003). The Gehry office designed the Guggenheim Museum building by integrating analog and digital design methods, and they copied the geometric input of the physically prepared model to the computer environment (Figure 2.9).

Figure 2.9: The Guggenheim Museum Bilbao, Gehry Partners, 1993
(https://www.archdaily.com/422470/ad-classics-the-guggenheim-museum-bilbao-frank-gehry)

Thus, it was realized that CAD and CAM technologies made it easier to design and possible to produce complex curvilinear forms. It can be claimed that the interest in amorphous curvilinear forms and digitalization increased in architecture with the Bilbao Effect created by Gehry's building. At the same time, most manual methods used in construction processes were abandoned, and their digital versions were used along with the file to factory processes. This situation has started to reduce chiefly the construction time and cost (Iwamoto, 2009).

2.1.3. Computer-aided Computational Design Period

In the late 1990s, many designs were realized by discovering 2D and 3D digital production methods, such as CNC cutting machines and 3D modeling programs, i.e., 3ds Max, Google SketchUp, MAYA, Rhino, etc. Moreover, with the invention of programs or plug-ins, such as Digital Project, GenerativeComponents, Grasshopper, MAX script, MEL script, and Processing, the foundations of parametric and generative designs were laid (Dunn, 2012). Thus the era of computational and computer-based design began. In these computational approaches, parameters enable the generation of complex architectural form ideas by defining a set of possibilities, and a designer can produce infinite products with the same set of input parameters. Different possibilities of similar design ideas or functional schemes can be investigated through parameters, and these are more prominent than form (Kolarevic, 2003).

One of the pioneering projects in this era was Paracube, designed by Marcos Novak in 1997(Figure 2.10). For this project, a cuboid was defined with six different parametric surfaces, each in its coordinates, and all calculations were made so that the surfaces formed a smooth and fluid topological cube. In his studies, Novak was more concerned with the relationship of parameters than manipulating objects and geometries (Figure 2.10) (Kolarevic, 2003).

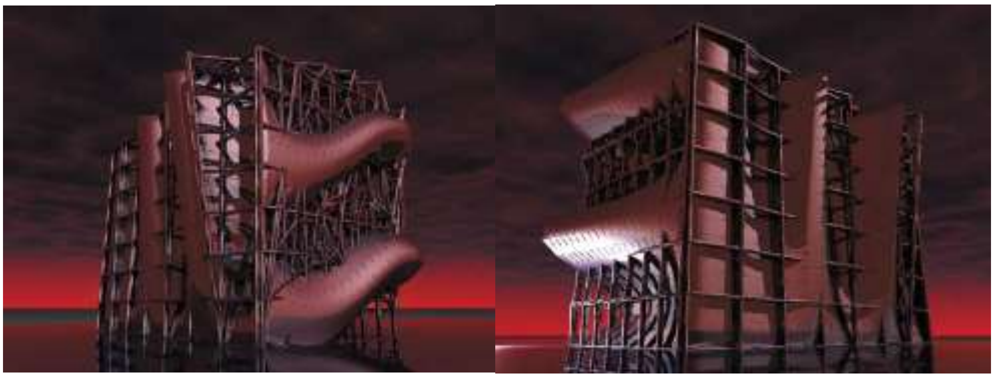

Figure 2.10: Paracube, Marcos Novak, 1997-1998 (http://www.archilab.org/public/2000/catalog/novak/novak03.htm)

Moreover, Mark Burry showed that an unstable, topologic form, the result of which is unknown, could be described with fixed inputs (Figure 2.11) (Kolarevic, 2003)

Figure 2.11: Paramorph by Mark Burry (https://mcburry.net/2012/01/)

One of the first buildings designed using purely computational design and production methods was Waterloo International Railway Station, designed by Nicholas Grimshaw and Partners (Figure 2.12). This building consists of a series of trusses and arches designed parametrically, and the spans of the arches increase along the station to facilitate the passage of the users, but the sizes increase in a particular order, with fixed rules and rates to provide a smoother transition between arcs (Figure 2.12) (Aish and Bredella, 2017).

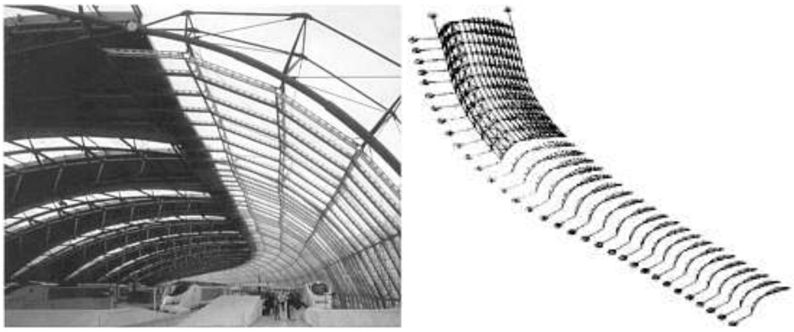

Figure 2.12: (Left) International Terminal, Waterloo Station (1993), London, UK, architect Nicholas Grimshaw and Partners. (Right) 36 dimensionally different, parametrically designed arches (Kolarevic, 2003)

Cayan (Infinity) Tower designed by SOM architecture can be an example of computational approaches. The design is based on floor plans and their relationality. Each floor of this 80-story building has been rotated 1.2 degrees so that each floor can benefit from the surrounding landscape as much as possible (Figure 2.13).

Figure 2.13: Cayan (Infinity) Tower and its computational design process (https://www.archdaily.com/331128/in-progress-infinity-tower-som)

As Terzidis (2016) asserts, today, although most designers cannot take full advantage of the design power of computers, these technologies are already being adopted in the public sphere, and architects and theoreticians are still discovering the potentials of digitalization and computational designs.

Traditional tools have been replaced by computers, as seen in architecture. This situation has offered designers new methods and possibilities. The utopian period was discursive and did not result in concrete examples, but as can be seen from the examples, the other two periods facilitated the design of more curvilinear forms.

This thesis study approaches the architectural form that changes with digitalization in this context. In other words, it can be said that the digitalization process in architecture provided the option to replace rectilinear forms produced with traditional methods, first to curvilinear forms created by manipulating on the computer screen and then to ones that were generated by coding. These three processes can generally be followed chronologically, although there are exceptions.

2.2. Form Generation and Curvilinearity

The form is an entity that includes the physical properties of objects such as shape, size, color, texture, location, and direction (Ching, 1996). It is known that digitalization processes provide many opportunities to designers as they provide new methods and some conveniences, and for this reason, more experimental forms are seen in terms of these properties. In this part of the study, firstly, the change of architectural form with digitalization will be discussed mathematically and geometrically. Then, the design and construction of curvilinearity before and after digitalization will be explained. Lastly, methods of generating and deriving digital curvilinear forms, digital form classifications will be presented.

2.2.1. Change of Formal Geometry with Digitalization

The relationship between architecture and geometry has been a subject of research throughout time. Geometry and mathematics assisted architects in performing necessary calculations during the planning and construction of the form, and thus they play a vital role in architecture. With the digitalization era, geometrical relations, which have been used for a long time in history, have been replaced by new relations since digitalization presents new techniques and eases. This section examines the geometric difference of forms before and after digitalization. First, the geometric relations used before and after the digital period will be mentioned, and then this issue will be discussed in the context of curvature.

The relationship between architectural form and geometry is as old as Pythagoras. According to Pythagoras, everything in the universe is in an “order and harmony”, and these systems can be understood with integers, mathematical regularities, and proportions. Leon Battista Alberti (1404-1472) stated in his book “De re Aedificatoria” based on Pythagoras' theorem that a perfect architecture and beauty can only be designed with a “geometric harmony and order”. Many architects followed Alberti's principles towards achieving harmony in architecture from the 16th to the 18th centuries. One of the most powerful elements in determining another architectural form was the "golden ratio," or the other proportions gathered from nature. The golden ratio was the ideal proportion and the epitome of aesthetics and harmony over long periods. Until this century, modernist approaches, basic principles of the golden ratio, harmony, and order mostly applied. For instance, Le Corbusier developed his anthropometric measurement system based on Fibonacci numbers and the golden ratio (Figure 2.14).

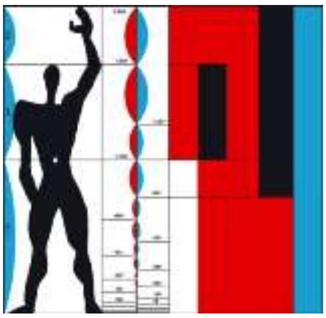

Figure 2.14: Modulor System of Le Corbusier, 1948 (https://www.archdaily.com/902597/on-the-dislocation-of-the-body-in-architecture-le-corbusiers-modulor)

Euclidian elements remained a standard well into the 20th century, and Le Corbusier, one of the pioneers of modern architecture, insisted on platonic solids and their relationships (Figure 2.15) (Schumacher, 2018).

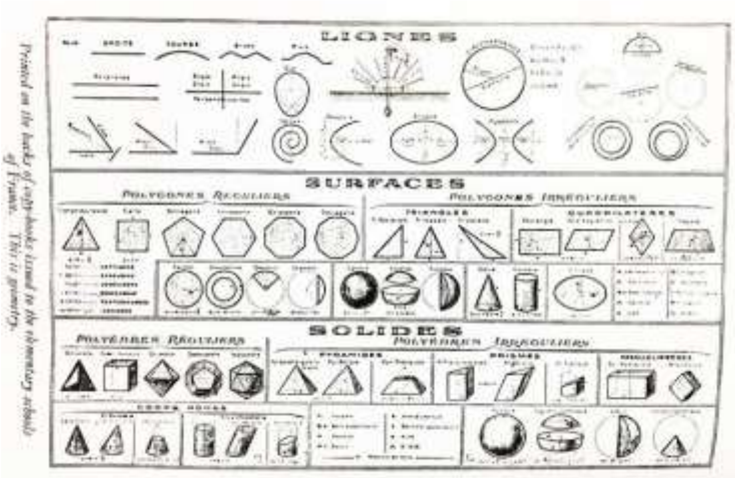

Figure 2.15: Le Corbusier’s geometry about architecture, The City of Tomorrow and its Planning, Paris,1925(https://www.patrikschumacher.com/Texts/The%20Progress%20of%20Geometry%20as%20Design%20Resource.html)

Vitruvius (80–70 BC – 15 BC), in addition, in his book On Architecture (De Architectura), asserts that symmetry and proportion are essential for beauty and technique in architecture, and he especially emphasizes symmetry. Concepts such as symmetry, harmony, rhythm, balance, order, measure, and proportion in architecture can be shown as elements of form that create repetition and aesthetic pleasure in design.

On the other hand, Jean-Nicolas-Louis Durand (1760–1834) developed a universal modular planning grid and a typological architectural system that included all these principles (Figure 2.16).

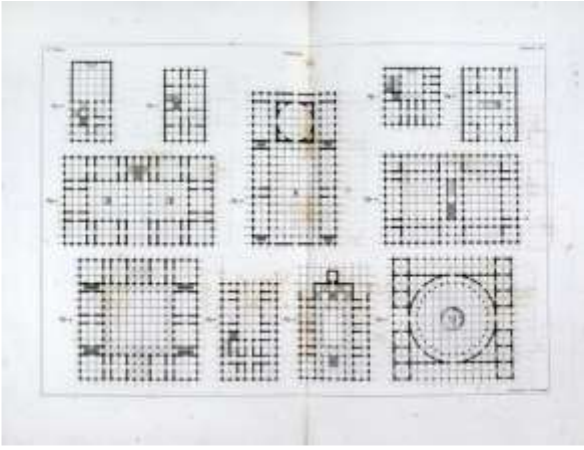

Figure 2.16: Durand’s grid system for courtyards(https://www.designactionstudio.com/beyond-nature-1

In other words, the architectural forms designed with the pre-digitalization tools were mostly limited to these mentioned rules. In order to build and design building forms, it was necessary to find various constants to be used among people to ease construction periods. For this reason, the primary geometric forms such as circle, triangle, and square were processed and systematized with a particular order, forming the architectural form. The architectural form was created by shaping the pure forms by adding, fragmenting, and extracting with the concepts of symmetry, harmony, rhythm, balance, order, and measure (Ching, 1996). Architectural forms were classified as “regular and irregular forms” based on these geometric principles, and this classification is widely used (Ching, 1996). According to Ching, regular forms are coherent and related, often symmetrical around one or more axes. Sphere, cylinder, cone, cube, and pyramid are regular forms. Irregular forms are forms whose parts are inconsistent with each other. They can be formed by subtracting irregular elements from regular forms or irregular combinations of regular forms (Ching, 1996)

Today, CAD geometries (The “rubber-sheet” geometry afforded by NURBS and meshes) are used in form-finding and construction processes (Figure 2.17) (Dunn, 2012).

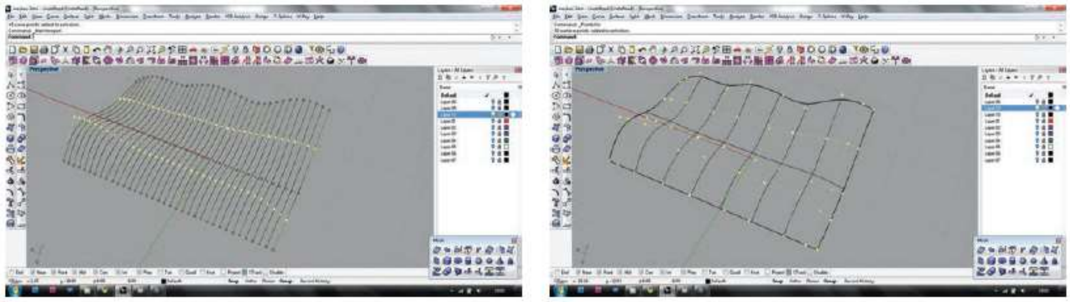

Figure 2.17: NURBS surface created with control points (Dunn, 2012)

Most form-finding systems in digital tools do not work with the principle of "primary forms and their combination." İt is possible today to design a form in which all conventional geometric relations are established with computers, using cumulative architectural knowledge and arrangement, but it is also possible to rethink and rediscover this architectural knowledge. Therefore, while creating forms digitally, decomposition, deformation, or dispersion methods are preferred rather than principles such as order, symmetry, and proportion (Rubinowicz, 2014) or high-level abstractions and nested relations systems are more important than the order and harmony of particular objects (Terzidis, 2003) (Figure 2.18).

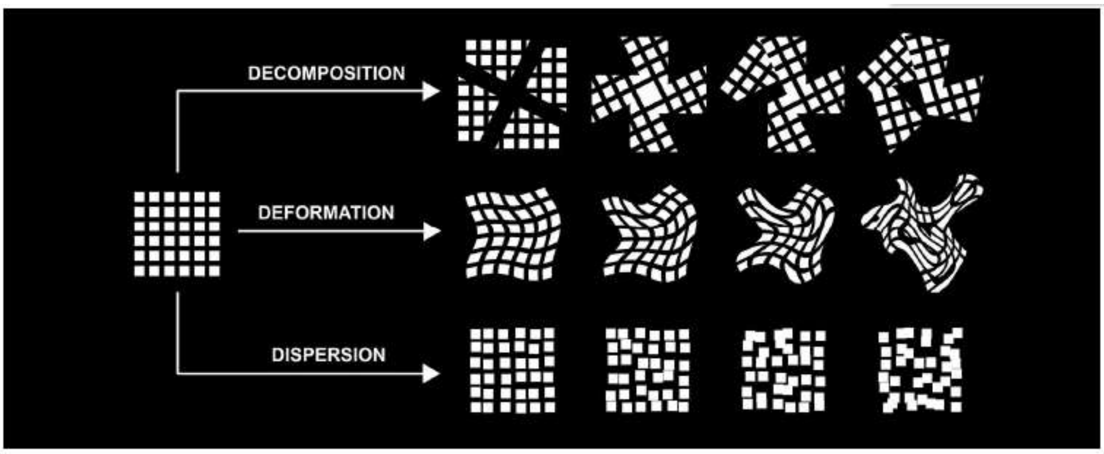

Figure 3.18: Schemes presenting methods of decomposition, deformation, and dispersion (Rubinowicz, 2014)

The system, which was used in the past and was based on the proportions in the plan and section drawings, and on descriptive or euclidean geometries, today left its place to associative, topological geometric relations (Kolarevic, 2003).

When geometry is discussed in the scope of curvature, approximations using tangent and straight-line segments were used to create curvilinear forms before digitalization. According to Greg Lynn (1999), understanding topological geometry in these pre-digital curvilinear forms was misunderstood and contained different geometric relationships from today's curvilinear buildings. Most of the pre-digital examples included discrete geometry relationships of radial elements of various sizes. In other words, curvature was provided by a polycentric system with the combination of various radial elements and segments of them. The relationships between these radial elements were often based on intersections, tangent, and symmetry rules (Figure 2.19) (Lynn, 1999).

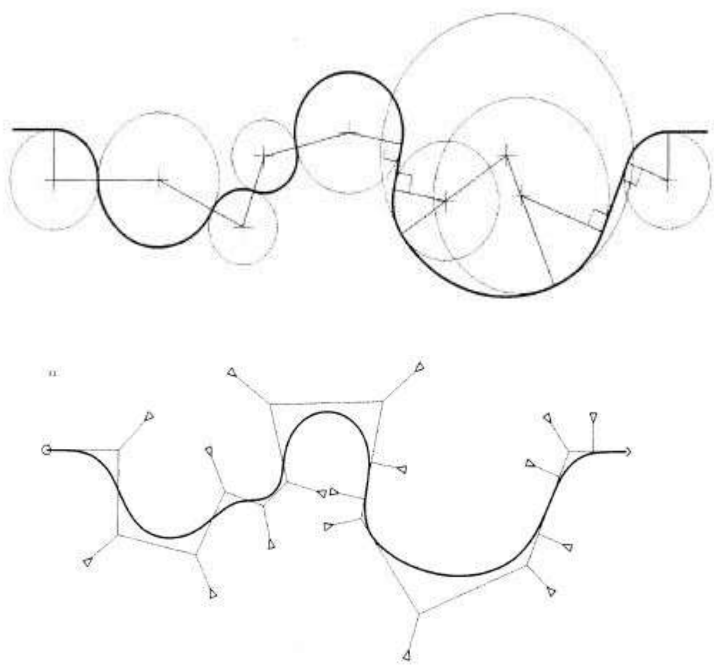

Figure 2.19: (Above) Curves defined by fixed radius and tangency (Below) Similar curve defined by digital geometry (Lynn, 1999)

Curvilinear forms created with today's technologies, on the other hand, are designed and produced through different units such as "NURBS," "Bezier curve," "B - Spline," rather than through primary forms and their relationships. "NURBS (Non-Uniform Rational B Splines)" allows forms to be more fluid and smooth. In NURBS, the curvature is achieved by adjusting various "points," "weights," and "knots." (Dunn, 2012). NURBS is a topological model that uses geometries such as the Bezier curve and B-spline (basis spline) to create curvilinear forms. Bezier curve provides control of curvature with two points defined on its own. The B-spline controls the curvature with points defined externally. However, only NURBS can be used to control and combine curvatures in various directions, sizes and degrees. Primary curvilinear forms such as cylinders can also be designed efficiently (Hopkins, 2006). According to Kolarevic (2003), NURBS can be thought of as flexible strips of plastic and metal fixed in place. It is as if some weights are hung on these strips to achieve the desired softness of form. NURBS enables designers to design curvilinear forms smoothly and without complex calculations. Typically, Leibniz's differential calculus calculations are required to calculate such curvilinear forms. Tools like adjustable triangles and compasses in history were used to make these algebra calculations, but now even the most straightforward CAD programs can quickly solve these complex calculus problems (Lynn, 1999). Architects do not have to make these complex geometric calculations; instead, computers make these computations (Chiarella, 2004). In addition, thanks to NURBS, the information of form can be transferred to the CNC machine, and production can be achieved easily too (Dunn, 2012).

With the possibilities provided by digitalization, designers did not adhere to the conventional rules accepted before and tried new and avant-garde methods and geometric relationships. That is why it is clear that the standard classification of

Ching (1996) is insufficient to explain the forms created with the help of today's digitalization. For this reason, digital forms should be better defined, and new methods of derivation and generation should be examined (Terzidis, 2003). In the following chapters, these form generation and derivation methods will be discussed in more detail.

2.2.2. Curvilinear Form before and after Digitalization

It is generally known that the assumption that curvilinear forms emerged with digitalization is incorrect. Both primitive and complex examples of curvilinear forms are also encountered in pre-digitalization periods. However, as the digital age provides convenience in these forms, it removes some of the limitations of the designers, which led them to try different forms. This chapter will discuss the design, construction, and production of curvilinear forms before and after using computer technologies.

The early examples of curvilinear forms in architecture have existed since the beginning of building shelters, and there are buildings with curvilinear forms due to the structural and constructional understanding coming from nature in vernacular architecture examples (Figure 2.20).

Figure 2.20: (Left) Traditional Igloo Houses (https://www.bibalex.org/SCIplanet/en/Article/Details?id=13527), (Right) Traditional Zulu Beehive Huts (https://africa.quora.com/Traditional-Zulu-Beehive-Huts-South-Africa)

The structural advantages of the curvilinear form have been discovered and used from ancient times. These structures were preferably used in religious places and areas where wide-spanning was desired to symbolize infinity (Bardzinska-Bonenberg, 2016). For instance, in the Roman Period, Pantheon with its 43.2 m span and in Byzantine Period, Hagia Sophia or Brunelleschi’s Florence Cathedral in the Renaissance era were the best uses of these forms of their era such as domes, arches, and vaults (Middendorf,2001) (Figure 2.21).

Figure 2.21: (Left) Roman Pantheon, 126-128 A.D. (https://www.archdaily.com/802201/ad-classics-roman-pantheon-emperor-hadrian/585d498fe58ece636c00002f-ad-classics-roman-pantheon-emperor-hadrian-image), (Middle)Hagia Sophia, 537 (https://www.nationalgeographic.com/history/article/hagia-sophia-stripped-museum-status-paving-way-mosque), (Right) Florence Cathedral ,1436 (http://www.museumsinflorence.com/musei/cathedral_of_florence.html)

In the Baroque and Rococo periods, architects tried to go beyond the Cartesian grids (Kolarevic, 2003). Curvilinear forms were used not only in the load-bearing elements but also in the facades turned into a folding form both in plan and section (Çıngı, 2007) (Figure 2.22).

Figure 2.22: (Left) Melk Abbey, Germany, 1089 (https://www.freud.org.uk/event/lacan-deleuze-and-the-baroque/), (Right) The Basilica della Collegiata, Sicily, 1768 (https://www.wondersofsicily.com/sicily-baroque.htm)

Then, in the 1920s, with the short Art Nouveau period, organic, biomorphic, and fluid forms that mimicked nature took their place in building forms (Figure 2.23).

Figure 2.23: (Left) Stairway of the Hôtel Tassel, 1892 (https://www.britannica.com/place/Hotel-Tassel), (Right) Casa Milà, 1912 (https://www.arkitektuel.com/casa-mila/)

In this period, Gaudi's approach to curvature can be distinguished. Gaudi was one of the names who used curvilinear forms best in spatial and structural organization and on the facade. He recommended many sophisticated design methodologies for the curvilinear forms to build (Barrios Hernandez, 2006). Gaudi used different geometrical relations and, depending on these, different methodologies to construct and design curvilinear forms. He used 1:10 or 1:25 scale 3D plaster models or hanging models with strings and chains during the design process (Burry, 2002) (Figure 2.24).

Figure 2.24: 1:10 hanging model for the Colònia Güell Chapel, Antoni Gaudí (Burry, 2016).

Later, in the 1960s and 1970s, some architects and engineers such as Heinz Isler or Frei Otto worked with Gaudi-like form-finding methods and made many experimental free-form designs. Frei Otto worked with soap bubbles to understand how objects change forms under natural factors and forces. Otto also worked on the possibility of creating curvilinear forms in other ways. He obtained curvilinear forms with lightweight tensile and membrane structures conducting with soap bubble experiments (Figure 2.25) Additionally, Isler created the forms by hanging the wet fabric freely and then folded the edges based on his own experience to increase the stiffness of the shell. He also hardened the models by freezing them outdoors in cold weather or adding a cement mixture. Finally, he managed to obtain the optimum geometry (Figure 2.25). These examples were all for the effort to obtain efficient curvilinear forms.

