PERCEPTION OF SPATIAL ENCLOSURE AS A FUNCTION OF DIFFERENT SPACE BOUNDARIES

A Master's Thesis

by

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PERCEPTION OF SPATIAL ENCLOSURE AS A FUNCTION OF DIFFERENT SPACE BOUNDARIES

The Graduate School of Economics and Social Science

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by

TUĞÇE ELVER

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İHSAN DOĞRAMACI BİLKENT UNIVERSITY

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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

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ABSTRACT

PERCEPTION OF SPATIAL ENCLOSURE AS A FUNCTION OF DIFFERENT SPACE BOUNDARIES

Elver, Tuğçe

MFA, Department of Interior Architecture and Environmental Design

Supervisor: Prof. Dr. Halime Demirkan

July 2018

The aim of this research is to examine the relationship between the perception of spaciousness and curvilinear boundaries related to different specific properties of the environment such as size, light, texture and color. This relationship is identified by the aesthetic judgements and emotional responses of the participants through a virtual environment. Study conducted in virtual reality environment and 128 participants participate in this research study. Sixteen different physical property spaces were designed to measure the perception of spaciousness, aesthetic judgement and emotional responses. Each participant was responsible for only one specific property. The survey has included both ranking and open-ended questions for each setting. Specific properties and curved boundary type was found that there was a significant impact on perception of spaciousness as independent of each other. In this direction, aesthetic and emotional researches were analyzed between specific property group and boundary type group. As a result of the study, perception of spaciousness is positively related with the curved boundary types. Also, the result showed that, perception of spaciousness is positively related with the large size, bright light, transverse texture and cool color spaces. Findings on perception of spaciousness was supported with the relevant adjectives of aesthetic judgements and emotional responses.

Keywords: Aesthetics; Curvilinearity, Emotion, Perception of Spaciousness, Space Boundary

ÖZET

FARKLI MEKAN SINIRLARININ MEKAN ALGISI ÜZERİNDEKİ ETKİLERİ

Elver, Tuğçe

İç Mimarlık ve Çevre Tasarımı Yüksek Lisans Programı

Tez Danışmanı: Prof. Dr. Halime Demirkan

Temmuz 2018

Bu çalışma farklı mekan özelliklerini (boyut, ışık, doku ve renk) göz önüne alarak, eğrisel yatay ve dikey mekan sınırlarının insanların ferahlık algısı üzerinde olan etkisini araştırmaktadır. Sanal gerçeklik yolu ile elde edilen veriler, estetik yargılar ve duygusal yanıtlar ile desteklenmektedir. Araştırma sanal gerçeklik ortamında 128 katılımcıyla gerçekleştirilmiştir. İnsanların farklı fiziksel özelliklere sahip mekanlardaki ferahlık algısını, estetik yargılarını ve duygusal yanıtlarını ölçmek için 16 mekan tasarlanmıştır. Katılımcılar boyut, ışık, doku ve renk mekan türlerinden yalnızca birine katılmıştır. Her bir mekan için nitel ve nicel araştırma yapılmıştır. Farklı fiziksel özelliklere sahip mekan türleri ile eğrisel mekan sınırlarının birbirinden bağımsız olarak insanların ferahlık algısında önemli derecede etkiye sahip olduğu sonucuna varılmıştır. Bu doğrultuda estetik ve duygu araştırmaları mekan türleri grubu ve mekan sınırları gurubu olarak bütünsel bir şekilde analiz edilmiştir. Araştırma sonucunda eğrisel sınırların ferah olarak algılandığı sonucuna ulaşılmıştır. Ayrıca geniş boyutlu, aydınlık, yatay dokulu ve soğuk renkli mekan türlerinin ferahlık algısıyla daha fazla ilişkisi olduğuna varılmıştır. Buna bağlı olarak insanların farklı mekan türlerindeki ferahlık algısı estetik yargı ve duygusal yanıt sıfatları ile kuvvetli sonuçlar ile desteklenmiştir.