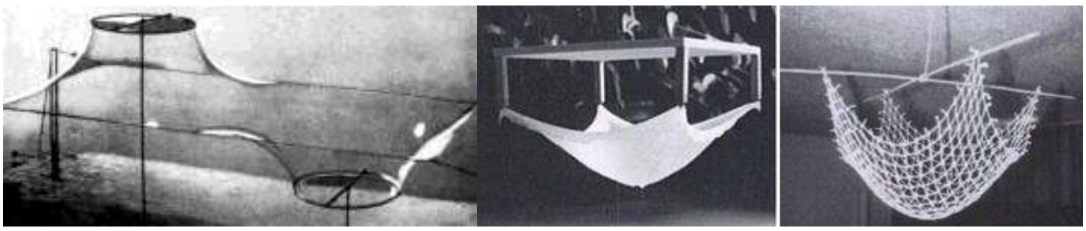

Figure 2.25: (Left) Frei Otto Experimenting with Soap Bubbles (https://www.researchgate.net/figure/Frei-Otto-Experimenting-with-Soap-Bubbles_fig2_318103333), (Right) Heinz Isler hanging Models (https://www.researchgate.net/profile/Jorge-Fernandes-3/publication/311321180/figure/fig5/AS:668461428654080@1536385032019/Heinz-Isler-hanging-Models-7.jpg)

In this period, names such as Felix Candela, Eladio Dieste, Eduardo Torroja, Pier Luigi Nervi worked on minimal curves and organic forms based on the mathematically precise, optimal loadbearing hyperbolic paraboloid shapes. They pushed the limits of how much span could be created with minimum shell thickness with the advent of prestressed concrete. The advantage of the geometric shapes were the formwork manufacturing.

In the modernist period, with standardization and uniformity, more rectilinear and static forms were common, but many modernist architects such as Le Corbusier, Eero Saarinen, Jorn Utzon, Alvar Aalto were also interested in curvilinear forms (Figure 2.26).

Figure 2.26: (Left) Notre Dame du Haut Ronchamp, Le Corbusier, 1954 (https://www.arkitektuel.com/ronchamp/), (Right) TWA Flight Center, Eero Saarinen, 1956 (https://www.dezeen.com/2019/02/17/twa-hotel-eero-saarinen-jfk-airport-new-york-city/)

Before digital tools, curvilinear building designs were based on physical models or geometric construction principles, and the design and construction processes were separate. Most of the time, manual methods such as compasses, curved plastic aids (French curves), pencils attached to ropes, and clay models were used as tools to obtain the forms, and therefore it was hard to exceed a certain level of complexity curvilinear forms. Names like Gaudi and Otto were looking for ways to create forms experimentally. Lastly, the time and economy of constructing these curvilinear forms were mainly higher than the conventional rectilinear ones. Still, despite the intricate design and construction conditions, curvilinear forms were being built because, first of all, these curvilinear forms had the structural strength to provide maximum spans with minimum load-bearing elements. For this purpose, many architects such as

Gaudi, Isler, Otto, and Nervi worked especially on curvature. Secondly, apart from its advantage for structural optimization, the curvature is considered sacred in many cultures and perceived as a symbol of power.

Nowadays, digitalization processes have made the construction and design of curvilinear forms both faster and more economical and encouraged architects to exceed the limits in this regard because digital design knowledge also includes digital manufacturing knowledge, thus removing costly and lengthy steps in the production and construction phases. Today, CAM technologies have also developed besides CAD. Various fabrication technologies exist now, classified as CNC cutting, subtractive, additive, or formative (Kolarevic, 2003). These CAM technologies are widely available and have been extensively used on several recently completed projects worldwide. For instance, for the construction of the curvilinear form of the Heydar Aliyev Centre, a total of almost 17,000 individual panels with different geometries were required. While it would take too much time and effort to produce these panels manually, these panels were cut with CNC cutting machines, and an unconventional structural solution was proposed thanks to digital tools (Figure 2.27).

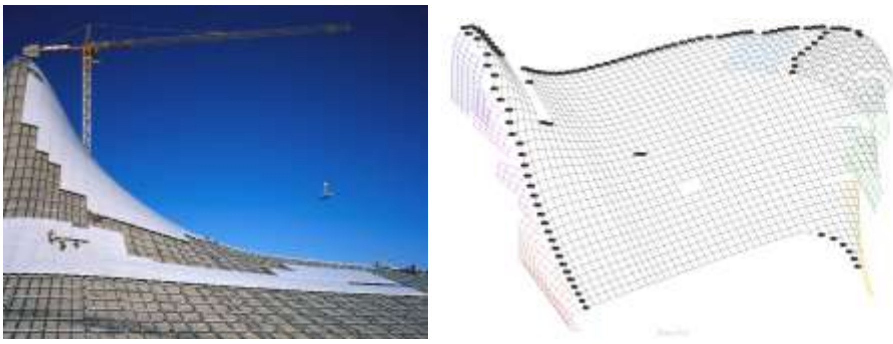

Figure 2.27: Construction of Haydar Aliyev Centre’s panels, Zaha Hadid Partners, 2013 (https://www.rok-office.com/projects/1000-haider-aliyev-cultural-centre/)

Likewise, various double-curved surfaces were proposed for BMW Pavilion, and CNC machines produced these glass panels (Figure 2.28).

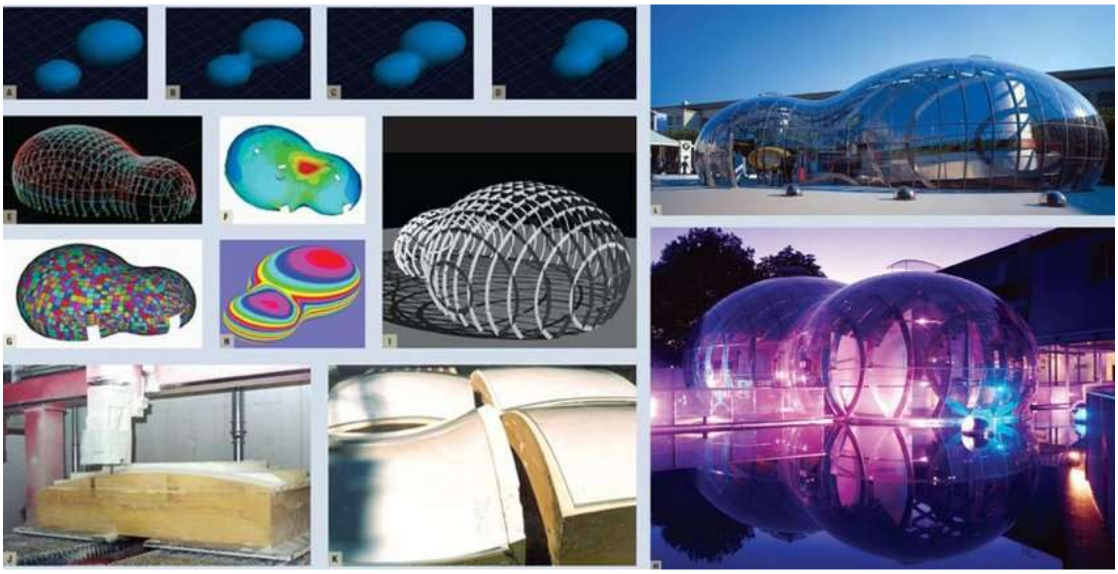

Figure 2.28: Construction of BMW Bubble pavilion, Franken Architecten (https://www.researchgate.net/figure/BMW-Bubble-pavilion-by-Franken-Architects-18_fig5_334469158)

“Digital practices have the potential to narrow the gap between representation and building, affording a hypothetically seamless connection between designing and making.” (Iwamoto, 2009). For this reason, curvilinear forms are used more frequently, but their effect on the user is still uncertain. It is evident that digital curvatures are different from traditional curvilinear.

2.2.3. Digital Form Generation and Derivation Methods

The digitalization process is mentioned chronologically before, but the forms are not analyzed in detail. For this reason, in this section, the forms used in the digital era are classified and analyzed in detail. Building forms designed in the visual stimuli for this study to which the participants gave emotional responses was determined by this analysis.

It is hard to describe the post-digitalization architectural forms with the old conventional form classifications because of an entirely different geometric infrastructure. The use of computers in architecture provides architects to research novel forms. For this reason, a new form classification should be conducted (Terzidis, 2003). It is vital to classify digital forms for this study because defining and distinguishing forms in digitalization processes will be helpful in the method of the thesis. Here, it can be said that it is possible to create rectilinear forms within these classifications, but it should be taken into account that there is an emphasis on curvature for this thesis and these digital form classifications are mostly for classifying digital curvilinear forms.

There are two standard classifications of digital forms in the literature that are related to this study. The first is Terzidis's, and the second is Kolarevic's (Table 2.2). There are some similarities and differences between these two classifications.

Table 2.2: Digital Form Classifications

		Keywords
Kostas Terzidis (2003) Digital Form Classification	Caricature Form	exaggeration and deformation
	Hybrid Form	morphing
	Kinetic Form	motion
	(Un)folding Form	self-referential
	Warped Eye	deforming the viewpoints
	Algorithmic Form	the computational procedure, coding
Branko Kolarevic (2000) Digital Form Classification	Topological Architecture	no tearing or addition, transformation
	Isomorphic Architecture	amorphous assemblages of parametric blobs
	Animate architectures	motion and forces
	Metamorphic architecture	metamorphosis, deformation
	Parametric architecture	parameter, coding
	Evolutionary architecture	evolution, genetic code, pseudo-organisms

Kostas Terzidis divided digital forms into six groups, as seen from the table, and the first is “Caricature form.” Caricature form can be described as intentional exaggeration and deformation of a form. For example, Gehry's "Dancing House" project was designed with a caricature and exaggeration of the dance action of two dancers. (Figure 2.29) Since no exaggeration is aimed at the building cases prepared for this study, this form type was not used in this study.

Figure 2.29: Two dancers’ inspiration for Frank Gehry’s Dancing House
(https://2formstudio.blogspot.com/2013/03/dance-in-architecture.html)

The second form type of Terzidis is the “Hybrid form.” The method used to create the hybrid form is "morphing," Morphing ends with a change in the appearance, character, condition, and function of a form. This form’s hybridity does not stem from the combination of two or more entities. Theoretically, hybrid form is the combination of the characters of the same form in various phases. It is “about a particular moment in time when the past and the future overlap within the same form”. Since various phases of any deformation are not used in the building cases of this thesis, it can be said that this form group is not used.

The third form of Terzidis is the “Kinetic Form.” Kinetics is a term often associated with motion. Motion is expressed as position or displacement over time. This term can be perceived as the motion of the form with the environmental forces and their effect. The aim is to describe motion with a stationary building (Figure 2.30). This method is also not one of the methods used to create building cases of the study.

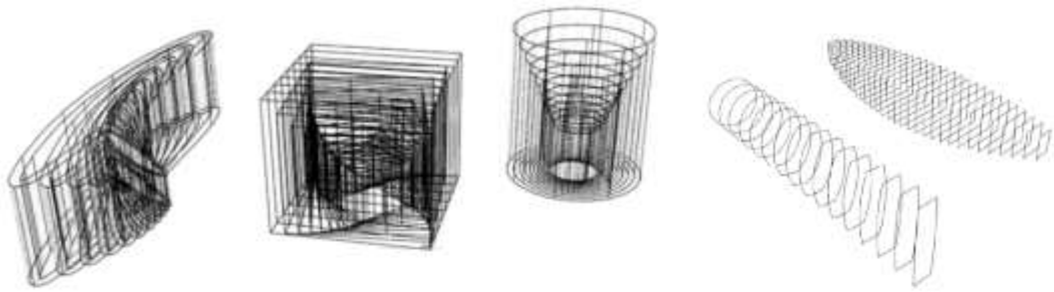

Figure 2.30: Some methods of expressing motion in form (Left) Superimposition (Right) Sequential juxtaposition (Terzidis, 2003)

The fourth digital form type of Terzidis is “(Un) Folding Form.” Folding is a “self-referential” state in which one part is laid onto another, with no elements added or removed. Folding allows the object to pass from one dimension to another without breaking the topology. Unfolding, on the other hand, can be viewed as the reverse process of folding. Folding cannot be an endless process, but many forms can be produced with the cooperation and balance of folding and its opposite, unfolding. The study's building cases are not created via folding method.

The other form type of Terzidis is “Warped Eye.” These forms can be produced in the physical environment by deforming the viewpoints. That is, warped eye form can be produced with hyperbolic transformations and distortions of Euclidean forms. (Figure 2.31). This form type is also not one of the approaches utilized to produce the study's building cases.

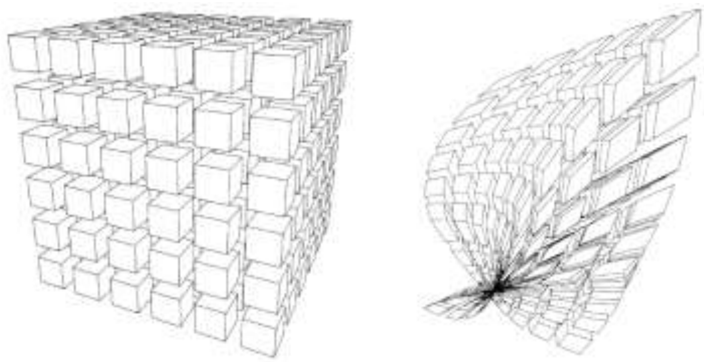

Figure 2.31: (Left) Euclidean form, (Right) Warped form (Terzidis, 2003)

The last form in Terzidis' classification is “Algorithmic Form.” The algorithm is a computational procedure and can solve a problem in many steps. It is a method of deriving logical principles and includes a high level of abstraction. Creating the form algorithmically destroys individuality and offers a rational, consistent, and systematic solution depending on efficiency, speed, and generality. The algorithmic process can also be unpredictable.

The second classification system for the digital forms is what Kolarevic proposed (2000). He focused on various form generation techniques used in digital environments. Kolarevic (2000) has grouped this architectural classification under six headings in the context of form generation.

The first group is “Topological Architecture.” Topology is a branch of mathematics in which two objects are considered equal when they are continually converted to each other. Topological transformation is created by bending, twisting, stretching, and shrinking operations, and there is absolutely no tearing or addition of external parts in this process (Figure 2.32) (Carlson, 2017). Topological forms are not utilized when creating building cases for the study.

Figure 2.32: Topological transformation of doughnut and teacup
(https://cems.riken.jp/en/laboratory/qmtrt)

The second of Kolarevic's classification is "Isomorphic Form." Combined amorphous assemblages of parametric blobs and metaballs inflected by their mutual internal forces can be called isomorphic surfaces. These surfaces have regions of influence that can be additive or subtractive. This ensures that new and various forms are constantly produced by various regional influences and the intensity of blobs and metaballs (Figure 2.33). Isomorphic forms were not included in the preparation of building cases too for this study.

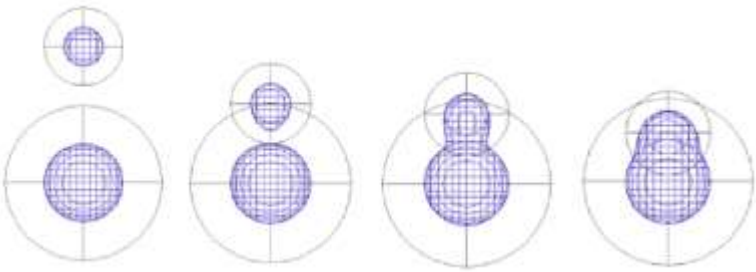

Figure 2.33: Isomorphic surface generation (Kolarevic, 2000)

Cardiff Bay Opera House by Greg Lynn in 1994, BMW-Pavilion by Bernhard Franken in 1999 and, Kunsthaus Graz by Colin Fournier and Peter Cook in 2003 can be accepted as examples and pioneering of isomorphic architecture (Figure 2.34)

Figure 2.34: (Left) Cardiff Bay Opera House Greg Lynn, 1994 (Kolarevic, 2000), (Middle) BMW-Pavilion Bernhard Franken 1999, (Right) Kunsthaus Graz, Colin Fournier, and Peter Cook, 2003 (https://www.museum-joanneum.at/kunsthaus-graz/architektur)

The third form of Kolarevic is the “Animate Form.” The concept of animate architectures first became popular when Greg Lynn (1999) suggested that the animation technique could be used not only as a representation tool but also for form derivation. Lynn’s House Prototype project in Long Island and his Authority Bus Terminal project in New York can be fine examples for this approach (Figure 2.35). In these projects, Lynn (1999) experienced the motion of an object or the hierarchical system of objects under various environmental forces by using animation techniques such as keyframe animation, forward and inverse kinematics, dynamics (force fields) and particle emission, and the shape of all surfaces was designed with efficiency to work with these forces (Figure 2.35).

Figure 2.35: Lynn’s Port Authority Bus Terminal in New York (Kolarevic, 2000)

The fourth form of Kolarevic is the “Metamorphic Architecture.” Metamorphosis means "a striking alteration in appearance, character, or circumstances" (Merriam-Webster n.d.). Metamorphism is a word of biological origin and can be expressed in architecture as the transformation of an object into another object by being deformed. Metamorphic form generation can be achieved by key shape animation, a bounding box (lattice deformation), a spline curve, or deformations of the modeling area around the model using one of the coordinate system axis or planes. In bounding box deformations, objects are considered in a virtual cage defined by points, and the form is deformed by changes made in this cage. With this method, the form change is simulated under a homogeneous, artificial force applied from the outside (Figure 2.36). In the stages of deriving the forms of the building cases used in this study, bounding box deformations were used, so it can be said that buildings with metamorphic forms were used in this study.

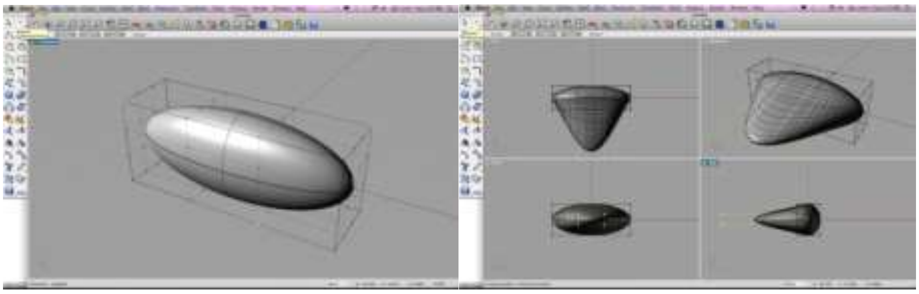

Figure 2.36: Bounding box deformations in Rhino (https://www.instructables.com/How-to-Cage-Edit-Objects-in-Rhino-3D/)

The fifth form of Kolarevic’s (2000) classification is the “Parametric Architecture.” The parameter can be defined as "an arbitrary constant whose value characterizes a member of a system"(Merriam-Webster n.d.). In architecture, parametric design is an algorithmic process in which rules and parameters that defines the relationships between design intent and design response are defined and coded (Jabi, 2013).

Different objects or combinations can be easily created in parametric design by assigning different values to different parameters and diversifying their relationships. The parameters and their networks are parametric; the designer does not design the exact form but decides on the parameters and their relationships (Burry 1999). In this thesis, some building cases were produced with various parameters and relations, so parametric forms were used.

“Evolutionary architecture” is the last form of Kolarevic’s (2000) classification. Just as genetic codes are constantly designed to create the best prototype depending on external factors in the evolutionary process, a genetic code can be created, tested, and improved with the help of computers in the same way in architecture. Many "pseudo-organisms" are created in these processes, and a "fittest" design is selected according to the design problem determined at the beginning. In other words, evolutionary design is a set of processes in which the design is constantly iterated and improved (Figure 2.37) (Frazer 1995). The critical thing in evolutionary design is to establish the coding logic correctly.

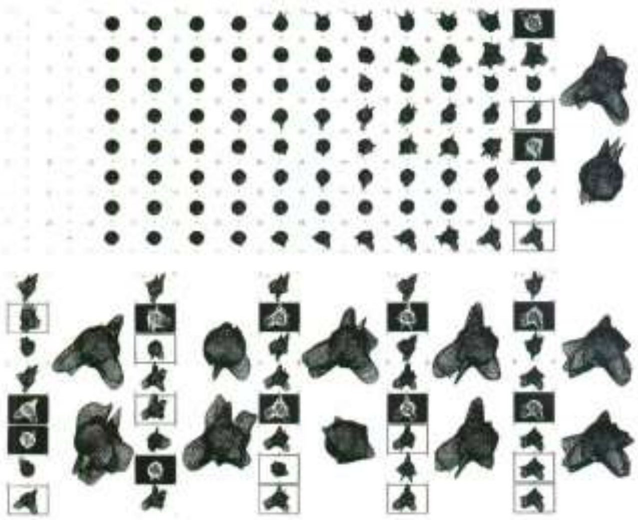

Figure 2.37: Evolutionary processes for form optimization, Universal Interactor at the Architectural Association, John Frazer, 1995 (Daly, 2004)

There are some common points in the classifications of Kolarevic and Terzidis. Deformation is emphasized in Terzidis's "caricature form" group and Kolarevic's "metamorphic architecture." It is the deformation and transformation of one form into another completely. In this sense, the two groups are similar, but Terzidis also emphasizes exaggeration in the "caricature form." While Terzidis's deformation highlights the characteristics of an existing form, it is not the same in Kolarevic’s metamorphic architecture. Another similarity between these classifications can be claimed to be between "topologic architecture" and "hybrid form." In both of these groups, there is a transformation of an initial form without addition and subtraction. However, while the hybrid form expresses a phase between the initial and the target form, it is unclear where the transformation will end in the topological architecture. A complete transformation can also be accomplished in the topological process. Also, parametric architecture and algorithmic architecture are sometimes confused with each other. In both systems, the design problem is solved by considering various components and correlations during the design process. While the algorithm is based on the use of "code," the parameter is based on manipulating "form." What makes the difference between these two design styles is whether the program used is graphic-based or not. Program plug-ins like Rhino Grasshopper are graphics-based, relationships are defined graphically instead of scripting, and the program instantly creates the 3D object. Programs such as Rhino (RhinoScript), Maya (MelScript), 3dsMax (MaxScript) require the designer to use a computer scripting language (Leach, 2014).

Some relationships can also be established between these form classifications and the digitalization periods mentioned before, because some characteristics of these forms are similar to those in specific periods. In the first period of digitalization, it was not possible to talk about a project constructed in the real environment as a product of digitalization; however, in the second stage, there was manipulation and deformation of the forms in the computer environment without computational approach; in the third stage, coding and algorithmic processes came into play. In this context, when the form classifications are examined, Terzidis's "caricature, hybrid, kinetic, (un)folding and warped eye forms" can be considered within the “computer-aided drawing and manipulation period.” Likewise, Kolarevic's "topological, isomorphic, animate, and metamorphic architectures" can also be included in this period because, methodically, in the design of each of these forms, computers do all the calculations, and architects focus on form, not computational features. On the other hand, it is possible to accept Terzidis's "algorithmic form" and Kolarevic's "parametric and evolutionary architectures" within the "computer-aided computational design period" because each of these methods is computational methods and the designer’s focus is on parameters or codes, not the form directly during the design process.

The metamorphic and parametric forms that belong to these classifications and form derivation techniques were used in this study’s method. While creating the building cases used for the method, selections were made between these methods, considering the feasibility and technical knowledge. This chapter formed the theoretical infrastructure of the method part of this thesis.

CHAPTER 3

EMOTION AND ENVIRONMENT

Users are in a relationship with the environment they are in and it is known that this relationship arouses some emotions on the user. For this reason, the relationship between the environment and the user is a subject worth examining. It is necessary to define the environment first to understand the interrelationship between human and the environment. According to the Merriam-Webster dictionary, the environment is all the external conditions and factors that affect the life and development of an organism (Merriam-Webster n.d.). Researchers often classify environment as either the physical and social environment or the artificial and natural environment. The environment mentioned in this study is the artificial yet the physical one. However, the definition is still very comprehensive for this study. Throughout this work the environment has been reduced to building forms, and other environmental factors are kept constant.

The environment and people are in an interrelation. In this type of relationship, people shape their environment, which influences people's attitudes, behaviors, and emotions (Gifford, 2014; Mehrabian and Russell, 1974). The relationship between humans and the environment is also a comprehensive, multifaceted and multi-layered subject that this thesis cannot fully cover. The nature of this relation has been studied by many researchers in many contexts and scales. Merlau-Ponty (2002) views human interaction with the environment as the human body's experience with static space, with a particular focus on the body. On the other hand, Pallasma (1996) theorizes this interaction by focusing more on the senses and providing perception and experience. Moreover, environmental psychologists have included and examined concepts such as perception, cognition, territoriality, way-finding, legibility, personal space, place attachment, identity, affordances, personality, behavior, etc., into this relationship.

Additionally, researchers investigated the effect of artifacts such as color, texture, shape, etc., and their relation to user. In this thesis, the focus is not on people's perception processes of the place, their experiences or behaviors, but directly on individuals' assessments, emotional responses, and their correlation with building form.

The digitalization processes in architecture cannot be separated from the building form- emotional response relations because the use of computers in architecture has led to rediscovering and even pushing the limits of traditional form-finding techniques, which resulted in avoiding the singularity of traditional, rigid forms and moving to more curvilinear, non-standard and dynamic forms. This situation offers users a new environment. However, due to the mechanical nature of computational design tools, digitalization processes and digital forms are sometimes perceived as non-human, distant, and dull (Terzidis, 2003). Such a design model based on mechanics, mathematics, and physics is considered problematic because the form is not just an abstract entity with specific geometric properties (Terzidis, 2003). Architectural form is shaped with people and gains a meaning (May 1990).

For this reason, it is inaccurate to consider architecture as an object separate from people because "place" includes tangible features such as material, form, texture, and color on one hand, and on the other intangible cultural and human components created by man over time (Lefebvre, 1991). According to Canter (1997), space is an entity where activities and physical form are combined and experienced. On the contrary, the environment also affects people's feelings and behaviors (Mehrabian and Russell, 1974). For this reason, a designer must know the impact of the environment and its components on the human emotional responses to provide a satisfying architecture to the user.

In this chapter, the process of environmental assessment and the factors affecting this process will be discussed first. Then, the relationship between architectural building form and emotional and formal assessment will be mentioned. Finally, emotion and the measurement of emotional state will be discussed.

3.1. Assessment of the Environment

According to Lang (1987), the perception of space consists of two stages: sensory and mental. When a person encounters the space, he/she acquires information through senses, and then combines the information obtained from the senses with past experiences and emotions in mind. As a result of this process, he/she assesses the place (Lang, 1987). There are some models in the literature on the factors affecting the environmental assessment process.

Hershberger and Cass (1988) claimed that two factors, utility evaluative and aesthetic evaluative, are influential in the evaluation process of space. This dual model is seen as one of the models for assessing the environment. On the other hand, Rafaeli and Vilnai-Yavetz (2004) offered an alternative proposal. According to them, the "instrumentality, aesthetics, and symbolism" dimensions of artifacts are taken into account by the user during the process. Moreover, evaluating instrumentality is a hygienic process. Aesthetic evaluation is a sensory process, and symbolization contains an associative process. As a result of these three evaluation scales, the person evaluates the environment, creating an emotional state and response (Figure 3.1) (Rafaeli and Vilnai-Yavetz, 2004).

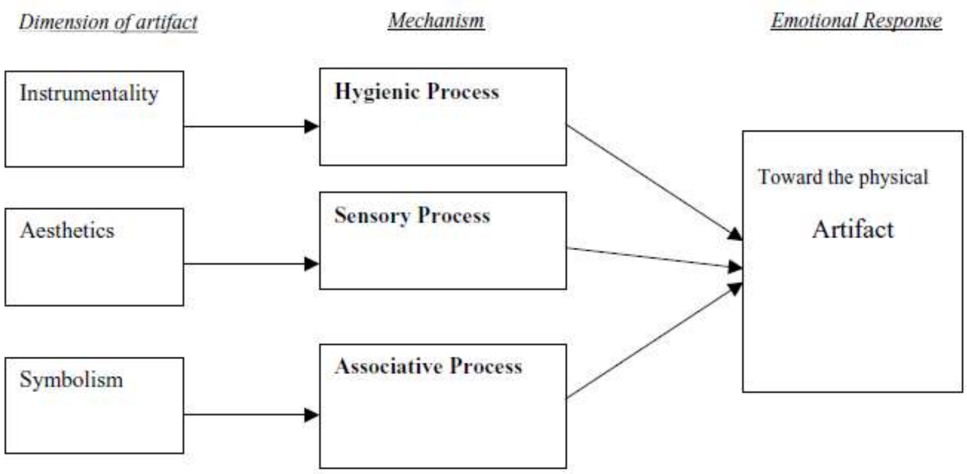

Figure 3.1: Model of the impact of physical artifacts on emotions (Rafaeli and Vilnai-Yavetz, 2004)

Another model is; Desmet and Hekkert's (2007) theory on the user's product experience commonly used as a source in environmental psychology studies. Desmet and Hekkert (2007) argue that the product assessment depends on the degree of satisfaction of the users' senses (aesthetic experience), the meanings that users attribute (experience of the meaning), and emotions (emotional experience) (Figure 3.2).

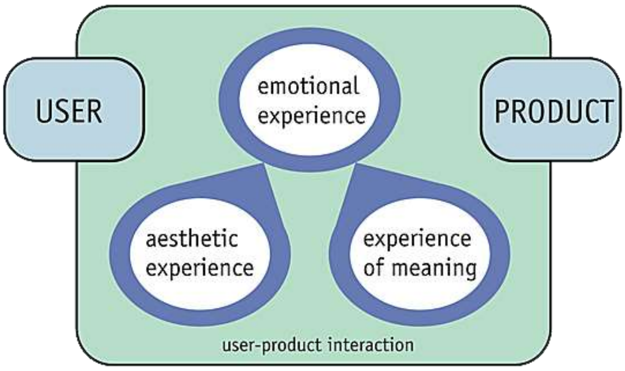

Figure 3.2: Framework of product assessment (Desmet and Hekkert, 2007)

It can be said that based on these studies, utility, aesthetic and symbolic factors are influential in environmental assessments. In this thesis, the focus is on formal assessment, which is the part of the aesthetic assessment, not utility and symbolic ones, because it is a process in which formal features are also evaluated (Lang, 1987). In addition, the aesthetic factor is significant in environmental assessments, and it ends with an emotional response (Rafaeli and Vilnai-Yavetz, 2004).

3.1.1. Assessment of Aesthetic Factor

One of the critical factors in people's evaluation of the environment is aesthetics, and studies usually agree on two components in evaluating environmental aesthetics: "formal and symbolic or associational" (Nasar ed., 1988).

According to Nasar (1988), people focus on the properties of the objects such as "size, shape, color, complexity, etc..." for formal evaluation, which is one of the conditions of aesthetic evaluation. The symbolic evaluation factor produces connotations by focusing on what the object implies (Nasar ed., 1988). The different reactions given when looking at a real and an artificial flower can be an example of this situation. Although they have precisely the same features in form and appearance, being artificial or natural causes different meanings to be attributed to flowers and affects the evaluation (Nasar ed., 1988).

In addıtion, an evolutionary background may explain individuals' positive or negative responses and preferences to aesthetic factors. For example, the fact that a place provides a clear view or a place to take shelter affects the assessments positively because it allows for survival. Such physical factors affect the aesthetic assessment of the environment mentally and symbolically (Appleton, 1988; Kaplan, 1988).

According to Lang (1987), to analyze aesthetic experience, it is necessary to separate individuals' "sensory, formal and symbolic" interactions with their environment. Sensory aesthetics are influenced by the colors, odors, sounds, and textures of the environment. Formal aesthetics is the evaluation of features of the environment such as visual rhythm, shape, and complexity. Symbolic aesthetics is the evaluation of the implications of the physical environment. For example, in some cultures, shapes like a circle, rectangle, or patterns, such as symmetry, contain associational meanings.

In summary, aesthetic assessment is a situation where senses, physical environment, and features, symbolic meanings are combined and result in various emotions. The formal characteristics of an environment play an essential role in its aesthetic assessment.

3.1.2. Assessment of Rectilinear and Curvilinear

Formal properties have a significant place for aesthetic assessment processes. The form contains the physical properties of objects such as shape, size, color, texture, position, orientation (Ching, 1996). This study focuses on building forms' rectilinear or curvilinear characteristics, and other features are kept constant. The curvature mentioned here is a novel curvature created by digital design methods mentioned before in Chapter 2.

There are many studies on the effect of curvilinear or rectilinear architectural forms on people. For example, an experiment on 112 male infants aged ten months found that infants show different interest levels in various levels of curvature. It was observed that the most striking of the 3-dimensional orange wooden line pieces shown to the babies was the most curved piece (Figure 3.3) (Hopkins, 1976).

Radius (Inches)	Inverse of Radius	Median Adult Judgment*
3*	.33	0.00
4	.25	1.75
4½*	.22	2.25
6	.16	3.00
7½	.13	3.00
9*	.11	4.75
12	.08	5.25
Straight line*	.00	7.50

Figure 3.3: (Left) Line drawing of 4 stimuli, (Right) Judgement levels of line segments (Desmet and Hekkert, 2007)

On the other hand, Lundholm (1941) statistically concludes that "beauty in a pure line is portrayed by characteristics like “unity of direction, continuity, the roundness of curves, and lack of angles" based on people's responses to drawings and paintings. Additionally, Küller (1980) noted that pleasure rates were higher in rounded architectural forms than rectilinear forms. Likewise, Hesselgren (1987) took the issue on an urban scale and found that a curved street was evaluated more favorably than a straight street. In addition, it has been determined that curvilinear forms evoke more positive emotions in the interior, both in the formation of the space and in the furniture forms, than rectilinear ones (Dazkir and Read 2012; Örer, 2016). In another study, Salingaros (1998) examined the forms in nature mathematically and found that curvilinear forms are perceived more comfortable in the subconscious because of their similarities with the forms in nature.

Most of the studies in the literature show that individuals' reactions and evaluations about curvilinear forms are more optimistic than rectilinear ones. For this reason, it is expected that the emotional responses to the curved digital forms will also be more favorable than rectilinear ones for this study.

3.1.3. Differences between the Assessments of Various User Groups

In the relationship between the environment and the user, defining the user is as important as defining the environment. Beyond all these forms of appraisals, it is clear that not all users evaluate the environment the same way, although researchers try to find commonalities. In this context, it is possible to come across studies comparing the evaluations of various user groups. However, comparisons between the evaluations of architects and non-architects are frequently encountered because it is an expected result that the architect who plays a role in the design of an environment and the people outside the profession perceive and evaluate this environment differently.

One of the first studies conducted between these two groups is Michelson's article "Most People Don't Want What Architects Want" (1968). The study is on an urban scale. According to these research findings, people prefer suburban life to residential styles of city centers. However, Michelson (1968) considers the history of urbanization as the opposite of this desire and highlights the gap between architects and laypeople. Likewise, when the semantic differential ratings of buildings of architects, pre-architects, and laypersons were compared, significant differences were found between architects and the other two groups, and the educational process can be considered as a factor in these differences (Hershberger, 1969). In addition, when

Devlin (1990) compared respondents' perceptions of the two Chicago office buildings, he found that while architects made abstract and conceptual evaluations, laypeople made affective and descriptive evaluations. Also, when Nasar asked architects to predict users 'evaluations, she found that architects were not successful in predicting users' tastes (Nasar, 1988).

Many studies on this subject agree that architects and non-architects make different evaluations, but some studies make similar evaluations (Hubbard, 1996; Stamps, 1993). In this study, the architect-non architect grouping is discussed from a broader perspective and focused on the architectural form evaluations of people who have or have not studied art, design or architecture, because it was predicted that the evaluations of these two groups of people might be different.

3.2. Emotion and Mehrabian and Russell PAD Model

In the previous sections, it has been mentioned that various factors affect environmental assessments and result in an emotional response. That is why it is critical to define, understand, and find methods for measuring emotion.

Emotion is an essential factor in people's environmental assessments (Russel, 1992). It dramatically affects people's approach to an object or environment. That is why emotions should be understood. Scherer (1987) defines emotion as;

> "Emotion is defined as an episode of interrelated, synchronized changes in the states of all or most of the five organismic subsystems in response to the evaluation of an external or internal stimulus event as relevant to major concerns of the organism."

Emotion has five components, which are cognitive component, neurophysiological component, motivational component, motor expression component, and subjective feeling component (Scherer, 2005). However, the number of emotions and their verbal expression has been considered a complex and problematic issue in the literature. However, some theoreticians consider some emotions such as anger, fear, joy, and sadness as "basic or modal emotions" (Scherer, 2005).

Since emotion is such a broad and obscure subject, its measurement is also complicated. Scherer (2005) claims that precise and multiple methods should be determined to measure emotion precisely and scientifically, all five subsystems and components should be considered during measurement;

> “In an ideal world of science, we would need to measure (1) the continuous changes in appraisal processes at all levels of central nervous system processing (i.e., the results of all of the appraisal checks, including their neural substrata), (2) the response patterns generated in the neuroendocrine, autonomic, and somatic nervous systems, (3) the motivational changes produced by the appraisal results, in particular action tendencies (including the neural signatures in the respective motor command circuits), (4) the patterns of facial and vocal expression as well as body movements, and (5) the nature of the subjectively experienced feeling state that reflects all of these component changes.”

Desmet (2010) also asserts that it is challenging to reduce emotion to a single phenomenon and claims that various expressive reactions should be focused on four measurements; "expressive reactions (e.g., smiling), physiological reactions (e.g., heart pounding), behavioral reactions (e.g., approaching), and subjective feelings (e.g., feeling happy).” When all these reactions are measured and compared, the result is entirely reliable, but it is necessary to be technically advanced and have complex and technological equipment for such a measurement. For this reason, subjective, verbal, or non-verbal evaluations of individuals can be used to measure emotions (Desmet, 2010). One of the most widely used models to measure emotion is Mehrabian and Russell's PAD scale.

The emotion model proposed by Mehrabian and Russell (1974) is widely used today as a reliable model in environmental psychology and marketing. According to this model, all stimuli are perceived emotionally and end with a behavior. The stimulus mentioned here is the physical environment and its components. For the emotional state, Mehrabian and Russell (1974) proposed three bipolar scales, abbreviated as PAD; “Pleasure (displeasure), Arousal (non-arousal), and Dominance (submissiveness).” The pleasure scale shows the respondent's level of happiness and satisfaction. Arousal measures the degree of environmental stimuli and how alert the respondent is in that environment. The dominance scale measures how much control an individual has in the environment or whether the environment suppresses him. Sixteen semantic antonyms adjective pairs are used to measure the levels of pleasure, arousal, and dominance by researchers (Table 3.1).

Table 3.1: Mehrabian and Russell adjective pairs

Pleasure	Happy - Unhappy Pleased - Annoyed Satisfied -Unsatisfied Contented - Melancholic Hopeful - Despairing Entertained - Bored
Arousal	Stimulated - Uninterested Excited - Calm Frienzied - Sluggish Dull - Jittery Wide awake - Sleepy Aroused - Unaroused
Dominance	Influencial - Influenced In control - Care for Dominant - Submissive Autonomous - Guided

Finally, according to these pleasure, arousal, and dominance rates, the person eventually displays "approach or avoidance" behavior (Figure 3.4). Some studies have found that the dominance scale is ineffective (Russell & Pratt, 1980; Donovan & Rossiter, 1982). Therefore, the dominance scale is ignored in some of the recent studies.

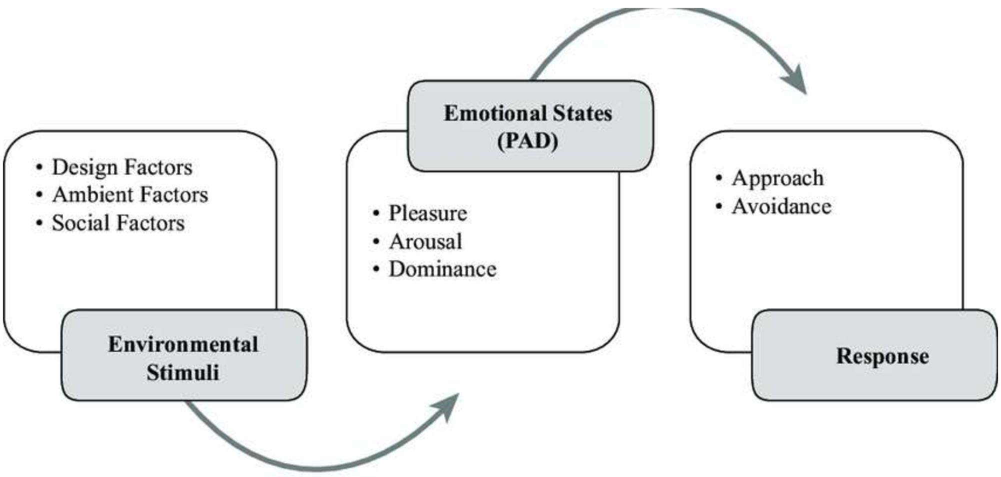

Figure 3.4: Mehrabian and Russell model (Kizito and Ngozi, 2017)

When this scale's pleasure and arousal scores are placed on a dimensional bipolar scale, some emotional evaluations emerge. For instance, the mood between aroused and unpleasant is "distressing." There is "exciting" between aroused and exciting, "gloomy" between unpleasant and sleepy, and "relaxing" between sleepy and pleasant. These variables falling in the following circular order around a perimeter: pleasant (0°), exciting (45°), arousing (90°), distressing (135°), unpleasant (180°), gloomy (225°), sleepy (270°), and relaxing (315°) (Figure 3.5) (Russell and Pratt, 1980).

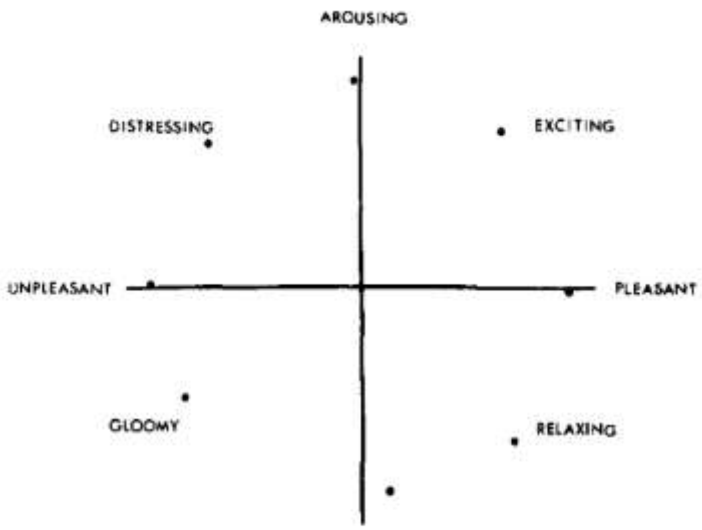

Figure 3.5: Dimensional bipolar scale of Russell and Pratt (1980)

In this study, Mehrabian and Russell's model was used to measure users' emotional responses about curvilinear forms after digitalization. Pleasure and arousal scales were included in the questionnaire. In addition, Russell and Pratt's rating scale was also used for analysis for the thesis.

CHAPTER 4

METHODOLOGY

The physical environment is changing with digitalization, and digital curvilinear forms in architecture come to the fore. Moreover, architectural form affects people's emotions and assessments of the environment. In order to observe the effect, in this study, primarily, this thesis studied the emotional responses and assessments of people against curvilinear architectural forms and rectilinear ones. Also, it is intended to observe the effects of the different methods of producing digital curved forms in users' responses on this subject. For this reason, visual stimuli with some architectural building forms were created digitally, and a questionnaire was conducted.

4.1. The Questionnaire

There are many ways to measure people's assessments of the environment, but a questionnaire that is a method based on subjective evaluations of individuals was found appropriate in this study. A questionnaire involving Mehrabian and Russell’s (1984) adjective pairs was conducted to measure participants' emotional responses.

In the introduction part of the survey, the users were informed that their information would only be used for this study, that their information would be kept confidential, and that the survey would take an average of 15-20 minutes (See Appendix A1-A2).

The questionnaire is composed of two parts in general terms. Questions about the demographic information of the users were included in the first section: some questions that measured users' evaluations and emotional responses for visual stimuli in the second part (See Appendix A1-A2).

In the demographic part, questions such as gender, age, and the subject of education were asked to participants. These questions were asked to determine the participant profile. The second part aimed to measure the emotional responses of respondents and their desire to be in these buildings. For this purpose, some of the PAD adjective pairs of Mehrabian and Russell were used. Twelve adjective pairs used for the pleasure and arousal scales were added to the survey for evaluation, but since some studies did not find the dominance scale very effective and the survey time wanted to be shortened, the dominance adjective pairs were removed from the questionnaire (Russell & Pratt, 1980; Donovan & Rossiter, 1982). For the Pleasure scale, adjective pairs "Unhappy – Happy, Annoyed – Pleased, Unsatisfied – Satisfied, Melancholic – Contented, Despairing – Hopeful and Bored – Entertained" are used, while for the arousal scale, "Uninterested – Stimulated, Calm – Excited, Sluggish – Frenzied, Jittery - Dull, Sleepy - Wide-awake, Unaroused – Aroused" adjective pairs were used. A 5-point Likert scale was used for evaluations between these adjectives in order for respondents to rate between these adjectives (See Appendix A1-A2).

Finally, the participants were asked whether they would like to be in these building forms or not (See Appendix A1-A2). This question aimed to analyze whether the building forms affect the users' desire to be in when they look outside. In addition, the correlation between pleasure, arousal scales, and desire to be or live in is aimed to measure.

4.2. The set-up of building cases

The primary aim of this thesis was to measure the participants' emotional responses to digitalized and curved forms. In order to make accurate measurements, it was decided to prepare visual stimuli containing building forms symbolizing the pre-and post-digital era for the participants. In Chapter 2, digitalization processes in architecture were mentioned. These processes were chronologically named as "Utopian Computational Design Period," "Computer-aided Drawing and Manipulation Period," and "Computer-aided Computational Design Period." It was determined that although digitalization was possible in theory in the first Utopian Computational Design Period, it was not in practice, and there were no concrete examples. It was decided that the Computer-aided Drawing and Manipulation Period was a period of representation and manipulation in which computational designs were not made. In the Computer-aided Computational Design Period, it was indicated that coding and computational designs were made. This grouping reflected almost chronological successive digitalization processes in architecture. The pre-digitalization period and the utopian period were kept the same and expressed in classical, rectilinear forms.

Also, in Chapter 2, digital form classifications and production methods were mentioned. These digital form groups were paired with "computer-aided drawing and manipulation periods" or "computer-aided computational design periods" according to their computational characters. "Topological, isomorphic, animate, and metamorphic architectures (Kolarevic, 2000)", "caricature, hybrid, kinetic, (un)folding and warped eye forms (Terzidis, 2003)" was paired with computer-aided drawing and manipulation period. "Algorithmic form (Terzidis, 2003)" and "parametric and evolutionary architectures (Kolarevic, 2000)" were mapped to the computer-aided computational design period (Table 4.1).

Table 4.1: Form classification used in the set-up of building cases

Form	**Form Finding Technique**	**Period**
rectilinear	traditional design methods	Pre-digital and Utopian Computational Design Period
topological, isomorphic, animate, metamorphic (Kolarevic, 2000) caricature, hybrid, kinetic, (un)folding, warped eye (Terzidis, 2003)	deformation of 3d rectilinear in the digital environment	Computer-aided Drawing and Manipulation Period
parametric, evolutionary (Kolarevic, 2000) algorithmic (Terzidis, 2003)	algorithmic form generation, coding	Computer-aided Computational Design Period

In order to obtain meaningful results from the participants about the digitalization processes, building forms in visual stimuli were selected from Table 4.1. Adding the building forms that match the digital eras to the visual stimuli would prolong the questionnaire, so eliminations were made. Considering the knowledge and capability of the designer, rectilinear, metamorphic, and parametric forms were preferred because all cases and stimuli were generated for this study by the author. Metamorphic and parametric forms were reduced to curvilinearity as it was desired to measure emotional responses to post-digital curvature. A total of 12 building cases were prepared, which involves these building forms (See Appendix B1-B2-B3).

In order to make accurate measurements, there were three main rectilinear designs, which were manipulated as parametric curvilinear and metamorphic curvilinear. Apart from the three main designs and their three versions, three buffer settings were added to eliminate the respondents' prejudices that may arise from their awareness of the purpose of the study.

While designing the building cases, the first aim was to keep the sizes, colors, textures, positions, and orientations of the buildings as constant as possible because the effect of these features on users was desired to be controlled. The limits of the sizes were determined in order to fix the orientation, position, and sizes. A 35x70 meters unit was determined, and the main skeleton was formed using these units in plan view as square, L shape, and U shape (Figure 4.1). The heights were decided to be approximately 20meters (6-7 storeys). Also, a monochromatic color scheme (grayscale) was used to fix the colors between layouts and avoid the effect of color on participants' emotional responses.

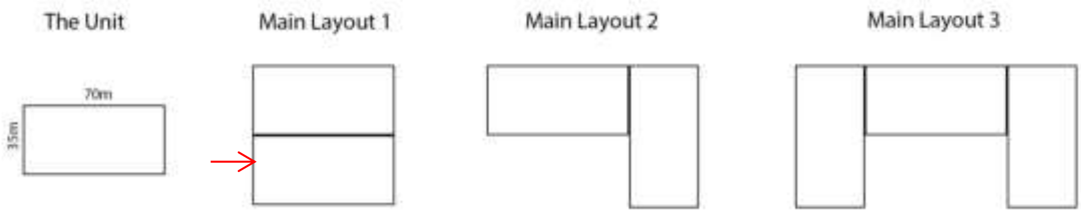

Figure 4.1: Preparation of main layouts

While designing, rectangular versions of building forms were prepared from the square, L shape, and U shape plan by extruding 20m height. The reason why these forms were chosen in the plan view is to measure the degree of enclosing’s effect (Appleton, 1988; Lang, 1987; Kaplan, 1988) because the square planned building keeps the user out, the L planned building creates an urban area of its own and envelopes the user moderately, and the U-planned building envelops the user on three sides and offers a more inclusive building form. Subsequently, the created 3D rectangular models were deformed by using “BoundingBox,” “SoftMove,” and “Smooth” commands in Rhinoceros 3D. Thus, metamorphic curvilinear forms emerged. In this method, rectilinear objects were considered as inside a virtual cage determined by points, and deformations were provided by assuming a homogeneous, artificial force from the environment applied to these points (Figure 4.2) (Figure 4.3) (Figure 4.4) (Kolarevic, 2000).

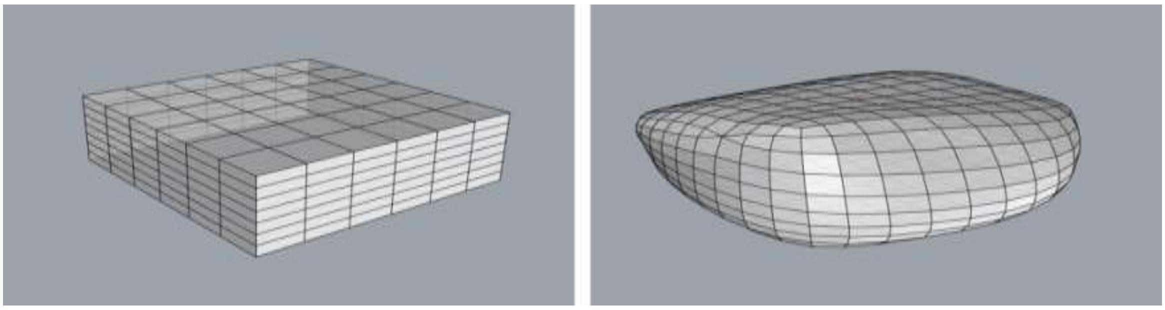

Figure 4.2: Layout 1- Square Shaped Plan Building, (Left) Rectilinear building form, (Right) Metamorphic Curvilinear Form

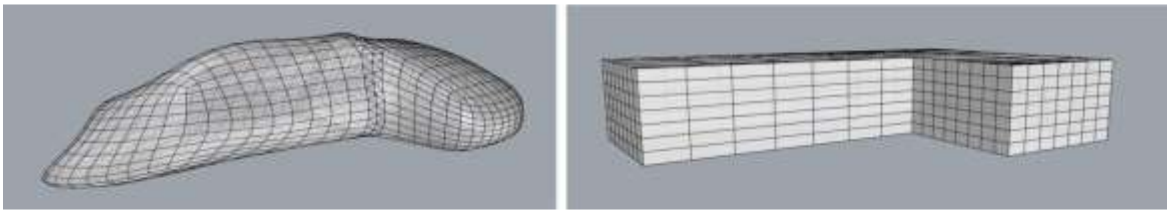

Figure 4.3: Layout 2- L Shaped Plan Building, (Left) Rectilinear building form, (Right) Metamorphic Curvilinear Form

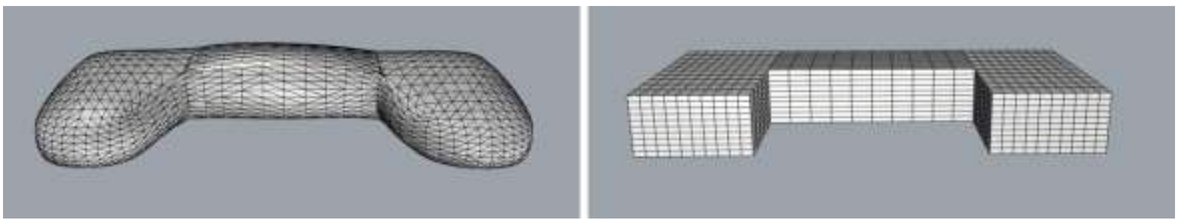

Figure 4.4: Layout 3- U Shaped Plan Building, (Left) Rectilinear building form, (Right) Metamorphic Curvilinear Form

Lastly, parametric curvilinear forms, the third version of the layouts, were derived through Grasshopper. With this method, the author designed the code to derive the architectural form, leading to obtaining form. Square, L, and U-shaped plan views were chosen as the initial parameter not to break the relation with other versions. Instead of simply extruding, with the use of the code, the plan views' corners were rounded, and they were copied at regular intervals and numbers (Figure 4.5) (Figure 4.6)

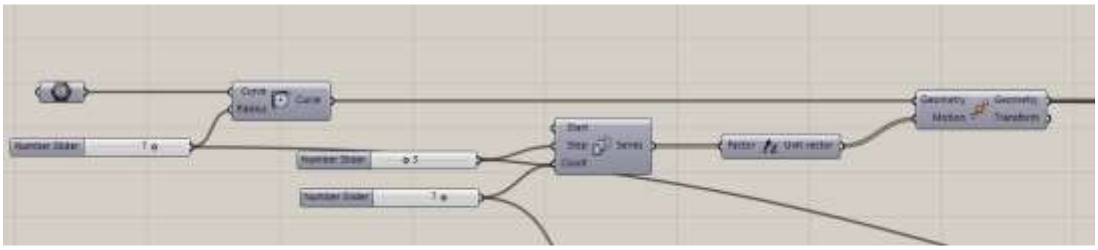

Figure 4.5: Example used Grasshopper code for rounding the corners of plan views and copy in the Z direction at regular interval

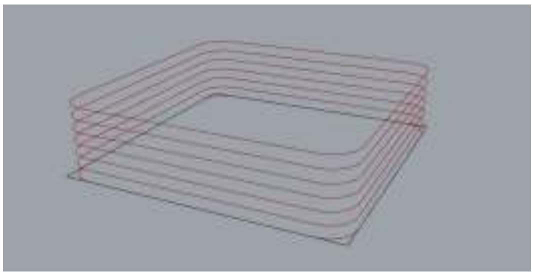

Figure 4.6: Visual representation of the code used in Figure 4.5

These copies were scaled at various rates and rotated at diverse angles (with the help of series of random commands). Then, a surface was created by lofting around the copied, scaled, and rotated plan views (Figure 4.7) (Figure 4.8).

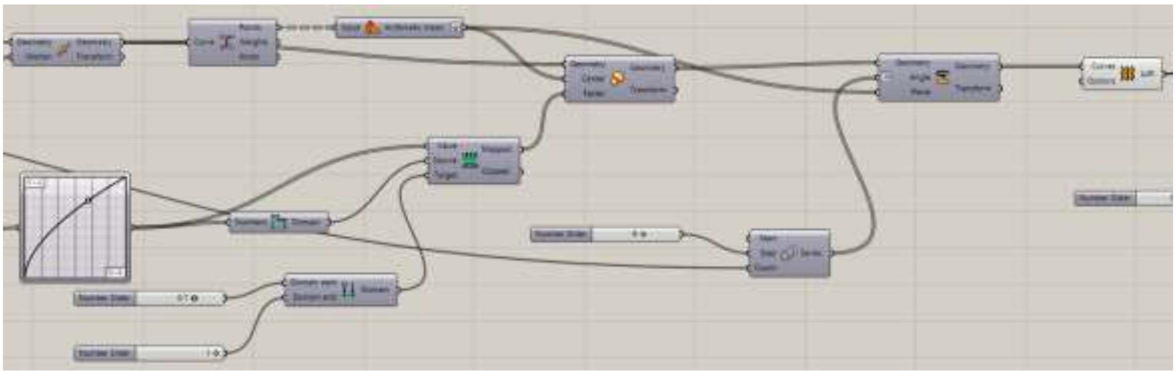

Figure 4.7: Example used Grasshopper code for scaling and rotating the copied curves and lofted surface

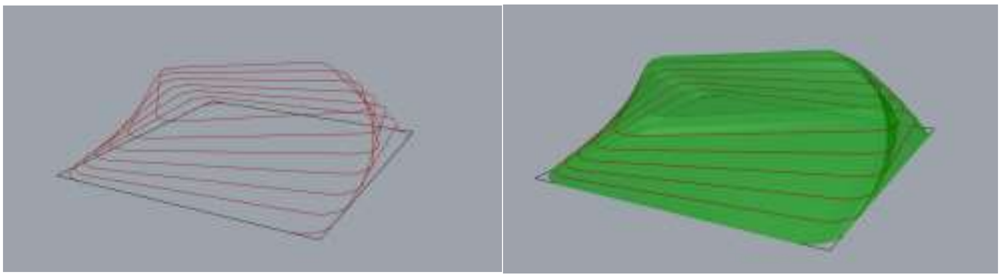

Figure 4.8: Visual representation of the code used in Figure 4.7

Then, some codes and parametric relations were used in façade designs to provide various opening ratios separately. Thus, parametric curvilinear forms emerged (Figure 4.9), (Figure 4.10), (Figure 4.11).

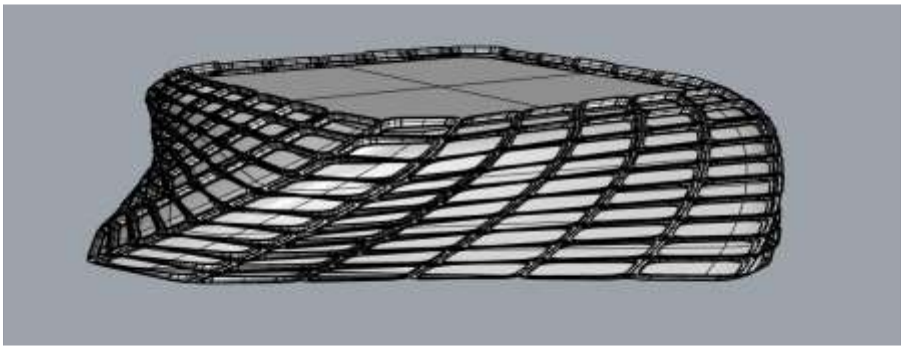

Figure 4.9: Layout 1- Square Shaped Plan Building, Parametric Curvilinear Form

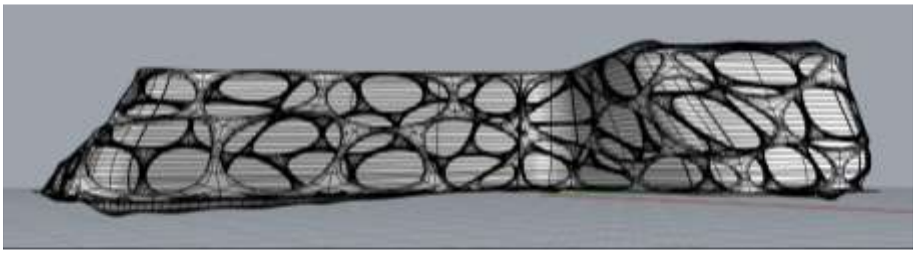

Figure 4.10: Layout 2- L Shaped Plan Building, Parametric Curvilinear Form

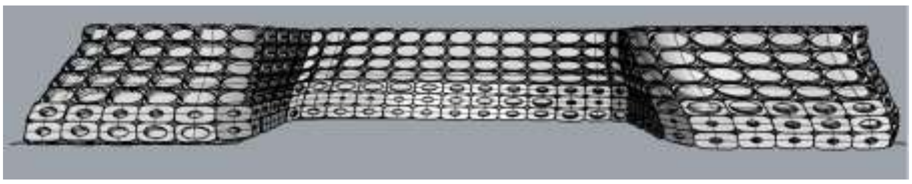

Figure 4.11: Layout 3- U Shaped Plan Building, Parametric Curvilinear Form

Finally, urban settings were designed around them, including roads, trees, plants, various urban furniture, and textures, to add a spatial identity to these building forms. In addition, human figures were added to the frames so that participants could better understand the scale of the building. However, it was aimed that the numbers and features of urban elements used should not be too distracting. While rendering the visuals of these places, attention was paid to keeping the frames at eye level. The frames were preferred as if the respondents were experiencing the building form from the outside. All building forms were rendered from the exact location and angle without changing the number and properties of peripheral elements.

In layout 1, there are buildings with a square plan. The building cases are positioned on the side of a highway, surrounded by pavement and a few trees. The rectilinear building form of this layout is abbreviated as SR (Square Plan- Rectilinear Form). SMC (Square Plan- Metamorphic Curvilinear Form) has a metamorphic curvilinear version of the cubic form. In SPC (Square Plan- Parametric Curvilinear Form), on the other hand, there is a parametric curvilinear building designed by coding (Figure 4.12) (See Appendix B1).


Figure 4.12: Layout 1- (Left) SR, (Middle) SMC, (Right) SPC

In the 2nd layout, the buildings have L-shaped plans. There is pavement around the buildings. The buildings have an urban area of their own, and there is urban furniture such as lighting elements and benches in this area in addition to trees. A rectilinear building of this layout is abbreviated as LR (L Shaped Plan- Rectilinear Form). LMC (L Shaped Plan- Metamorphic Curvilinear Form) has a metamorphic curvilinear version of the rectilinear form. In LPC (L Shaped Plan- Parametric Curvilinear Form), on the other hand, there is a parametric curvilinear building designed by coding (Figure 4.13) (See Appendix B2).

Figure 4.13: Layout 2- (Left) LR, (Middle) LMC, (Right) LPC

In the 3rd layout, the buildings have U-shaped plans. The buildings here have their urban area and are surrounded by a grassy area. Urban spaces that belong to them contain urban furniture such as trash cans, benches, and lighting elements, and there are plants such as trees and bushes in the squares. The rectilinear building of this layout is abbreviated as UR (U Shaped Plan- Rectilinear Form). UMC (U Shaped Plan- Metamorphic Curvilinear Form) has a metamorphic curvilinear version of the rectilinear form. In UPC (U Shaped Plan- Parametric Curvilinear Form), on the other hand, there is a parametric curvilinear building (Figure 4.14) (See Appendix B3).

Figure 4.14: Layout 3- (Left) UR, (Middle) UMC, (Right) UPC

Buffer settings were obtained by manipulating the heights of the rectilinear buildings of these three layouts. The environment and environmental elements were not changed. These three settings were not included in the analysis (Figure 4.15) (See Appendix B4).

Figure 4.15: (Left) Buffer Setting1- B1, (Middle) Buffer Setting2- B2, (Right) Buffer Setting3- B3

Some computer programs were used during the design and generation of digital building forms and renderings. Rhinoceros 3D and its plug-in Grasshopper were used to create 3D building forms, form-finding processes, and algorithmic generations. SketchUp software was used to place these building forms in an urban environment, and the Enscape program was used to add urban elements and get realistic renders.

4.3. Sample Group

The participants were selected by convenience sampling method. Only the respondents under 18 and those who could not speak Turkish were excluded from the survey since the questionnaire was Turkish. As a result, 114 respondents participated in the study voluntarily. Of the 114 people, 78 were women, and 36 were men. 15 people in the 18-24 age group, 44 people in the 25-34 age range, 27 people in the 35-44 age group, 15 people in the 45-54 age group, ten people in the 55-64 age group and three people over the age of 65 participated. In addition, 47 people graduated from the art, science, and architecture departments, while 67 graduated from other fields or graduated from primary school and high school (Table 4.2).

Table 4.2: Demographics of participants

		Number of participants
Gender	Female	78
	Male	36
Age	18-24	15
	25-34	44
	35-44	27
	45-54	15
	55-64	10
	65-74	3
Education Subject	Art. Design and Architecture	47
	Other	67

4.4 Survey Process

The questionnaire was sent to the respondent through a digital medium, as the world is under the influence of coronavirus. The questionnaire was carried out through online survey programs, and a website link to the survey was created. The link where the participants could easily access the questionnaire was sent to the participants via e-mail. Respondents were warned that they had to examine the visual stimuli on the computer screen to evaluate the survey results correctly.

Initially, a pilot study was conducted with 6 participants, and some minor changes were applied with the feedbacks of the respondents. Örer's (2016) research was used when the Mehrabian and Russell adjective pairs were translated into Turkish, but some changes were made in the translations with the participants' comments in the pilot study. In addition, the brightness and light settings were changed because the visual stimuli in the pilot study were found to be too dark by the participants.

In addition, since the order of the visual stimuli would affect emotional responses, it was set to be randomly displayed to each participant through the online questionnaire site.

CHAPTER 5

RESULTS AND DISCUSSION

This chapter presents the users' pleasure, arousal scores, and desire to be in these building cases. Statistical Package for Social Sciences (SPSS) software version 21 was used to analyze the collected data from the questionnaire.

All quantitative data were processed into the SPSS program for statistical analysis. First, to test the consistency of the items used in the questionnaire, the internal consistency reliability test was applied to all items. Moreover, normality tests were performed to choose the proper analysis method. Secondly, the mean values of the pleasure and arousal scores of the rectilinear and parametric and metamorphic curvilinear forms were calculated, and various comparisons were made by performing Paired- samples T-tests and ANOVA tests. Finally, correlation tests were conducted to investigate the relationship between the desire to be in the building and the pleasure arousal scores.

5.1. Reliability and Normality Tests

Before starting the statistical tests, the internal consistency reliability of the items was examined. The internal reliability of the items in the questionnaire was investigated in terms of Cronbach's alpha coefficients, and the test was applied to all items that measure pleasure and arousal scores and desire to be in. According to George and Mallery's (2003) rule, where $\alpha > 0.9$ is excellent, $\alpha > 0.8$ is good, $\alpha > 0.7$ is acceptable, $\alpha > 0.6$ is questionable, $\alpha > 0.5$ is poor), and $\alpha < 0.5$ is unacceptable in terms of reliability. The Cronbach's alpha for the overall questionnaire is 0.980 in this thesis which shows the reliability is very high (Table 5.1) (See Appendix C, Table C1). In addition, six adjective pairs belonging to the pleasure scale with 0.968 alpha values (See Appendix C, Table C2), six adjective pairs belonging to the arousal scale with 0.966 value (See Appendix C, Table C3), and the scale measuring the desire to be in with 0.811 alpha value is reliable (Table 5.1) (See Appendix C, Table C4).

Table 5.1: Internal Consistency Reliability Test Scores

	Cronbach's alpha (α)
Overall questionnaire	0.98
Pleasure Scale	0.968
Arousal Scale	0.966
Desire to Be in Scale	0.811

After the reliability tests, normality tests were performed to check whether the data set was normally distributed. Normality tests show that the data is distributed parametrically or non-parametrically. This information is essential for choosing the suitable analysis method because of the different parametric and non-parametric data sets analyses. Skewness and kurtosis values can be taken into account in the tests performed. A kurtosis value of ±1.0 is considered excellent in most studies, but a value of ±2.0 is acceptable as normally distributed in most cases (George and Mallery, 2003). In the normality tests performed in this study, since all kurtosis values are within the range of ±2.0 (See Appendix C, Table C5), they were accepted as a normal distribution, and parametric data analysis tests were applied.

5.2. Comparison of Pleasure and Arousal Scores of Rectilinear and Parametric-Metamorphic Curvilinear Forms

The purpose of these analyses was to compare emotional responses to rectilinear, metamorphic, and parametric digital curvilinear forms. For this reason, responses of rectilinear, parametric, and metamorphic curvilinear forms were collected and analyzed. The comparisons were made with ANOVA tests. These analyses compared the differences in emotional responses between rectilinearity and curvilinearity. In this part, metamorphic curvilinear forms created with 3D modeling and deformation techniques, parametric curvilinear forms created with coding and relationality were also compared for all three layouts in terms of pleasure and arousal.

5.2.1. Pleasure

To measure pleasure scores, pleasure means for rectilinear and metamorphic-parametric curvilinear forms were compared. As mentioned before, a 5-point Likert scale was used for items on the pleasure scale. In these responses, averages 1 to 3 were considered negative, three as neutral, and 3 to 5 as positive pleasure values.

According to the ANOVA test that applied, there is a difference between pleasure scores of rectilinear and metamorphic curvilinear forms for all layouts (for Layout 1 $p=0.0001$, $p<0.05$) (for Layout 2 $p=0.0001$, $p<0.05$) (for Layout 3 $p=0.0001$, $p<0.05$) (Figure 5.1) (See Appendix C, Table C6).

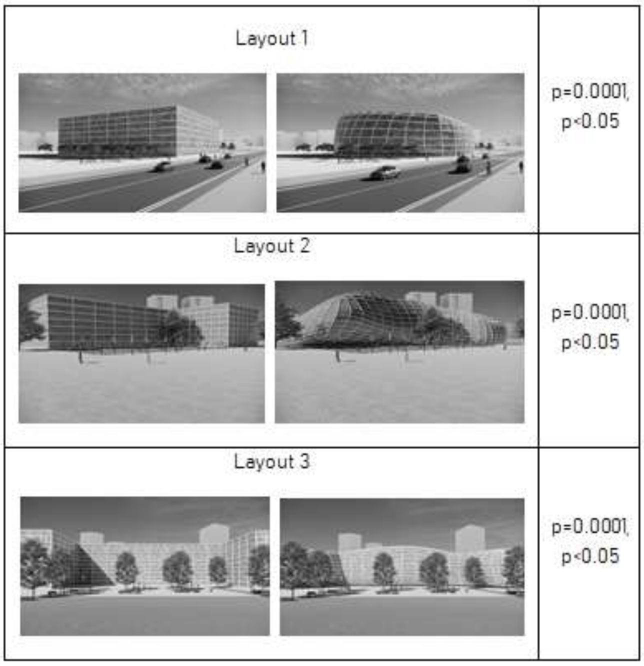

Figure 5.1: ANOVA test results for the pleasure scores of rectilinear and metamorphic curvilinear forms

Also, for all layouts, a difference between pleasure scores of rectilinear and parametric curvilinear forms is determined (for Layout 1 $p=0.0001$, $p<0.05$) (for Layout 2 $p=0.0001$, $p<0.05$) (for Layout 3 $p=0.039$, $p<0.05$) (Figure 5.2) (See Appendix C, Table C6).

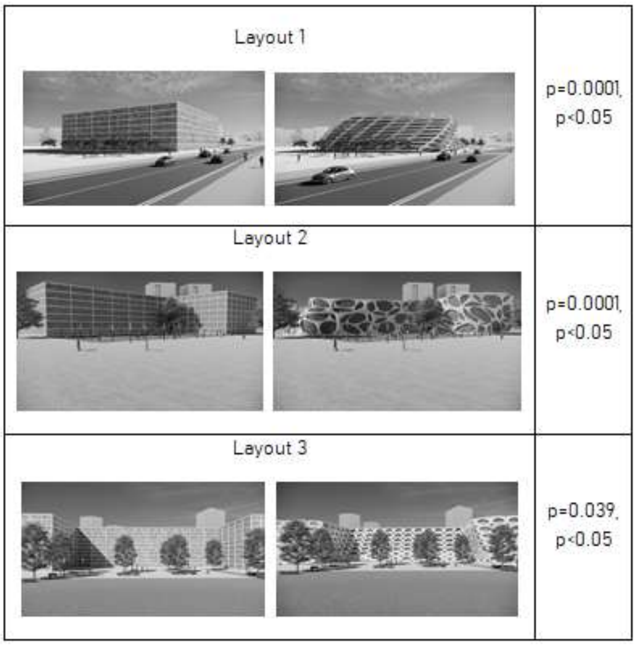

Figure 5.2: ANOVA test results for the pleasure scores of rectilinear and parametric curvilinear forms

However, no significant difference between the pleasure scores of metamorphic and parametric curvilinear forms was found for all layouts (for Layout 1 p=0.072, p>0.05) (for Layout 2 p=0.901, p>0.05) (for Layout 3 p=0.273, p>0.05) (Figure 5.3) (See Appendix C, Table C6).

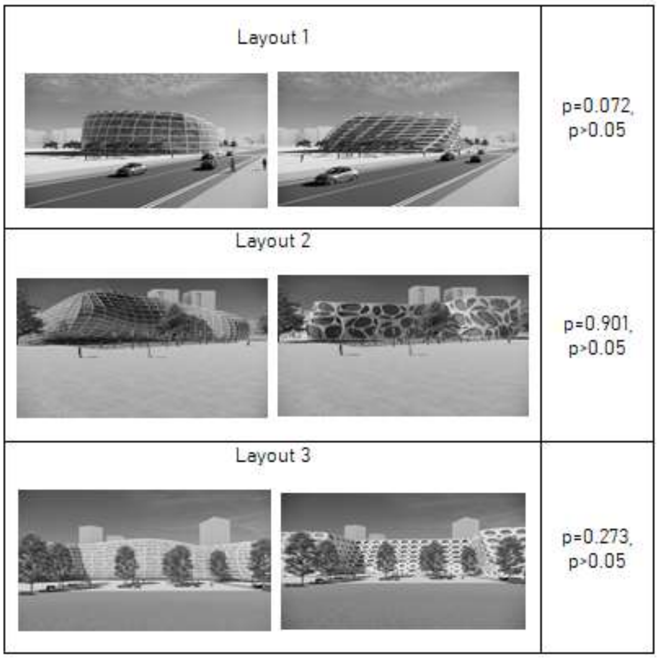

Figure 5.3: ANOVA test results for the pleasure scores of metamorphic and parametric curvilinear forms

In more detail, rectilinear building forms have negative pleasure scores , and both curvilinear building forms have positive pleasure scores for all layouts. While the rectilinear form in Layout 1 (SR) has a negative pleasure value with M=2.40<3, SD=0.916, the metamorphic (SMC) (M=3.31>3, SD=0.927) and parametric curvilinear (SPC) (M=3.61>3, SD=1.068) forms have positive values (Table 5.2). Likewise, for layout 2, pleasure means of the rectilinear form (LR) is negative with M=2.82<3, SD=0.982 and metamorphic (LMC) (M=3.42>3, SD=0.954) and parametric curvilinear (LPC) (M=3.49>3, SD=1.163) forms have positive pleasure scores(Figure 5.4) (Table 5.2). In Layout 3, rectilinear form (UR) is negative with M=2.86<3, SD=1.128 and metamorphic (UMC) (M=3.44>3, SD=1.017) and parametric curvilinear (UPC) (M=3.21>3, SD=1.132) forms are positive in terms of pleasure means (Figure 5.4) (Table 5.2). In addition, while the parametric curvilinear form of layout 1 (SPC) has the highest pleasure mean value, the lowest mean pleasure value belongs to layout 1 rectilinear (SR) building form (Table 5.2) (Figure 5.4) (See Appendix C, Table C7)

Table 5.2: Statistics of pleasure scores of settings

	Layout	Building Form	M	SD
□	Layout 1	SR	2.4	0.916
		SMC	3.31	0.927
		SPC	3.61	1.068
L	Layout 2	LR	2.82	0.982
		LMC	3.42	0.954
		LPC	3.49	1.163
U	Layout 3	UR	2.86	1.128
		UMC	3.44	1.017
		UPC	3.21	1.132

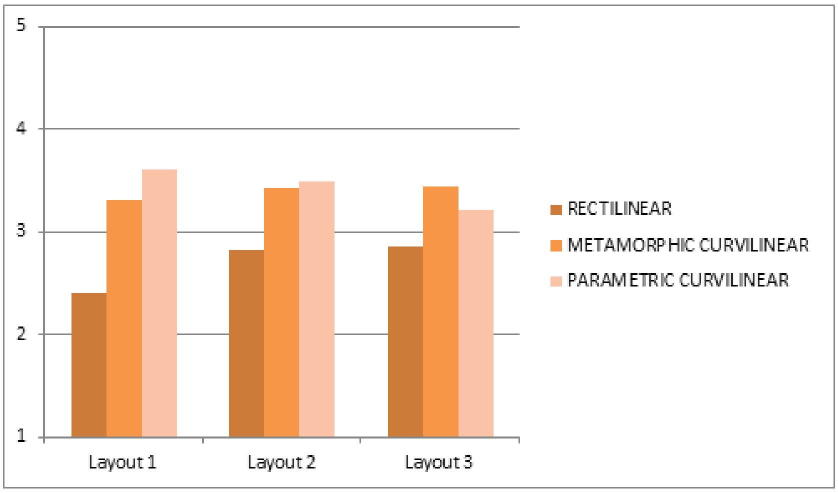

Figure 5.4: Diagram of pleasure scores of settings

5.2.2. Arousal

Same with the measurement of pleasure scores, arousal means for rectilinear and curvilinear forms for all layouts were compared. The scores ranged between 1 to 5 in all settings, as was the case in pleasure scores.

According to the ANOVA test results, there is a difference between arousal scores of rectilinear and metamorphic curvilinear forms for all layouts (for Layout 1 p=0.0001, p<0.05) (for Layout 2 p=0.0001, p<0.05) (for Layout 3 p=0.0001, p<0.05) (Figure 5.5) (See Appendix C, Table C8).

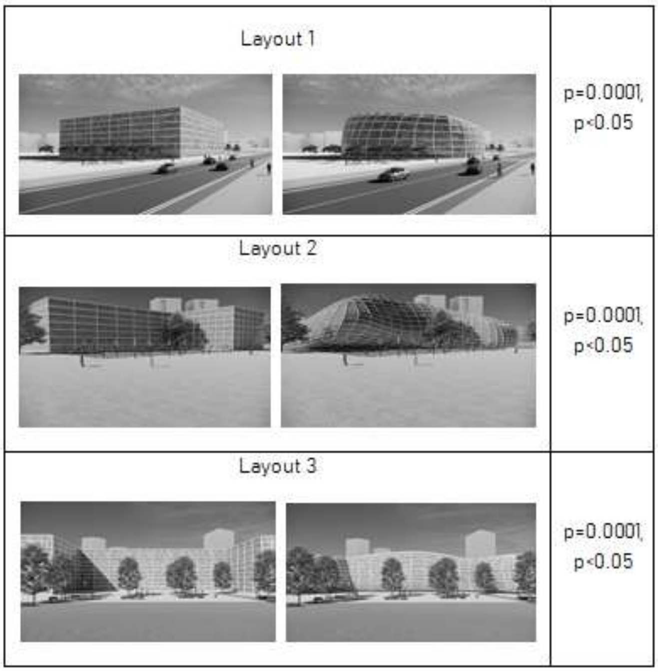

Figure 5.5: ANOVA test results for the arousal scores of rectilinear and metamorphic curvilinear forms

In addition, there is a difference between arousal scores of rectilinear and parametric curvilinear forms (for Layout 1 p=0.0001, p<0.05) (for Layout 2 p=0.0001, p<0.05) (for Layout 3 p=0.0001, p<0.05) (See Appendix C, Table C8) (Figure 5.6).

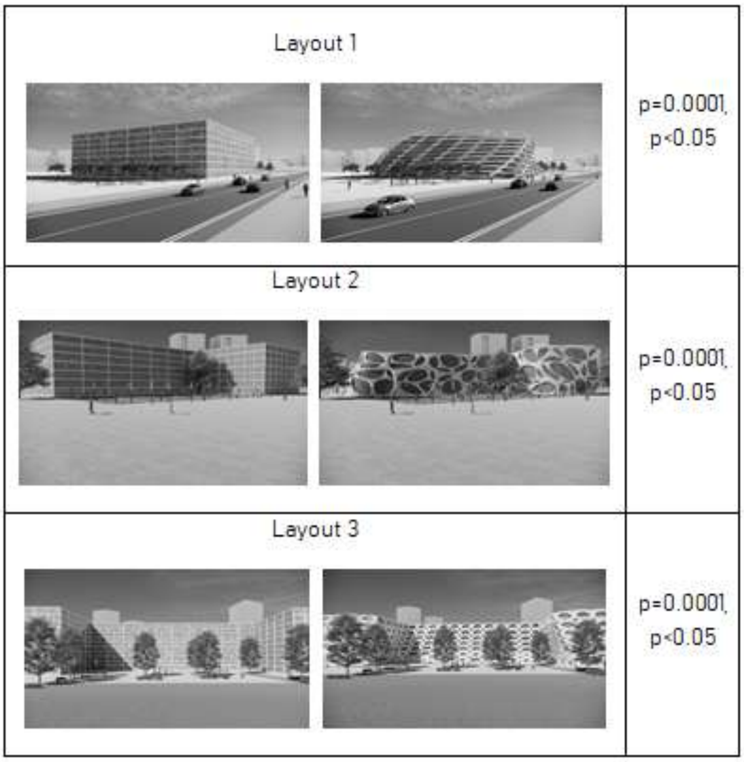

Figure 5.6: ANOVA test results for the arousal scores of rectilinear and parametric curvilinear forms

Likewise, a difference was found between the arousal scores given to the metamorphic (SMC) and parametric curvilinear (SPC) forms of Layout 1 ($p=0.002$, $p<0.05$) (Figure 5.7). However, no significant difference between the arousal scores of metamorphic and parametric curvilinear forms was found for layout 2 and layout 3 (for Layout 2 $p=0.907$, $p>0.05$) (for Layout 3 $p=0.999$, $p>0.05$) (See Appendix C, Table C8). Namely, the null hypothesis that there is no significant difference between rectilinear and curvilinear forms' arousal scores is rejected.

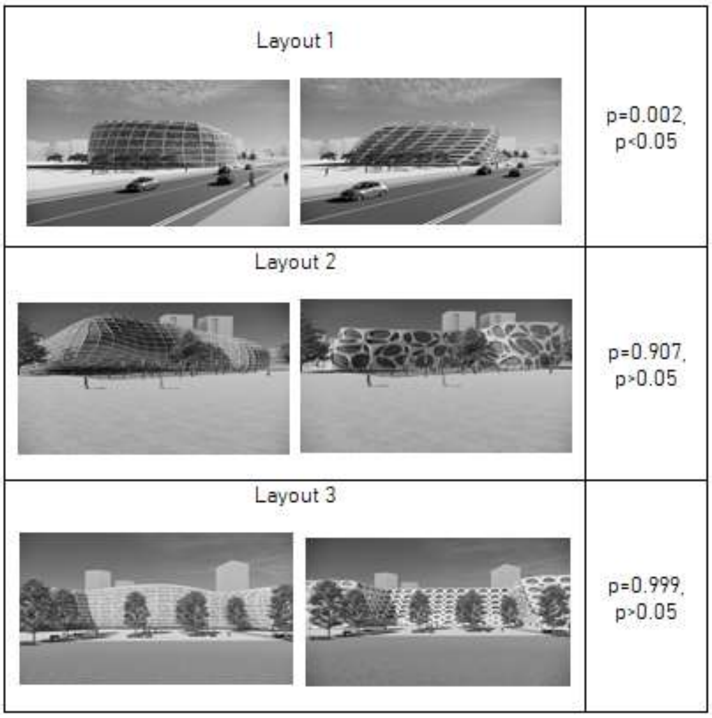

Figure 5.7: ANOVA test results for the arousal scores of metamorphic and parametric curvilinear forms

Moreover, the arousal scores for rectilinear forms are negative and positive for metamorphic- parametric curvilinear forms for all layouts. While the rectilinear form in Layout 1 (SR) has a negative arousal value with M=2.31<3, SD=0.997, the metamorphic (SMC) (M=3.41>3, SD=1.017) and parametric curvilinear (SPC) (M=3.89>3, SD=0.943) forms have positive values (Table 5.3) (Figure 5.8). In layout 2, arousal scores of the rectilinear form (LR) is negative with M=2.63<3, SD=0.944 and metamorphic (LMC) (M=3.64>3, SD=0.947) and parametric curvilinear (LPC) (M=3.70>3, SD=1. 1.026) forms have positive pleasure scores (Table 5.3) (Figure 5.8). Likewise, for layout 3, rectilinear form (UR) is negative with M=2.69<3, SD=1.029 and metamorphic (UMC) (M=3.42>3, SD=1.007) and parametric curvilinear (UPC) (M=3.42>3, SD=1.056) forms are positive in terms of arousal means (Table 5.3). In addition, while the parametric curvilinear form of layout 1 (SPC) has the highest arousal mean value, the lowest mean arousal value is layout 1's rectilinear (SR) building form (Table 5.3) (Figure 5.8) (See Appendix C, Table C9).

Table 5.3: Statistics of arousal scores of settings

	Layout	Building Form	M	SD
□	Layout 1	SR	2.31	0.997
		SMC	3.41	1.017
		SPC	3.89	0.943
L	Layout 2	LR	2.63	0.944
		LMC	3.64	0.947
		LPC	3.7	1.026
U	Layout 3	UR	2.69	1.029
		UMC	3.42	1.007
		UPC	3.42	1.056

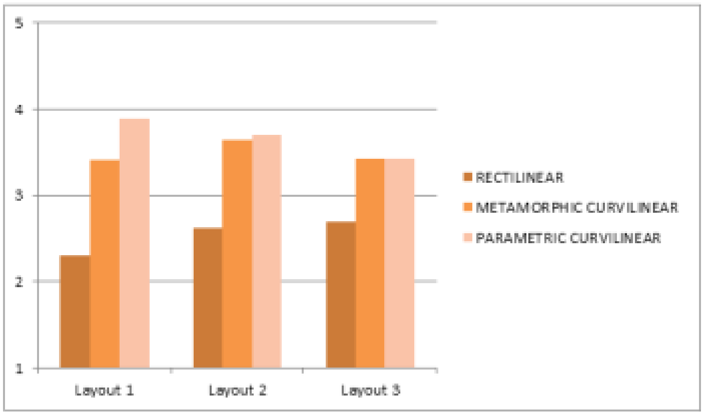

Figure 5.8 Diagram of arousal scores of settings

5.3. Comparison of Desires to Be in Rectilinear and Metamorphic- Parametric Curvilinear Forms

One-way ANOVA tests were separately performed for all layouts to compare the participants' desire to be in the rectilinear and metamorphic-parametric curvilinear forms. In addition, descriptive analyses were performed to analyze the distribution of responses.

According to the ANOVA test that applied Layout 1, a difference was found between the participants' desire to be in rectangular (SR) and metamorphic curvilinear forms (SMC) ($p=0.0001$; $p<0.05$) (Figure 5.9). Similarly, there is also a difference between the responses given to the rectangular (SR) and parametric curvilinear forms (SPC) ($p=0.0001$; $p<0.05$). However, there is no significant difference between the responses to metamorphic curvilinear (SMC) and parametric curvilinear forms (SPC) ($p=0.881$; $p>0.05$) (Figure 5.9) (See Appendix C, Table C10).

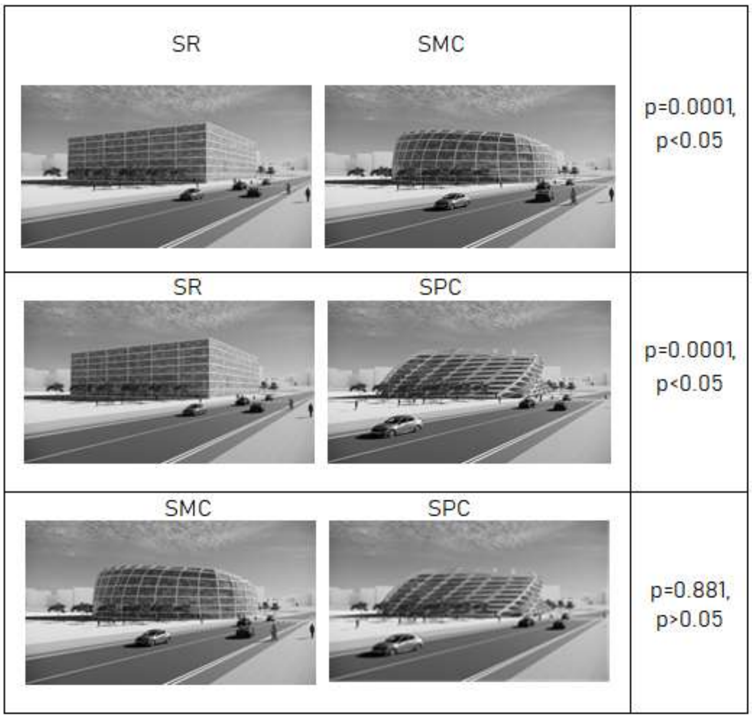

Figure 5.9: ANOVA test results of Layout 1 (☐) for the desires to be in

For the rectilinear setting (SR), 56.1% (64 participants) selected "I don’t want to be or live in this building," 37.7% (43 participants); "I would like to be in this building, but I don't want to be live in, "6.1% (7 participants); "I would like to be in live in this building" options (Table 5.4) (Figure 5.10). For metamorphic curvilinear setting (SMC), 21.9% (25 participants) selected "I don’t want to be or live in this building," 52.6% (60 participants); "I would like to be in this building, but I don't want to be live in, "25.4% (29 participants); "I would like to be in live in this building" options (Table 5.4) (Figure 5.10). For parametric curvilinear setting (SPC), 18.4% (21 participants) selected "I don’t want to be or live in this building," 55.3% (63 participants); "I would like to be in this building, but I don't want to be live in, "26.3%

(30 participants); "I would like to be in live in this building" options (Table 5.4) (Figure 5.10) (See Appendix C, Table C11).

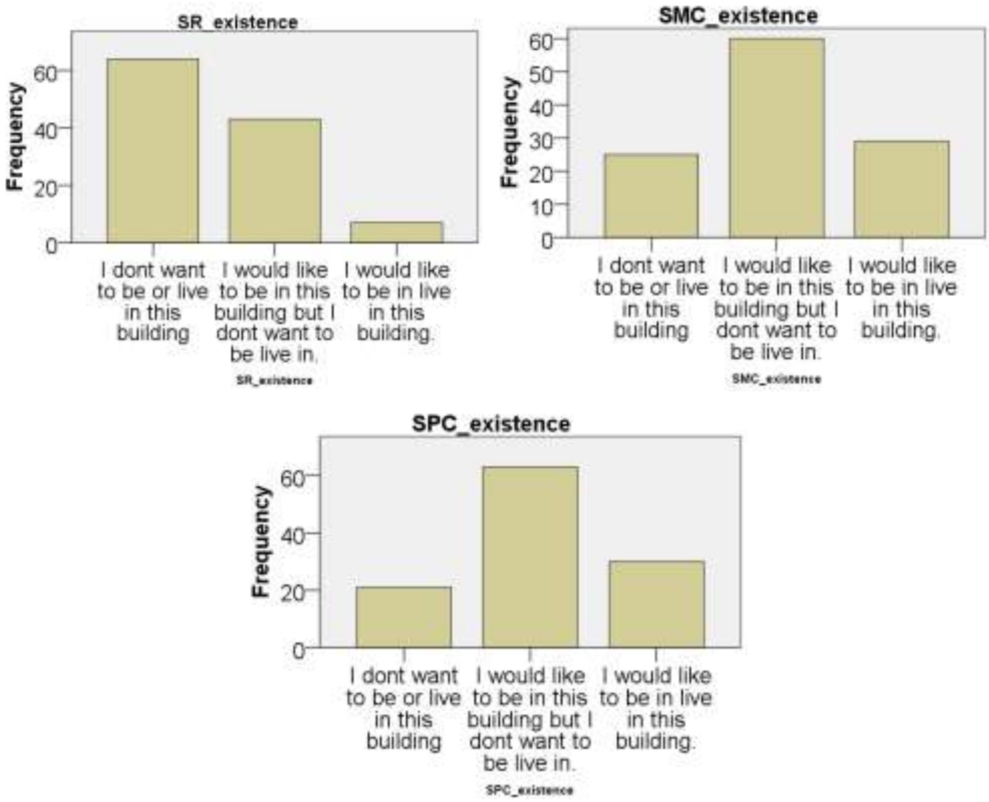

Figure 5.10: Bar chart for descriptive statistics of Layout1 (□)

Table 5.4: Frequency analysis of desires to be in for Layout 1 (□)

SR		
	Frequency	**Percent**
I don’t want to be or live in this building	64	56.1
I would like to be in this building but I don't want to be live in	43	37.7
I would like to be and live in this building	7	6.1
SMC		
	Frequency	**Percent**
I don’t want to be or live in this building	25	21.9
I would like to be in this building but I don't want to be live in	60	52.6
I would like to be and live in this building	29	25.4
SPC		
	Frequency	**Percent**
I don’t want to be or live in this building	21	18.4
I would like to be in this building but I don't want to be live in	63	55.3
I would like to be and live in this building	30	26.3

For Layout 2, there was no significant difference between the three groups (LR, LMC, LPC) (p=0.008; p>0.05). A difference has been identified between both rectilinear (LR) and metamorphic curvilinear forms (LMC) (p=0.038; p<0.05), as well as between rectilinear and parametric curvilinear forms (p=0.018; p<0.05). In contrast, no significant difference was found between the responses to parametric (LPC) and metamorphic (LMC) curvilinear forms (p=0.960; p>0.05) (Figure 5.11) (See Appendix C, Table C12).

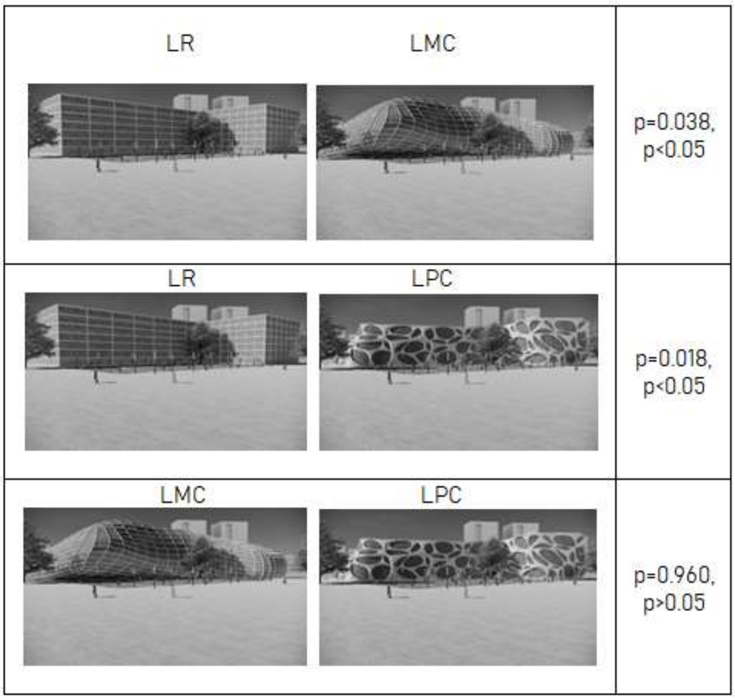

Figure 5.11: ANOVA test results of Layout 2 (**L**) for the desires to be in

For the rectilinear setting of Layout 2 (LR), 37.7% (43 respondents) selected "I don’t want to be or live in this building," 44.7% (51 participants); "I would like to be in this building, but I don't want to be live in, "17.5% (20 participants); "I would like to be in live in this building" options (Figure 5.12) (Table 5.5). For metamorphic curvilinear setting (LMC), 16.7% (19 respondents) selected "I don’t want to be or live in this building," 63.2% (72 respondents); "I would like to be in this building, but I don't want to be live in, "20.2% (23 respondent); "I would like to be in live in this building" options (Figure 5.12) (Table 5.5). For parametric curvilinear setting (LPC), 25.4% (29 p respondent) selected "I don’t want to be or live in this building," 43.0% (49 respondent); "I would like to be in this building, but I don't want to be live in, "31.6% (36 respondent); "I would like to be in live in this building" options (Figure 5.12) (Table 5.5) (See Appendix C, Table C13).

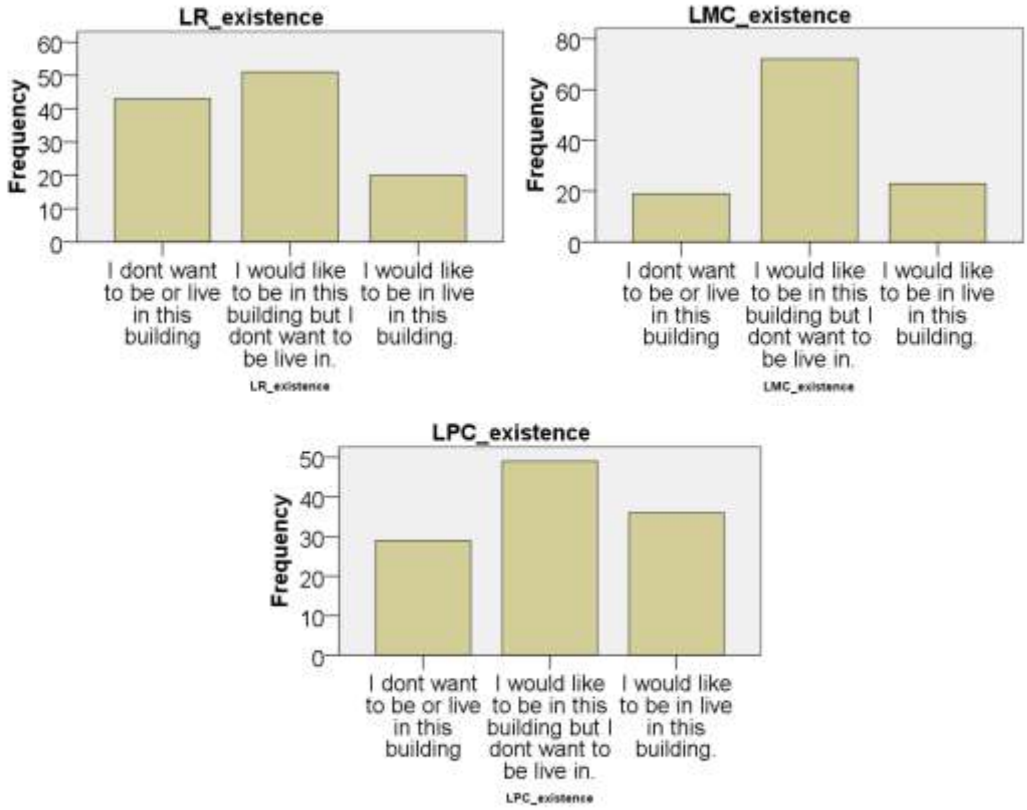

Figure 5.12: Bar chart for descriptive statistics of Layout2 (**L**)

Table 5.5: Frequency analysis of desires to be in for Layout 2 (L)

	Frequency	Percent
LR		
I don't want to be or live in this building	43	37.7
I would like to be in this building but I don't want to be live in	51	44.7
I would like to be and live in this building	20	17.5
LMC	**Frequency**	**Percent**
I don't want to be or live in this building	19	16.7
I would like to be in this building but I don't want to be live in	72	63.2
I would like to be and live in this building	23	20.2
LPC	**Frequency**	**Percent**
I don't want to be or live in this building	29	25.4
I would like to be in this building but I don't want to be live in	49	43
I would like to be and live in this building	36	31.6

No significant difference was found between any of the groups in Layout 3 (UR, UMC, UPC) ($p=0.149$; $p>0.05$). In more detail, no significant difference was detected between the responses to rectilinear (UR) and metamorphic curvilinear (UMC) ($p=0.156$; $p>0.05$), rectilinear (UR) and parametric (UPC) curvilinear ($p=0.470$; $p>0.05$), metamorphic (UMC) and parametric (UPC) curvilinear forms ($p=0.781$; $p>0.05$) (Figure 5.13) (See Appendix C, Table C14).

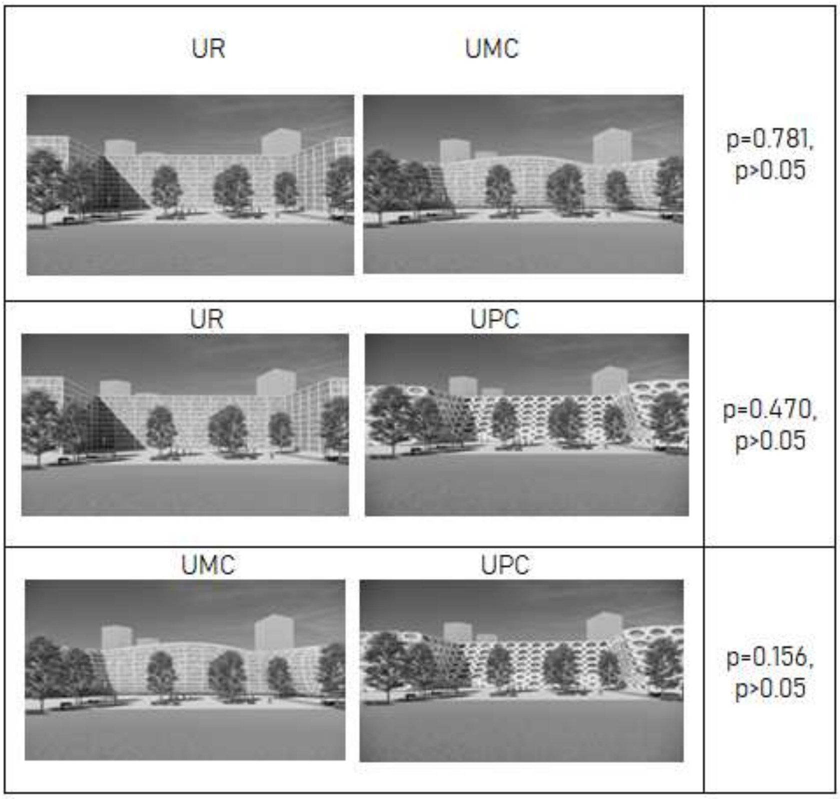

Figure 5.13: ANOVA test results of Layout 3 (**U**) for the desires to be in

For the rectilinear setting (UR), 36.8% (42 respondents) selected "I do not want to be or live in this building," 44.7% (51 participants); "I would like to be in this building, but I don't want to be live in, "18.4% (21 participants); "I would like to be in live in this building" options (Table 5.6) (Figure 5.14). For metamorphic curvilinear setting (UMC), 28.1% (32 respondents) selected "I don’t want to be or live in this building," 43.0% (49 respondents); "I would like to be in this building, but I don't want to be live in, "28.9% (33 respondent); "I would like to be in live in this building" options (Table 5.6) (Figure 5.14). For parametric curvilinear setting (UPC), 33.3% (38 respondents) selected "I don’t want to be or live in this building," 39.5% (45 respondents); "I would like to be in this building, but I don't want to be live in, "27.2% (31 respondent); "I would like to be in live in this building" options (Table 5.6) (Figure 5.14) (See Appendix C, Table C15).

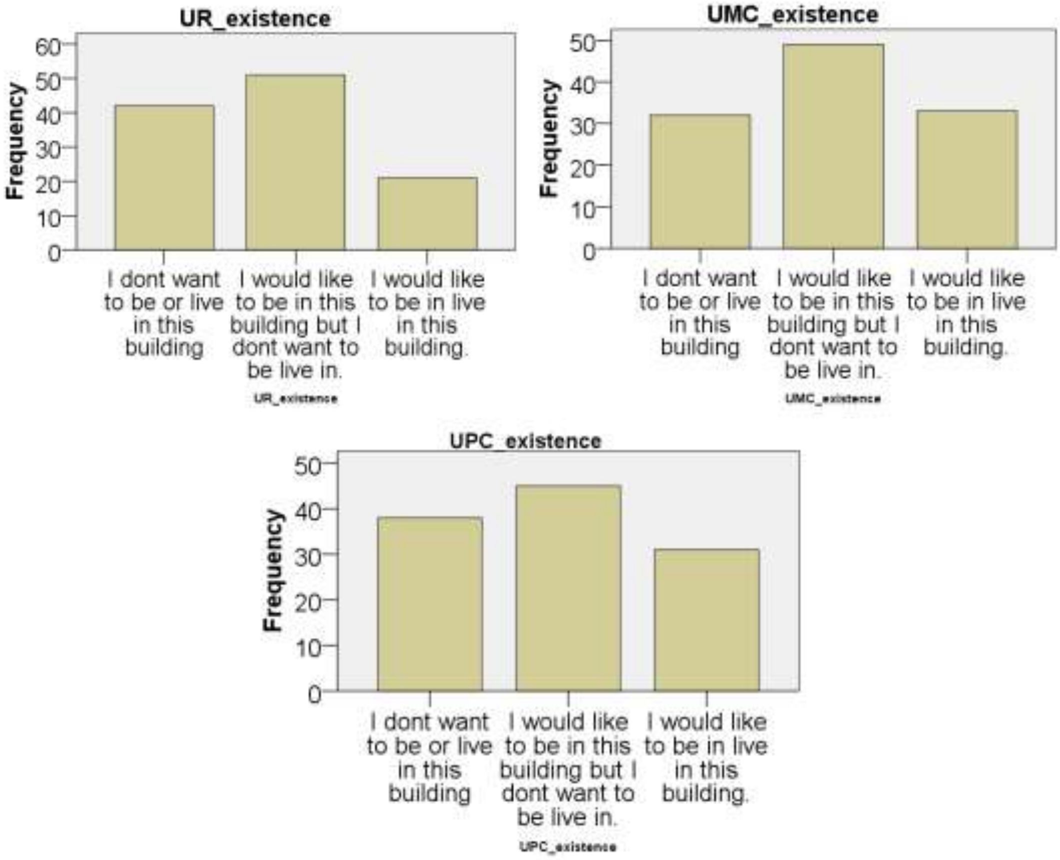

Figure 5.14: Bar chart for descriptive statistics of Layout3 (**U**)

Table 5.6: Frequency analysis of desires to be in for Layout 3 (**U**)

UR		
	Frequency	**Percent**
I don’t want to be or live in this building	42	36.8
I would like to be in this building but I don't want to be live in	51	44.7
I would like to be and live in this building	21	18.4
UMC		
	Frequency	**Percent**
I don’t want to be or live in this building	32	28.1
I would like to be in this building but I don't want to be live in	49	43
I would like to be and live in this building	33	28.9
UPC		
	Frequency	**Percent**
I don’t want to be or live in this building	38	33.3
I would like to be in this building but I don't want to be live in	45	39.5
I would like to be and live in this building	31	27.2

5.4. Pleasure and Arousal Scores for Factor Education Subject

The purpose of this chapter is to analyze whether people's graduation from one of the Arts, design, and architecture faculties makes a difference in their decisions. In Chapter 4, studies showing differences between the decisions made by architects and laypersons were mentioned. In this study, not only the distinction between architects and non-architects was made, but it was observed whether there was a more vast difference between those who received design and art education and those who did not.

In order to carry out this analysis, people who selected “Social Sciences and Humanities,” “Science and Engineering Sciences,” and “other “answers in the education subject part of the questionnaire were combined under one group, and the Independent Sample T-test applied for overall rectilinear, curvilinear forms’ pleasure and arousal scores.

5.4.1. Pleasure

There is no significant difference between the pleasure scores for the rectilinear ($t=-2.054$; $df=112$; $p=0.042$; $p>0.05$; 2-tailed), metamorphic ($t=-0.757$; $df=112$; $p=0.451$; $p>0.05$; 2-tailed) and parametric curvilinear ($t=-1.610$; $df=112$; $p=0.110$; $p>0.05$; 2-tailed) forms of the people who have or have not studied arts, design or architecture according to the test results (Table 5.7) (See Appendix C, Table C16).

Table 5.7: Independent Sample T-test results for pleasure scores of factor education subject

	t	df	Sig (2-tailed)
Rectilinear	-2.054	112	p=0.042; p>0.05
Metamorphic Curvilinear	0.757	112	p=0.451; p>0.05
Parametric Curvilinear	-1.610	112	p=0.110; p>0.05

For the rectilinear forms, the pleasure score of those who did not study arts, design, and architecture was M=2.83, SD=0.909, and for the ones who studied was M=2.50, SD=0.716. For metamorphic curvilinear forms, the pleasure score of those who did not study arts, design, and architecture was M=3.44, SD=0.838, and for the others was M=3.33, SD=0.671. Also, for parametric curvilinear forms, the pleasure score of those who did not study arts, design, and architecture was M=3.55, SD=0.1.020, and for the others, it was M=3.27, SD=0.805 (Table 5.8) (See Appendix C, Table C16).

Table 5.8: Pleasure Scores for Factor Education Subject

Building Form	Art, Design and Architecture Education		Non- Art, Design and Architecture Education	
	M	SD	M	SD
Rectilinear	2.5	0.716	2.83	0.909
Metamorphic Curvilinear	3.33	0.671	3.44	0.838
Parametric Curvilinear	3.27	0.805	3.55	1.02

5.4.2. Arousal

According to test, there also no significant difference determined between the arousal scores for the metamorphic (t=-0.293; df=112; p=0.770; p>0.05; 2-tailed) and parametric curvilinear (t=-0.289; df=112; p=0.343; p>0.05; 2-tailed) forms of the people who have or have not studied arts, design or architecture (Table 5.9) (See Appendix C, Table C17).

Table 5.9: Independent Sample T-test results for arousal scores of factor education subject

	t	df	Sig (2-tailed)
Rectilinear	-2.832	112	p=0.005; p<0.05
Metamorphic Curvilinear	-0.293	112	p=0.770; p>0.05
Parametric Curvilinear	-0.953	112	p=0.343; p>0.05

For the rectilinear forms, the pleasure score of those who did not study arts, design, and architecture (M=2.83, SD=0.909) was higher than those who studied (M=2.50, SD=0.716).In detail, participants who did not study arts, design, and architecture have arousal scores of M=2.73, SD=0.934, and the others have M=2.29, SD=0.612, for rectilinear forms. Moreover, respondents who did not study arts, design, and architecture have arousal scores of M=3.51, SD=0.809, while the others have M=3.47, SD=0.749, for metamorphic curvilinear forms. Additionally, for parametric curvilinear forms, participants who did not study arts, design, and architecture have arousal scores of M=3.73, SD=0.905, and the others have M=3.58, SD=0.737 (Table 5.10) (See Appendix C, Table C17).

Table 5.10: Arousal Scores for Factor Education Subject

Building Form	**Art, Design and Architecture Education**		**Non- Art, Design and Architecture Education**	
	M	**SD**	**M**	**SD**
Rectilinear	2.29	0.612	2.73	0.934
Metamorphic Curvilinear	3.47	0.749	3.51	0.809
Parametric Curvilinear	3.58	0.737	3.73	0.905

5.5. Comparisons of Layouts

Designs were made based on the square, L, and U-shaped plans to see if the degree of enclosure would change the users' emotional responses while creating the visual stimuli. In this chapter, ANOVA analyses were made to make comparisons between the layouts to determine the differences that the degree of enclosure caused.

According to ANOVA test results; there is no significant difference between the pleasure ($F=0.914$; $df=2$; $p=0.402 >0.05$) (See Appendix C, Table C18) and arousal ($F=1.424$; $df=2$; $p=0.712 >0.05$) (See Appendix C, Table C19) scores of three layouts (Table 5.11).

Table 5.11: ANOVA test results of pleasure and scores for layout difference

	F	df	Sig
Pleasure scores	0.914	2	p=0.402 >0.05
Arousal Scores	1.424	2	p=0.712 >0.05

In more detail, both pleasure ($M=3.25$, $SD=0.759$) and arousal ($M=3.33$, $SD=0.716$) scores of Layout 2 are higher than the other layouts (Table 5.12). The layout with the lowest mean among the pleasure scores is Layout 1 ($M=3.11$, $SD=0.740$). The layout which has the lowest arousal mean value is layout 3 ($M=3.18$, $SD=0.752$) (Table 5.12) (See Appendix C, Table C20).

Table 5.12: Pleasure and Arousal Scores of Layouts

	Layout	M	SD
□	Layout 1_ pleasure	3.11	0.74
L	Layout 2_ pleasure	3.25	0.759
U	Layout 3_ pleasure	3.17	0.812
□	Layout 1_ arousal	3.2	0.741
L	Layout 2_ arousal	3.33	0.716
U	Layout 3_ arousal	3.18	0.752

5.6. Correlations between Variables

Bivariate correlation analysis was performed to analyze the relationship between the adjective pairs of the pleasure and arousal scales and the relationships between the pleasure, arousal, and desire to be in scales. To deeply understand the relationships between the factors used in this study, Pearson correlation tests were applied to the factors.

According to the test results, there is a positive relationship between the desire to be in these building forms and the pleasure (r=0.568; p=0.001<0.05) and arousal (r=0.575; p=0.001<0.05) scales. Similarly, there is also a high positive relationship between the pleasure and arousal scales (r=0.969; p=0.001<0.05) (Table 5.13) (See Appendix C, Table C21).

Table 5.13: Bivariate correlation analysis results of correlations between variables

		existence	arousal	pleasure
existence	Pearson Correlation	1	0.575**	0.568**
	Sig. (2-tailed)		0.0001	0.0001
arousal	Pearson Correlation	0.575**	1	0.969**
	Sig. (2-tailed)	0.0001		0.0001
pleasure	Pearson Correlation	0.568**	0.969**	1
	Sig. (2-tailed)	0.0001	0.0001	

According to the analysis made on the adjective pairs of the Pleasure scale, it has been determined that all adjective pairs have a positive and high relationship with each other. However, the highest positive correlation is between the adjective pairs "satisfied-unsatisfied" and "hopeful-despairing" (r=0.934; p=0.001<0.05). The lowest correlation is between "hopeful-despairing" and "happy-unhappy" items (r=0.881; p=0.001<0.05) (See Appendix C, Table C22).

Similarly, it was concluded that all adjective pairs are positively related to each other in the adjective pairs in the arousal scale (See Appendix C, Table C23). According to correlation matrix table, the highest correlation is between the "sleepy-wide awake" and "jittery-dull" adjective pairs (r=0.957; p=0.001<0.05) and the lowest one is between "calm-excited" and "uninterested-stimulated" items (r=0.830; p=0.001<0.05) (See Appendix C, Table C23).

The positive correlation between Mehrabian and Russell's arousal and pleasure adjective pairs and the desire to be in in a building shows the strong relationship between emotional evaluation and the desire to be in or live in a building. In other words, it can be said that users' emotional evaluations affect their desire to be in a place or not.

5.7. Emotional Responses of Participants

Russell and Pratt (1980) claimed that pleasure and arousal scores are essential in the emotional evaluation of the environment and that these scales can be used to measure various emotional states (more detailed in chapter 4). For this purpose, the pleasure and arousal scores of all visual stimuli were placed on the analytical plane developed by them to analyze the users' emotional states in more detail. For this purpose, scatter plot graphics were prepared in SPSS.

According to the results, for layout 1, most of the emotional responses to buildings with metamorphic and parametric curvilinear forms were collected in pleasant-arousing, that is, they created “exciting” emotions in the participants. The emotions created by these two forms are predominantly the same, but the percentage of those who feel "exciting" for the parametric curvilinear form is higher than for the metamorphic one. For the rectilinear form, most of the responses were in the unpleasant-sleepy range, that is, it felt "gloomy" (Figure 5.15).

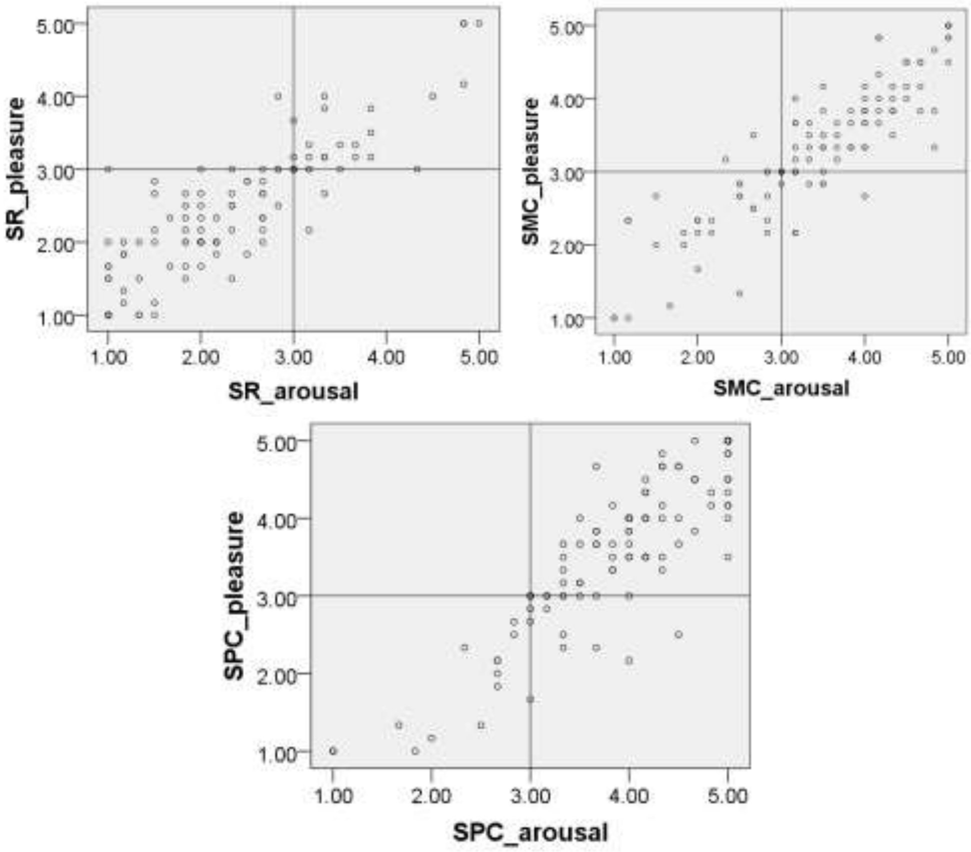

Figure 5.15: Analytical Plane of Bipolar Dimensions for Layout 1 (☐)

In Layout 2, the results are similar to layout 1. Most of the emotional responses to parametric and metamorphic curves are in the pleasant-arousing range, that is, they can be considered as "exciting" and there is no significant difference in the percentages of emotion distributions of these two forms. The answers given for the rectilinear form are generally in the unpleasant- sleepy range, that is, the feeling of "gloomy" is dominant (Figure 5.16).

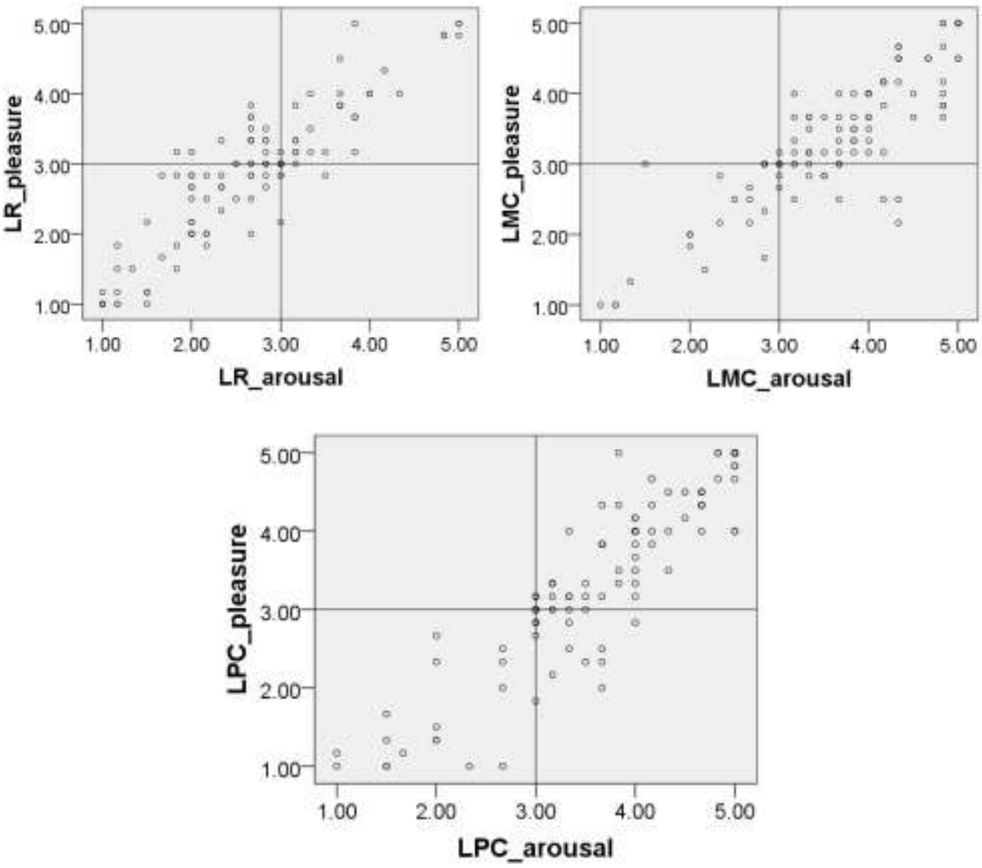

Figure 5.16: Analytical Plane of Bipolar Dimensions for Layout 2 (**L**)

In Layout 3, like other layouts, rectilinear form "gloomy", parametric and metamorphic curvilinear forms are in the "exciting" range. However, the distributions are not as clear as in other layouts. At the same time, the "exciting" range for the rectilinear form is also quite high, and the number of those who feel "gloomy" for the parametric curvilinear form is also high (Figure 5.17).

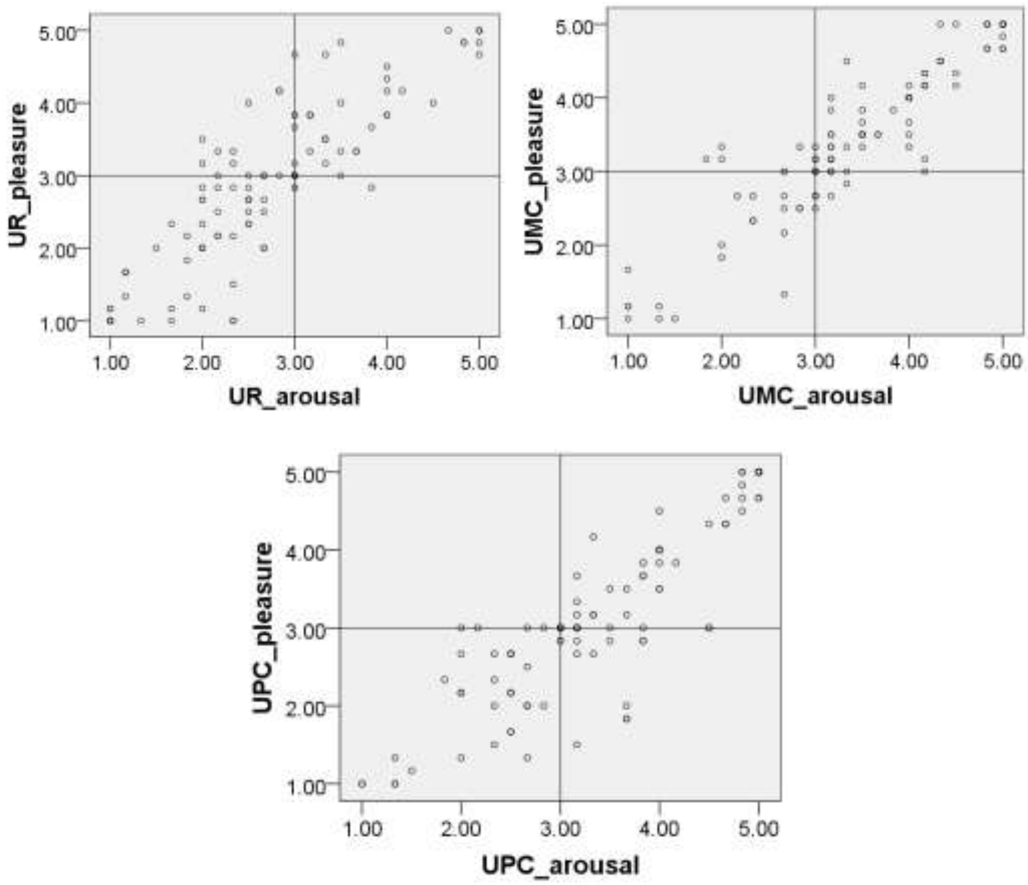

Figure 5.17: Analytical Plane of Bipolar Dimensions for Layout 3 (**U**)

5.8. Discussions

The first aim of this study was to measure users' emotional responses to curved and digitalized building forms and compare them with responses to traditional rectilinear forms. Secondly, it was desired to see the effect of the method of creating the digital curvature on the responses. In order to make measurements, building cases with rectilinear, parametric, and metamorphic curvilinear forms were studied. It was predicted that the participants would give different emotional responses to various forms. Therefore, the arousal and pleasure scores of respondents were compared.

The results may indicate that building forms differentiated people's emotional responses. In addition, there is a difference between the pleasure and arousal scores assigned to the digital curvilinear and rectilinear forms. For all layouts, the results show that the pleasure and arousal scores given to curvilinear forms are higher than rectilinear forms. Similarly, pleasure and arousal scores of rectilinear forms are negative for all layouts (under three) and positive (above three) for digital curvilinear forms. In addition, rectilinear forms were appraised as "gloomy," while curvilinear forms as "exciting" for all layouts.

It can be claimed that there is no significant difference in the pleasure scores given to different methods of producing digital curvilinear forms because the results for layout 1 and layout 3 indicates that there is a significant difference, but for layout 2, there is no difference between metamorphic and parametric curvilinear forms’ pleasure scores. In addition, the pleasure scores assigned to parametric curvilinear forms are higher than those of metamorphic ones in general.

When the arousal scores of the metamorphic and parametric building forms are examined, it has been determined that there is no difference for layout 2 and layout 3, but only for layout 1. Therefore, it can be claimed that there is no significant difference between the arousal scores given to the metamorphic and parametric forms. Both of these forms aroused the feeling of "excitement" on people.

When the users' desire to be in these buildings is examined, it is seen that they are in a positive and strong relationship with pleasure and arousal scores. In answers to the question of desire to be in for Layout 1 and layout 2, there is a significant difference for rectilinear and metamorphic-parametric curvilinear forms, and no significant difference between parametric and metamorphic ones. In Layout 3, on the other hand, no difference was found in the answers given to the three building forms. However, for all layouts, rectilinear forms have more "I don't want to be or live in this building" response, while digital curvilinear forms have the higher respond of "I would like to be in this building but I don't want to be or live in".

Whether the participants studied art, design or architecture or not, did not affect their emotional responses. No difference was found between the answers given by these two groups in terms of pleasure and arousal scores. It was predicted that there would be a positive bias towards curvilinear forms in those who received design education, but this hypothesis was rejected. However, in general, those who do not study art, design and architecture have higher pleasure and arousal scores for all rectilinear or digital curvilinear building forms.

Considering the difference between the layouts and the degree of enclosure, there is no difference between the pleasure and arousal scores of the three layouts. In other words, it was seen that the degree of enclosure that stems from square, L or U-shaped plans did not make any difference on the responses of the users. However, although there is no significant difference, the pleasure and arousal scores of the l-plan building forms are higher than square and U plans.

Finally, it can be said that digital curvilinear forms created for this study in general evoke more positive emotions in participants than rectilinear forms. Curvilinear forms was evaluated as pleasant, aroused and excited, while rectilinear forms as unpleasant, sleepy and gloomy. In this sense, the study found similar findings with the studies in the literature and determined that curvilinear forms evoke more positive emotions. However, the contribution of this study has been the knowledge that digital curvilinear forms, which are not designed with classical methods, but produced with new geometric languages and methods, also may evoke more positive feelings.

CHAPTER 6

CONCLUSION

Computer technologies in architecture have primarily changed the design of buildings in recent years, as they present a unique geometric language and various form-finding methodologies. It is commonly acknowledged that, in most circumstances, computer technologies can make the design and production of curvilinear forms more cost-effective and faster than before digitalization and helped to design and construct amorphous curvatures. As a result, curvilinear forms have become increasingly popular in architectural theory and practice.

This study took a user-centered approach to the topic of digital curvilinearity. The purpose of this thesis is to measure users' emotional responses to these curvilinear building forms and compare them with those to rectilinear ones because one of the essential factors in evaluating the environment is aesthetic evaluation, and building form impacts it as mentioned in Chapter 3. For this reason, it is crucial to measure the emotional responses of users related to different building forms.

In this study, twelve building cases were built to measure people's responses to various building forms, including rectilinear and digital curvilinear forms. The emotional responses are measured according to Mehrabian and Russell's adjective pairs via an online questionnaire with visuals of separate building forms.

According to the survey results, the participants' responses to the digital curvilinear forms designed for this thesis are more positive and higher than the traditional rectilinear forms. However, there is no significant difference between the reactions given to the manipulations or drawings made in the computer environment and the forms derived by coding. These results may help designers while making their formal decisions. Moreover, there was no significant difference between the emotional evaluations of people who had or did not have art, design, and architecture education. This situation can be interpreted as the design and design-related training that the users received did not affect the evaluations of the participants for the building cases crated. Finally, it was determined that the participants were more willing to be in digital curvilinear buildings that created for this study than in rectilinear buildings, and their desire to be in various digital curvilinear forms did not differ for various digital curvilinear forms. In this case, it was found that the building forms affect the users' desire to be in, and this desire is in parallel with their emotional evaluations.

The subject of digitalization in architecture is a subject that has been researched theoretically, technically, methodologically, but studies on the evaluations of users on this digitalization process are not very common. For this reason, this study is essential, and the research results can be helpful for architects and designers. At the same time, the results can help both architects and urban designers in their formal decisions. Designers may use the study's findings to create a better physical environment experience for users. However, it is difficult to generalize such that digital curvilinear forms evoke positive feelings and rectilinear forms negative feelings in users. It cannot be determined whether users are approaching it out of purely personal curiosity. In addition, it is not known whether the situation will be different in building case sets with a different reclinear or digital curvilinear form.

6.1 Limitations of the Research

There were some limitations while conducting the thesis study. As the world is under the influence of coronavirus, the questionnaire could not be conducted face-to-face with the participants and was sent to them via digital media. It was stated to the participants that they had to answer the questions on the computer screen, but it was still not possible for everyone to see and evaluate the visual stimuli from the same size, brightness, etc.. of screens. The survey could have been conducted face-to-face and more controlled from a single screen if it had not been during the pandemic period.

Another limitation was related to the length of the survey due to the attention period of people. For this research, only three main rectilinear designs and their metamorphic and parametric curvilinear versions were presented to the participants. As such, the survey took about 15-20 minutes. It was desired to add more digital curvilinear building cases but could not be added due to time constraints. If more building cases were added, the attention and interest of the participants might decrease as the duration of the survey would be longer. For this reason, no more cases were added to get more reliable results.

Finally, due to difficulties and the coronavirus, the experience of space has been reduced to sight for this work. In more realistic environments, participants could experience the form with many senses, and their emotional evaluations could be measured under these conditions.

6.2 Suggestions for Future Studies

There is not much work on the formal results of digitalization processes and user evaluations, and therefore, more studies can be done on this subject. This study was done by preparing 3D renders and presenting them to the participants; the same study can be presented in virtual environments and repeated using devices that can increase reality.

This study was kept at the scale of building forms; however, the formal effects of digitalization on the users' evaluations can be measured by conducting similar studies in the interior environment, landscape architecture, and urban design. The users' emotional responses can be measured in interiors and neighborhoods.

Moreover, some groups of classified digital forms corresponding to digitalization processes were selected in the study, and others were eliminated. This work can also be replicated using topological, isomorphic, animate, caricature, hybrid, kinetic, (un) folding, warped eye, evolutionary, and algorithmic building forms. On the other hand, emotional responses to conventional curvilinear forms and digital curvilinear ones can also be compared in future studies

In this study, only the emotional responses of the users and the curvilinearity of the digital forms were taken into account. However, complexity in forms is also another result of digitalization. The relationship between the user and digital forms can be examined in this context. In addition, factors such as familiarity, meaning, belonging etc., of these forms can be studied in future studies.

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APPENDICES

APPENDIX-A1

English Version of the Questionnaire

This questionnaire will be used for a master's thesis study to be carried out in I.D. Bilkent University, Faculty of Fine Arts, Design and Architecture, Department of Architecture. The aim of the study is to measure emotional responses to building forms. Only individuals over the age of 18 can participate the study. Personal information such as name, address, or phone number are never asked in the survey. Your answers will be used for this study only and will be kept strictly confidential. It takes about 10-15 minutes to answer the questions. In this survey, images of 12 buildings will be shown and you will be asked to answer some questions regarding them. Please use computer or tablet screen for reliable results.

Thank you for participating our research. If you have any questions or any technical problems, you can contact us at naciye.kara@bilkent.edu.tr.

Part-I Demographic Information

Gender

○ Female ○ Male

Age

○ 18-24

○ 25-34

○ 35-44

○ 45-54

○ 55-64

○ 65-74

Subject of Education

○ Social Sciences and Humanities

○ Science and Engineering Sciences

○ Art, Design and Architecture

○ Other (please specify)

Part-II

Please rate how you feel when you see the building in the visual according to the following adjectives.

	1	2	3	4	5	
Unhappy						Happy
Annoyed						Pleased
Unsatisfied						Satisfied
Melancholic						Contented
Despairing						Hopeful
Bored						Entertained
Uninterested						Stimulated
Calm						Excited
Sluggish						Frenzied
Jittery						Dull
Sleepy						Wide-awake
Unaroused						Aroused

Part-III

Would you like to live or be in the building you have seen?

- ○ I would like to be and live in this building.
- ○ I would like to be in this building, but I do not want to live in.
- ○ I don't want to be or live in this building.

APPENDIX-A2

Turkish Version of the Questionnaire

Bu anket, I.D. Bilkent Üniversitesi, Güzel Sanatlar Tasarım ve Mimarlık Fakültesi, Mimarlık Bölümünde yapılacak olan bir yüksek lisans tezi çalışması için kullanılacaktır. Çalışmanın amacı, mimari yapılara verilen duygusal tepkileri ölçmektir. Bu araştırmaya yalnızca 18 yaşın üzerindeki bireyler katılabilir. Ankette, isim, adres veya telefon numarası gibi kişisel bilgiler kesinlikle sorulmamaktadır. Verdiğiniz cevaplar, sadece bu çalışma için kullanılacak olup, kesinlikle gizli tutulacaktır. Soruları cevaplamak için yaklaşık 10-15 dakika harcamanız gerekmektedir. Bu ankette, 12 adet yapıya ait görseller gösterilecek ve bunlara yönelik bazı soruları cevaplamanız istenecektir. Anketin sağlıklı sonuçlanması için bilgisayar ve ya tablet ekranı kullanmanız önerilir.

Araştırmamıza katıldığınız için teşekkür ederiz. Sorunuz ya da herhangi bir teknik probleminiz olursa, naciye.kara@bilkent.edu.tr mail adresiyle iletişime geçebilirsiniz.

Part-I Demografik Bilgiler

Cinsiyet

○ Kadın ○ Erkek

Yaş

○ 18-24

○ 25-34

○ 35-44

○ 45-54

○ 55-64

○ 65-74

Eğitim aldığınız veya almakta olduğunuz alan nedir?

○ Sosyal ve Beşeri Bilimler

○ Fen ve Mühendislik Bilimleri

○ Güzel Sanatlar, Tasarım ve Mimarlık

○ Diğer (lütfen belirtiniz)

Part-II

Görseldeki yapıyı gördüğünüzde kendinizi nasıl hissettiğinizi aşağıdaki sıfatlar doğrultusunda derecelendiriniz.

	1	2	3	4	5	
Mutsuz						Mutlu
Rahatsız olmuş hissettim						Rahatlamış hissettim
Tatmin olmadım						Tatmin oldum
Hüzünlü						Neşeli
Umutsuz hissettim						Umut dolu hissettim
Sıkıldım						Eğlendim
İlgimi çekmedi						İlgimi çekti
Sakin hissettim						Heyecanlanmış hissettim
Uyuşuk hissettim						Coşkulu hissettim
Donuk hissettim						Enerjik hissettim
Uykulu hissettim						Zinde hissettim
Uyarılmamış hissettim						Uyarılmış hissettim

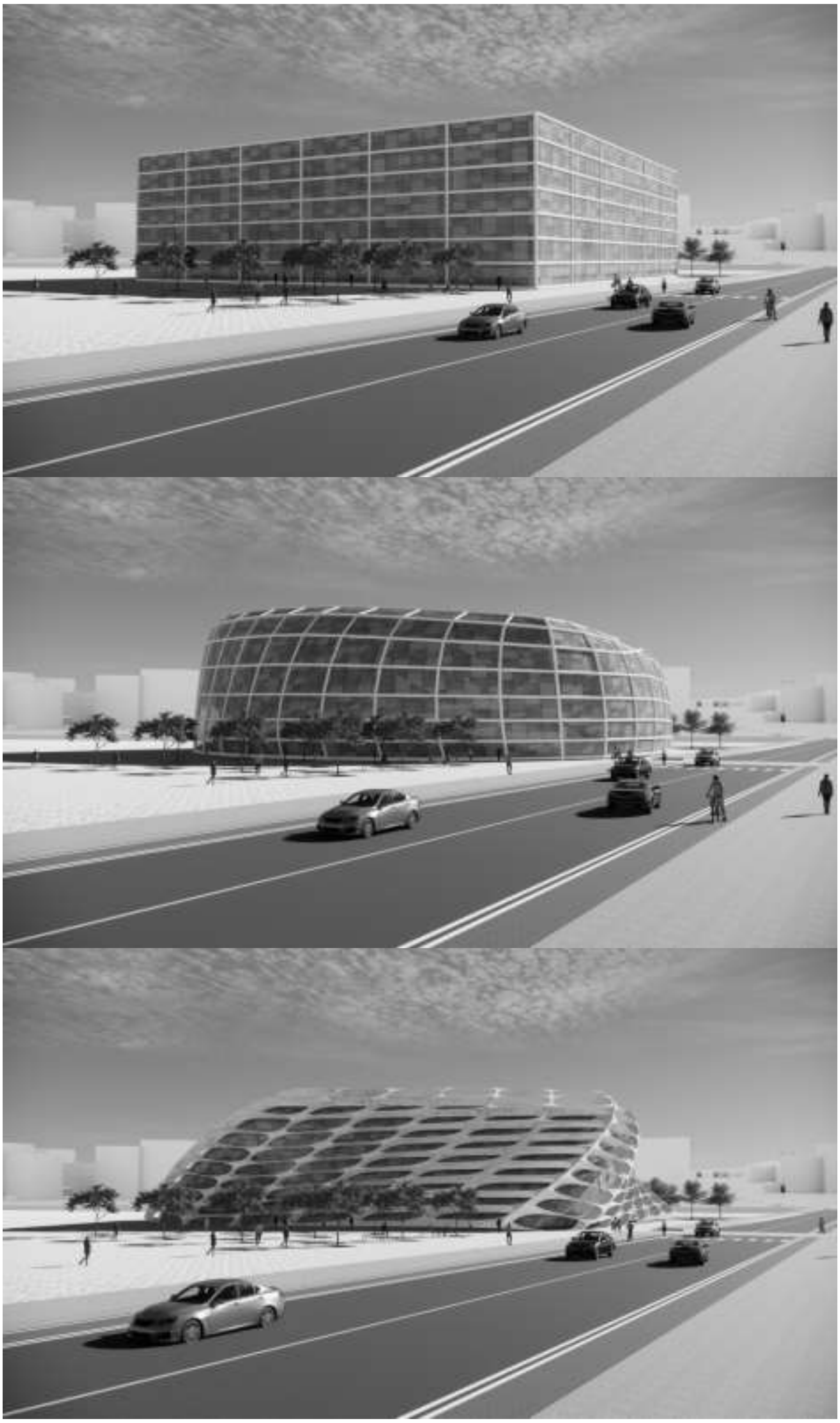
Part-II

Görmüş olduğunuz yapının içerisinde bulunmak ve ya yaşamak ister misiniz?

- ○ Bu yapıda bulunmak ve yaşamak isterim
- ○ Bu yapıda bulunmak veya yaşamak istemem
- ○ Bu yapıda bulunmak isterim ancak yaşamak istemem.

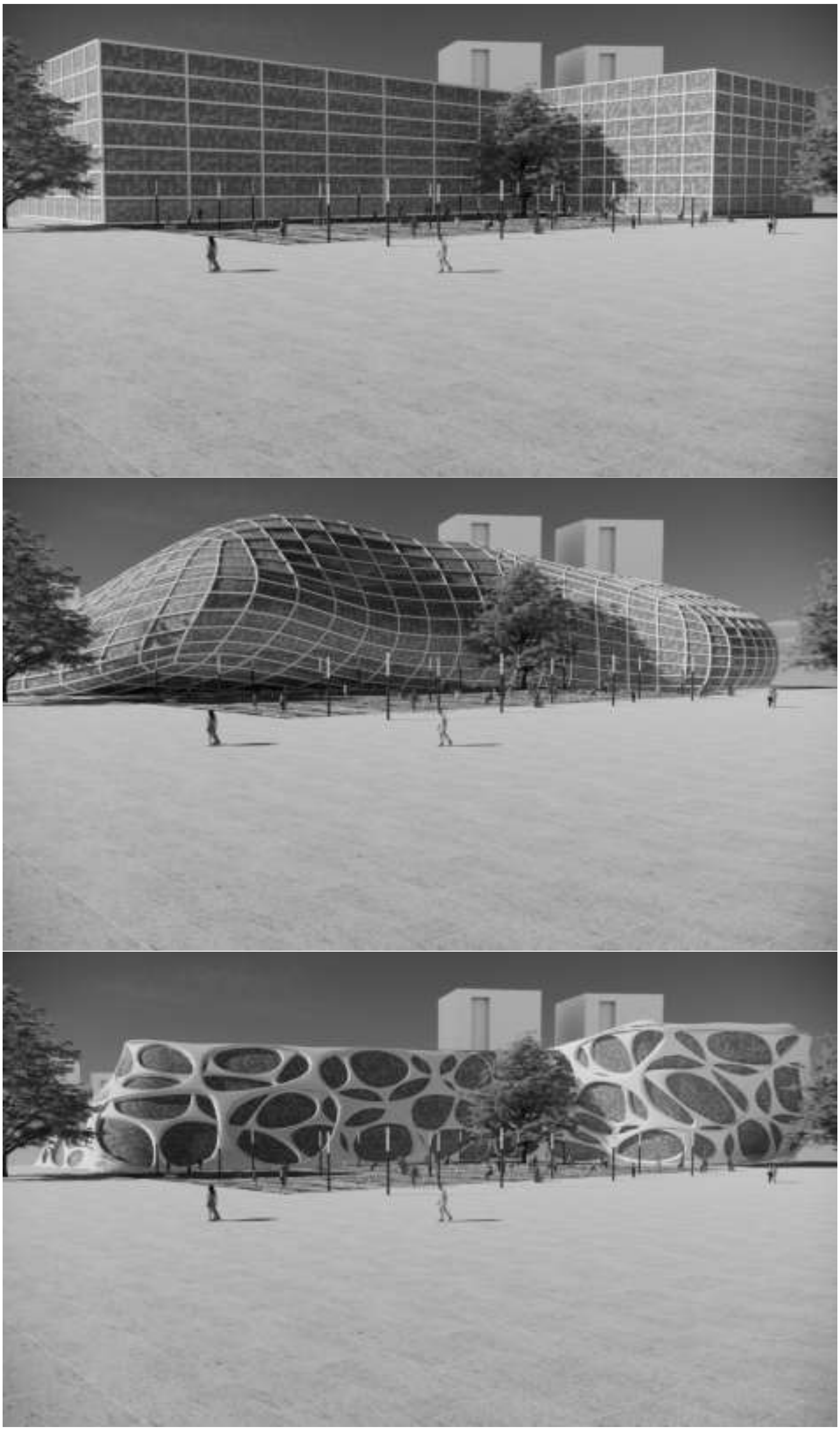
APPENDIX-B1

Layout 1: (Above) SR, (Middle) SMC, (Below) SPC



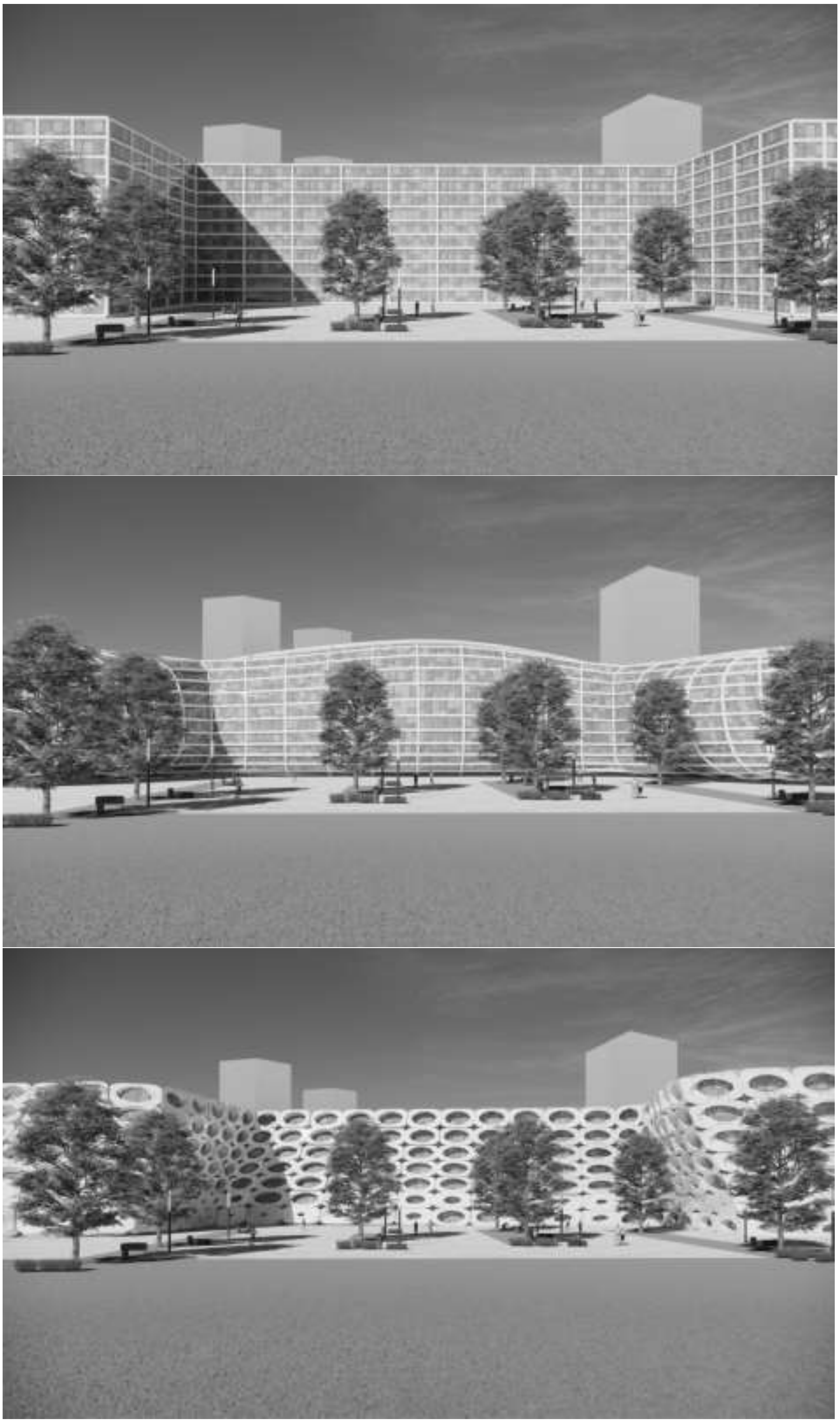
APPENDIX-B2

Layout 2: (Above) LR, (Middle) LMC, (Below) LPC



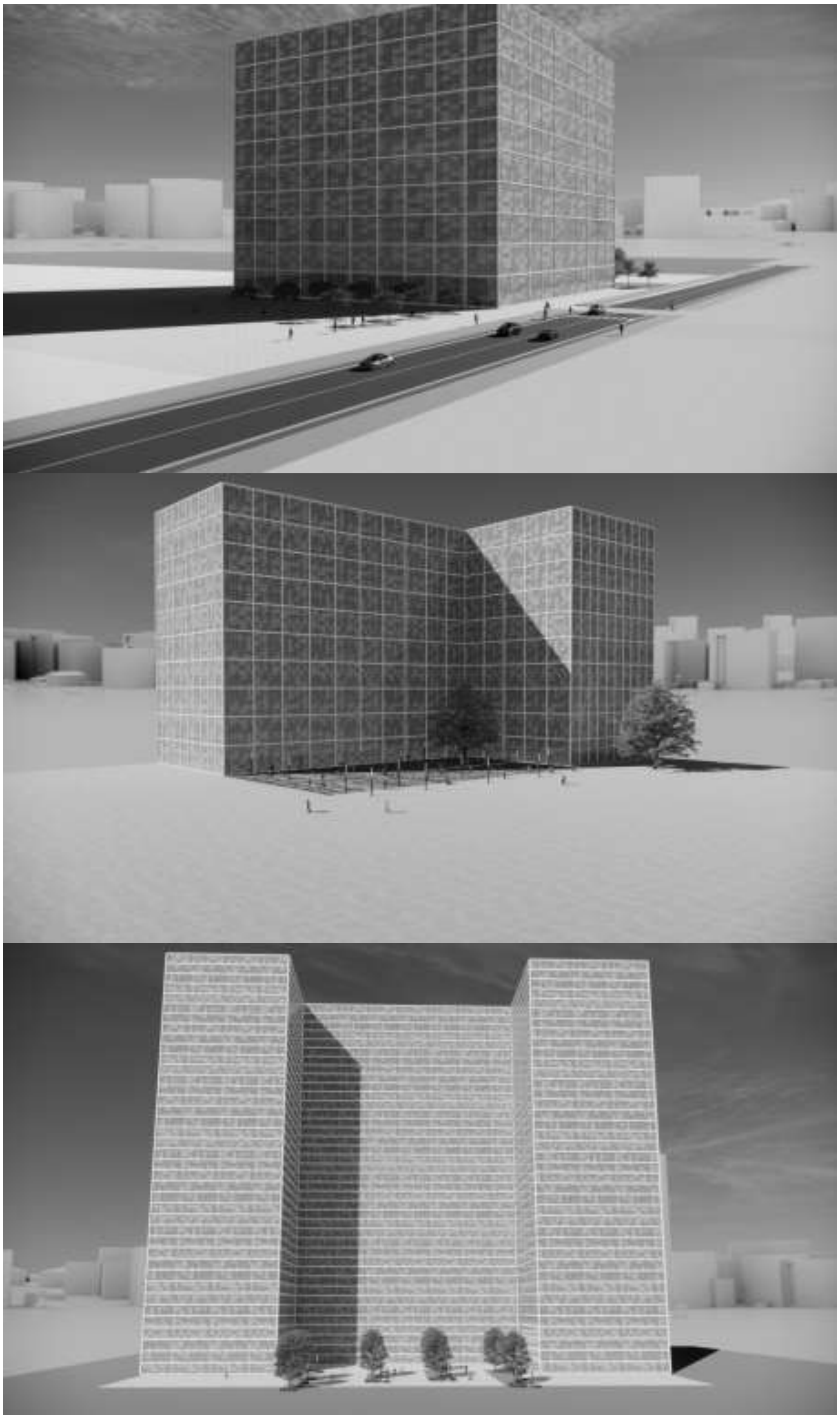
APPENDIX-B3

Layout 3: (Above) UR, (Middle) UMC, (Below) UPC



APPENDIX-B4

Buffer Settings: (Above) B1, (Middle) B2, (Below) B3



APPENDIX-C

Statistical Analysis

Table C1. Internal Consistency Reliability Test Scores for Overall Items

Reliability Statistics

Cronbach's Alpha	N of Items
.980	117

Table C2. Internal Consistency Reliability Test Scores of Pleasure Scale

Reliability Statistics

Cronbach's Alpha	N of Items
.968	54

Table C3. Internal Consistency Reliability Test Scores of Pleasure Arousal Scale

Reliability Statistics

Cronbach's Alpha	N of Items
.966	54

Table C4. Internal Consistency Reliability Test Scores of Desire to Be in Scale

Reliability Statistics

Cronbach's Alpha	N of Items
.811	9

Table C5. Normality test result

Descriptives

		Statistic	Std. Error
SMC_pleasure	Mean	3.3173	.08687
	Skewness	-.246	.226
	Kurtosis	-.015	.449
SPC_pleasure	Mean	3.6140	.10008
	Skewness	-.660	.226
	Kurtosis	-.086	.449
SR_pleasure	Mean	2.4064	.08580
	Skewness	.432	.226
	Kurtosis	.235	.449
LMC_pleasure	Mean	3.4298	.08942
	Skewness	-.266	.226
	Kurtosis	-.053	.449
LR_pleasure	Mean	2.8289	.09202
	Skewness	-.092	.226
	Kurtosis	-.124	.449
LPC_pleasure	Mean	3.4927	.10899
	Skewness	-.501	.226
	Kurtosis	-.552	.449
UR_pleasure	Mean	2.8655	.10566
	Skewness	-.017	.226
	Kurtosis	-.685	.449
UMC_pleasure	Mean	3.4459	.09534
	Skewness	-.360	.226
	Kurtosis	-.080	.449
UPC_pleasure	Mean	3.2120	.10606
	Skewness	.049	.226
	Kurtosis	-.760	.449
SMC_arousal	Mean	3.4196	.09531
	Skewness	-.408	.226
	Kurtosis	-.351	.449
SPC_arousal	Mean	3.8947	.08841
	Skewness	-.910	.226
	Kurtosis	.862	.449
SR_arousal	Mean	2.3143	.09342
	Skewness	.569	.226
	Kurtosis	-.099	.449
LMC_arousal	Mean	3.6477	.08878
	Skewness	-.568	.226
	Kurtosis	.139	.449
LR_arousal	Mean	2.6389	.08842
	Skewness	.296	.226
	Kurtosis	.041	.449
LPC_arousal	Mean	3.7047	.09614
	Skewness	-.586	.226
	Kurtosis	-.182	.449
UR_arousal	Mean	2.6959	.09643
	Skewness	.333	.226
	Kurtosis	-.146	.449
UMC_arousal	Mean	3.4284	.09435
	Skewness	-.329	.226
	Kurtosis	-.117	.449
UPC_arousal	Mean	3.4211	.09890
	Skewness	-.088	.226
	Kurtosis	-.691	.449

Table C6. ANOVA Tests for the Pleasure Scores of Rectilinear and Metamorphic-Parametric Curvilinear Forms

Layout 1:

Multiple Comparisons

Dependent Variable: Layout_1_pleasure

Scheffe

(I) Layout_1	(J) Layout_1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SR	SMC	-.91082*	.12890	.000	-1.2277	-.5939
	SPC	-1.20760*	.12890	.000	-1.5245	-.8907
SMC	SR	.91082*	.12890	.000	.5939	1.2277
	SPC	-.29678	.12890	.072	-.6137	.0201
SPC	SR	1.20760*	.12890	.000	.8907	1.5245
	SMC	.29678	.12890	.072	-.0201	.6137

*. The mean difference is significant at the 0.05 level.

Layout_1_pleasure

Scheffe[a]

Layout_1	N	Subset for alpha = 0.05	
		1	2
SR	114	2.4064	
SMC	114		3.3173
SPC	114		3.6140
Sig.		1.000	.072

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Layout 2:

Multiple Comparisons

Dependent Variable: Layout_2_pleasure

Scheffe

(I) Layout_2	(J) Layout_2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
LR	LMC	-.60088*	.13746	.000	-.9388	-.2629
	LPC	-.66374*	.13746	.000	-1.0017	-.3258
LMC	LR	.60088*	.13746	.000	.2629	.9388
	LPC	-.06287	.13746	.901	-.4008	.2751
LPC	LR	.66374*	.13746	.000	.3258	1.0017
	LMC	.06287	.13746	.901	-.2751	.4008

*. The mean difference is significant at the 0.05 level.

Layout_2_pleasure

Scheffe[a]

Layout_2	N	Subset for alpha = 0.05	
		1	2
LR	114	2.8289	
LMC	114		3.4298
LPC	114		3.4927
Sig.		1.000	.901

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Layout 3:

Multiple Comparisons

Dependent Variable: Layout_3_pleasure

Scheffe

(I) Layout_3	(J) Layout_3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
UR	UMC	-.58041*	.14492	.000	-.9367	-.2241
	UPC	-.34649	.14492	.039	-.7028	.0098
UMC	UR	.58041*	.14492	.000	.2241	.9367
	UPC	.23392	.14492	.273	-.1224	.5902
UPC	UR	.34649	.14492	.039	-.0098	.7028
	UMC	-.23392	.14492	.273	-.5902	.1224

*. The mean difference is significant at the 0.05 level.

Layout_3_pleasure

Scheffe[a]

Layout_3	N	Subset for alpha = 0.05	
		1	2
UR	114	2.8655	
UPC	114		3.2120
UMC	114		3.4459
Sig.		.039	.273

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Table C7. Descriptive Statistics for Pleasure Scores of Rectilinear and Metamorphic-Parametric Curvilinear Forms

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SMC_pleasure	114	1.00	5.00	3.3173	.92756
SPC_pleasure	114	1.00	5.00	3.6140	1.06853
SR_pleasure	114	1.00	5.00	2.4064	.91611
LMC_pleasure	114	1.00	5.00	3.4298	.95470
LR_pleasure	114	1.00	5.00	2.8289	.98251
LPC_pleasure	114	1.00	5.00	3.4927	1.16369
UR_pleasure	114	1.00	5.00	2.8655	1.12818
UMC_pleasure	114	1.00	5.00	3.4459	1.01791
UPC_pleasure	114	1.00	5.00	3.2120	1.13241
Valid N (listwise)	114				

Table C8. ANOVA Tests for the Arousal Scores of Rectilinear and Metamorphic-Parametric Curvilinear Forms

Layout 1:

Multiple Comparisons

Dependent Variable: Layout_1_arousal

Scheffe

(I) Layout_1	(J) Layout_1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
SR	SMC	-1.10526*	.13071	.000	-1.4266	-.7839
	SPC	-1.58041*	.13071	.000	-1.9018	-1.2591
SMC	SR	1.10526*	.13071	.000	.7839	1.4266
	SPC	-.47515*	.13071	.002	-.7965	-.1538
SPC	SR	1.58041*	.13071	.000	1.2591	1.9018
	SMC	.47515*	.13071	.002	.1538	.7965

*. The mean difference is significant at the 0.05 level.

Layout_1_arousal

Scheffe[a]

Layout_1	N	Subset for alpha = 0.05		
		1	2	3
SR	114	2.3143		
SMC	114		3.4196	
SPC	114			3.8947
Sig.		1.000	1.000	1.000

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Layout 2:

Multiple Comparisons

Dependent Variable: Layout_2_arousal

Scheffe

(I) Layout_2	(J) Layout_2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
LR	LMC	-1.00877*	.12895	.000	-1.3258	-.6917
	LPC	-1.06579*	.12895	.000	-1.3828	-.7487
LMC	LR	1.00877*	.12895	.000	.6917	1.3258
	LPC	-.05702	.12895	.907	-.3741	.2600
LPC	LR	1.06579*	.12895	.000	.7487	1.3828
	LMC	.05702	.12895	.907	-.2600	.3741

*. The mean difference is significant at the 0.05 level.

Layout_2_arousal

Scheffe[a]

Layout_2	N	Subset for alpha = 0.05	
		1	2
LR	114	2.6389	
LMC	114		3.6477
LPC	114		3.7047
Sig.		1.000	.907

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Layout 3:

Multiple Comparisons

Dependent Variable: Layout_3_arousal

Scheffe

(I) Layout_3	(J) Layout_3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
UR	UMC	-.73246*	.13658	.000	-1.0683	-.3967
	UPC	-.72515*	.13658	.000	-1.0609	-.3893
UMC	UR	.73246*	.13658	.000	.3967	1.0683
	UPC	.00731	.13658	.999	-.3285	.3431
UPC	UR	.72515*	.13658	.000	.3893	1.0609
	UMC	-.00731	.13658	.999	-.3431	.3285

*. The mean difference is significant at the 0.05 level.

Layout_3_arousal

Scheffe[a]

Layout_3	N	Subset for alpha = 0.05	
		1	2
UR	114	2.6959	
UPC	114		3.4211
UMC	114		3.4284
Sig.		1.000	.999

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Table C9. Descriptive Statistics for Arousal Scores of Rectilinear and Metamorphic-Parametric Curvilinear Forms

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
SMC_arousal	114	1.00	5.00	3.4196	1.01760
SPC_arousal	114	1.00	5.00	3.8947	.94392
SR_arousal	114	1.00	5.00	2.3143	.99748
LMC_arousal	114	1.00	5.00	3.6477	.94795
LR_arousal	114	1.00	5.00	2.6389	.94409
LPC_arousal	114	1.00	5.00	3.7047	1.02645
UR_arousal	114	1.00	5.00	2.6959	1.02961
UMC_arousal	114	1.00	5.00	3.4284	1.00734
UPC_arousal	114	1.00	5.00	3.4211	1.05601
Valid N (listwise)	114				

Table C10. ANOVA Results of Participants' Desire to Be or Live in for Layout1

Multiple Comparisons

Dependent Variable: Existence_Layout1

Scheffe

(I) Layout1	(J) Layout1	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
R	MC	-.53509*	.08712	.000	-.7493	-.3209
	PC	-.57895*	.08712	.000	-.7931	-.3648
MC	R	.53509*	.08712	.000	.3209	.7493
	PC	-.04386	.08712	.881	-.2580	.1703
PC	R	.57895*	.08712	.000	.3648	.7931
	MC	.04386	.08712	.881	-.1703	.2580

*. The mean difference is significant at the 0.05 level.

Existence_Layout1

Scheffe[a]

Layout1	N	Subset for alpha = 0.05	
		1	2
R	114	1.5000	
MC	114		2.0351
PC	114		2.0789
Sig.		1.000	.881

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Table C11. Descriptive Statistics of Participants' Desire to Be in for Layout1

Statistics

		SR_existence	SMC_existence	SPC_existence
N	Valid	114	114	114
	Missing	0	0	0
Mean		1.5000	2.0351	2.0789
Median		1.0000	2.0000	2.0000
Mode		1.00	2.00	2.00

SR_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	64	56.1	56.1	56.1
	I would like to be in this building but I dont want to be live in.	43	37.7	37.7	93.9
	I would like to be in live in this building.	7	6.1	6.1	100.0
	Total	114	100.0	100.0	

SMC_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	25	21.9	21.9	21.9
	I would like to be in this building but I dont want to be live in.	60	52.6	52.6	74.6
	I would like to be in live in this building.	29	25.4	25.4	100.0
	Total	114	100.0	100.0	

SPC_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	21	18.4	18.4	18.4
	I would like to be in this building but I dont want to be live in.	63	55.3	55.3	73.7
	I would like to be in live in this building.	30	26.3	26.3	100.0
	Total	114	100.0	100.0	

Table C12. ANOVA Results of Participants' Desire to Be in for Layout2

ANOVA

Existence_Layout2

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.789	2	2.395	4.926	.008
Within Groups	164.789	339	.486		
Total	169.579	341			

Multiple Comparisons

Dependent Variable: Existence_Layout2

Scheffe

(I) Layout2	(J) Layout2	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
R	MC	-.23684*	.09235	.038	-.4639	-.0098
	PC	-.26316*	.09235	.018	-.4902	-.0361
MC	R	.23684*	.09235	.038	.0098	.4639
	PC	-.02632	.09235	.960	-.2534	.2007
PC	R	.26316*	.09235	.018	.0361	.4902
	MC	.02632	.09235	.960	-.2007	.2534

*. The mean difference is significant at the 0.05 level.

Existence_Layout2

Scheffe[a]

Layout2	N	Subset for alpha = 0.05	
		1	2
R	114	1.7982	
MC	114		2.0351
PC	114		2.0614
Sig.		1.000	.960

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Table C13. Descriptive Statistics of Participants' Desire to Be in for Layout2

Statistics

		LR_existence	LMC_existence	LPC_existence
N	Valid	114	114	114
	Missing	0	0	0
Mean		1.7982	2.0351	2.0614
Median		2.0000	2.0000	2.0000
Mode		2.00	2.00	2.00

LR_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	43	37.7	37.7	37.7
	I would like to be in this building but I dont want to be live in.	51	44.7	44.7	82.5
	I would like to be in live in this building.	20	17.5	17.5	100.0
	Total	114	100.0	100.0	

LMC_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	19	16.7	16.7	16.7
	I would like to be in this building but I dont want to be live in.	72	63.2	63.2	79.8
	I would like to be in live in this building.	23	20.2	20.2	100.0
	Total	114	100.0	100.0	

LPC_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	29	25.4	25.4	25.4
	I would like to be in this building but I dont want to be live in.	49	43.0	43.0	68.4
	I would like to be in live in this building.	36	31.6	31.6	100.0
	Total	114	100.0	100.0	

Table C14. ANOVA Results of Participants' Desire to Be in for Layout3

ANOVA

Existence_Layout3

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.175	2	1.088	1.914	.149
Within Groups	192.693	339	.568		
Total	194.868	341			

Multiple Comparisons

Dependent Variable: Existence_Layout3

Scheffe

(I) Layout3	(J) Layout3	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
R	MC	-.19298	.09986	.156	-.4385	.0525
	PC	-.12281	.09986	.470	-.3683	.1227
MC	R	.19298	.09986	.156	-.0525	.4385
	PC	.07018	.09986	.781	-.1753	.3157
PC	R	.12281	.09986	.470	-.1227	.3683
	MC	-.07018	.09986	.781	-.3157	.1753

Existence_Layout3

Scheffe[a]

Layout3	N	Subset for alpha = 0.05
		1
R	114	1.8158
PC	114	1.9386
MC	114	2.0088
Sig.		.156

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Table C15. Descriptive Statistics of Participants' Desire to Be in for Layout3

Statistics

		UR_existence	UMC_existence	UPC_existence
N	Valid	114	114	114
	Missing	0	0	0
Mean		1.8158	2.0088	1.9386
Median		2.0000	2.0000	2.0000
Mode		2.00	2.00	2.00

UR_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	42	36.8	36.8	36.8
	I would like to be in this building but I dont want to be live in.	51	44.7	44.7	81.6
	I would like to be in live in this building.	21	18.4	18.4	100.0
	Total	114	100.0	100.0	

UMC_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	32	28.1	28.1	28.1
	I would like to be in this building but I dont want to be live in.	49	43.0	43.0	71.1
	I would like to be in live in this building.	33	28.9	28.9	100.0
	Total	114	100.0	100.0	

UPC_existence

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I dont want to be or live in this building	38	33.3	33.3	33.3
	I would like to be in this building but I dont want to be live in.	45	39.5	39.5	72.8
	I would like to be in live in this building.	31	27.2	27.2	100.0
	Total	114	100.0	100.0	

Table C16. Pleasure Scores for Factor Education Subject

Group Statistics

	new_education_subject	N	Mean	Std. Deviation	Std. Error Mean
rectilinear_pleasure	art_education	47	2.5083	.71662	.10453
	non_art_education	67	2.8350	.90989	.11116
metamorphic_curvilinear_pleasure	art_education	47	3.3322	.67103	.09788
	non_art_education	67	3.4436	.83879	.10247
parametric_curvilinear_pleasure	art_education	47	3.2707	.80563	.11751
	non_art_education	67	3.5580	1.02030	.12465

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
rectilinear_pleasure	Equal variances assumed	3.008	.086	-2.054	112	.042	-.32672	.15905	-.64186	-.01157
	Equal variances not assumed			-2.141	110.435	.034	-.32672	.15259	-.62910	-.02434
metamorphic_curvilinear_pleasure	Equal variances assumed	1.611	.207	-.757	112	.451	-.11146	.14732	-.40337	.18044
	Equal variances not assumed			-.787	109.998	.433	-.11146	.14171	-.39230	.16937
parametric_curvilinear_pleasure	Equal variances assumed	2.979	.087	-1.610	112	.110	-.28736	.17849	-.64101	.06630
	Equal variances not assumed			-1.677	110.367	.096	-.28736	.17131	-.62684	.05212

Table C17. Arousal Scores for Factor Education Subject

Group Statistics

	new_education_subject	N	Mean	Std. Deviation	Std. Error Mean
parametric_curvilinear_arousal	art_education	47	3.5839	.73738	.10756
	non_art_education	67	3.7363	.90579	.11066
metamorphic_curvilinear_arousal	art_education	47	3.4728	.74921	.10928
	non_art_education	67	3.5166	.80936	.09888
rectilinear_arousal	art_education	47	2.2908	.61289	.08940
	non_art_education	67	2.7313	.93427	.11414

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
parametric_curvilinear_arousal	Equal variances assumed	1.137	.289	-.953	112	.343	-.15239	.15996	-.46934	.16455
	Equal variances not assumed			-.988	109.451	.326	-.15239	.15432	-.45824	.15345
metamorphic_curvilinear_arousal	Equal variances assumed	.065	.800	-.293	112	.770	-.04377	.14940	-.33979	.25225
	Equal variances not assumed			-.297	103.705	.767	-.04377	.14738	-.33603	.24849
rectilinear_arousal	Equal variances assumed	7.139	.009	-2.832	112	.005	-.44056	.15558	-.74883	-.13230
	Equal variances not assumed			-3.039	111.571	.003	-.44056	.14498	-.72784	-.15329

Table C18. Pleasure Scores for Layout Differences

ANOVA

pleasure

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.088	2	.544	.914	.402
Within Groups	201.676	339	.595		
Total	202.764	341			

Multiple Comparisons

Dependent Variable: pleasure

Scheffe

(I) Building_Form	(J) Building_Form	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
S	L	-.13791	.10216	.403	-.3891	.1133
	U	-.06189	.10216	.832	-.3131	.1893
L	S	.13791	.10216	.403	-.1133	.3891
	U	.07602	.10216	.758	-.1752	.3272
U	S	.06189	.10216	.832	-.1893	.3131
	L	-.07602	.10216	.758	-.3272	.1752

pleasure

Scheffe[a]

Building_Form	N	Subset for alpha = 0.05
		1
S	114	3.1126
U	114	3.1745
L	114	3.2505
Sig.		.403

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Table C19. Arousal Scores for Layout Differences

ANOVA

arousal

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.424	2	.712	1.310	.271
Within Groups	184.180	339	.543		
Total	185.604	341			

Multiple Comparisons

Dependent Variable: arousal

Scheffe

(I) Building_Form	(J) Building_Form	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
S	L	-.12086	.09763	.466	-.3609	.1192
	U	.02778	.09763	.960	-.2123	.2678
L	S	.12086	.09763	.466	-.1192	.3609
	U	.14864	.09763	.315	-.0914	.3887
U	S	-.02778	.09763	.960	-.2678	.2123
	L	-.14864	.09763	.315	-.3887	.0914

arousal

Scheffe[a]

Building_Form	N	Subset for alpha = 0.05
		1
U	114	3.1818
S	114	3.2096
L	114	3.3304
Sig.		.315

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 114.000.

Table C20. Descriptive Statistics of Pleasure and Arousal Means for Layout Differences

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
S_total_pleasure	114	1.06	5.00	3.1126	.74059
L_total_pleasure	114	1.06	5.00	3.2505	.75941
U_total_pleasure	114	1.00	4.83	3.1745	.81213
S_total_arousal	114	1.06	5.00	3.2096	.74124
L_total_arousal	114	1.00	5.00	3.3304	.71677
U_total_arousal	114	1.22	5.00	3.1818	.75280
Valid N (listwise)	114				

Table C21. Correlations between Pleasure, Arousal and Desire to Be in Scores

Correlations

		existence	arousal	pleasure
existence	Pearson Correlation	1	.575**	.568**
	Sig. (2-tailed)		.000	.000
	N	114	114	114
arousal	Pearson Correlation	.575**	1	.969**
	Sig. (2-tailed)	.000		.000
	N	114	114	114
pleasure	Pearson Correlation	.568**	.969**	1
	Sig. (2-tailed)	.000	.000	
	N	114	114	114

**. Correlation is significant at the 0.01 level (2-tailed).

Table C22. Correlations between Adjective Pairs of Pleasure Scale

Correlations

		happy_unhappy	pleased_annoyed	satisfied_unsatisfied	melancholic_contented	hopeful_despairing	bored_entertained
happy_unhappy	Pearson Correlation	1	.917**	.903**	.929**	.881**	.898**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	114	114	114	114	114	114
pleased_annoyed	Pearson Correlation	.917**	1	.930**	.906**	.921**	.905**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	114	114	114	114	114	114
satisfied_unsatisfied	Pearson Correlation	.903**	.930**	1	.908**	.934**	.932**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	114	114	114	114	114	114
melancholic_contented	Pearson Correlation	.929**	.906**	.908**	1	.923**	.932**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	114	114	114	114	114	114
hopeful_despairing	Pearson Correlation	.881**	.921**	.934**	.923**	1	.929**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	114	114	114	114	114	114
bored_entertained	Pearson Correlation	.898**	.905**	.932**	.932**	.929**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	114	114	114	114	114	114

**. Correlation is significant at the 0.01 level (2-tailed).

Table C23. Correlations between Adjective Pairs of Arousal Scale

Correlations

		uninterested_stimulated	calm_excited	sluggish_frienzied	jittery_dull	sleepy_wideawake	aroused_unaroused
uninterested_stimulated	Pearson Correlation	1	.830**	.907**	.910**	.889**	.888**
	Sig. (2-tailed)		.000	.000	.000	.000	.000
	N	114	114	114	114	114	114
calm_excited	Pearson Correlation	.830**	1	.863**	.842**	.849**	.852**
	Sig. (2-tailed)	.000		.000	.000	.000	.000
	N	114	114	114	114	114	114
sluggish_frienzied	Pearson Correlation	.907**	.863**	1	.946**	.954**	.910**
	Sig. (2-tailed)	.000	.000		.000	.000	.000
	N	114	114	114	114	114	114
jittery_dull	Pearson Correlation	.910**	.842**	.946**	1	.957**	.925**
	Sig. (2-tailed)	.000	.000	.000		.000	.000
	N	114	114	114	114	114	114
sleepy_wideawake	Pearson Correlation	.889**	.849**	.954**	.957**	1	.922**
	Sig. (2-tailed)	.000	.000	.000	.000		.000
	N	114	114	114	114	114	114
aroused_unaroused	Pearson Correlation	.888**	.852**	.910**	.925**	.922**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	
	N	114	114	114	114	114	114

**. Correlation is significant at the 0.01 level (2-tailed).