Anahtar Kelimeler: Duygu, Eğrisellik, Estetik, Ferahlık Algısı, Mekan Sınırı

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AA= Approach-avoidance

AR= Arousal

AV= Affective Variable

FV= Formal Variable

HB-B= Horizontal Boundary – Bright

HB-C= Horizontal Boundary – Cool

HB-D= Horizontal Boundary – Dim

HB-L= Horizontal Boundary – Large

HB-L= Horizontal Boundary – Longitudinal

HB-S= Horizontal Boundary – Small

HB-T= Horizontal Boundary – Transverse

HB-W= Horizontal Boundary – Warm

PL= Pleasure

SV= Symbolic Variable

VB-B= Vertical Boundary- Bright

VB-C= Vertical Boundary – Cool

VB-D= Vertical Boundary – Dim

VB-L= Vertical Boundary – Longitudinal

VB-L= Vertical Boundary- Large

VB-S= Vertical Boundary – Small

VB-T= Vertical Boundary- Transverse

VB-W= Vertical Boundary- Warm

CHAPTER 1

INTRODUCTION

1.1. Problem Statement

Does the created space environment affect the perception of people?

Absolutely. Today, different properties that affect people's attitudes and feelings towards that space are critical issues that have an impact on people's life quality in created space environment. Previous theoretical and experimental studies in environmental psychology proposed that perception and feelings are essential components of spaces.

This thesis explores the perception of spaciousness in various physical properties and supports the idea with aesthetic judgement and emotional responses as components of feelings. Although numerous studies have been carried out in order to analyze the impact of perception on spaciousness, those were limited to one boundary type or one specific property variable and

few aesthetic and emotional aspects. Thus, this study aims to fill the investigation gap while analyzing the impacts of perception of spaciousness on boundary type (curve horizontal-vertical) and specific property (size, light, texture and color) with aesthetic judgement and emotional responses.

The previous research conducted on the perception of spaciousness either in general considers multiple physical variables (Bokharaei & Nasar, 2016), or the space boundaries that are curvilinear in different forms of the boundaries (Banaei, Ahmadi & Yazdanfar 2017a; Banaei, Hatami, Yazdanfar & Gramann, 2017b; Hobbs, Hunker, Demircay, Rodriguez & Issa, 2015). Also, there are studies that are focused on the aesthetic-emotion analyses related with the different geometric forms and curvilinearity (Alp, 1993; Dazkır, 2009; Dazkır & Read, 2012; Madani Nejad, 2007; Shemesh, Talmon, Karp, Amir, Bar & Grobman, 2016; Vartanian, Navarrete, Chatterjee, Fich, Leder, Modrono, Nadal, Rostrup, & Skov, 2013). However, this study intends to combine the perception of spaciousness with curve boundary type and different specific properties in the space. Furthermore, the perception of spaciousness is related to aesthetic judgement and emotional responses.

1.2. Aim of the Study

The aim of this research is to examine the relationship between the perception of spaciousness and curve boundary types with different specific properties of the environment such as size, light, texture and color. This relationship is identified by the aesthetic judgement and emotional responses of the participants in a virtual environment.

This study focuses on three main aspects in order to create a relationship between the perception of spaciousness-aesthetic judgement and the perception of spaciousness-emotional responses. Firstly, the study investigates the perception of spaciousness in related settings. Correspondingly, the study evaluates peoples' aesthetic judgements (affective, formal, symbolic) as a second stage and emotional responses of people (pleasure-arousal) as a final stage.

1.3. General Structure of the Study

The primary purpose of this study is to provide a relationship between spaciousness and components of feelings that consist of aesthetic judgements and emotional responses. To achieve this purpose, thesis includes six chapters. The first chapter is the introduction that consists of the problem statement, the aim of the study and the general structure of the thesis.

The second chapter with the title "Perceived Spaciousness of Boundaries" presents a brief review of literature while a focusing on the contexts of "Spaciousness in the Environment" and "Physical Properties of the Boundary".

In the third chapter, which is named as "Aesthetic and Emotion", the conceptual framework is proposed and analyzed separately. The context of "Aesthetic and Emotional Versus Curvilinearity" presents the literature review related to feeling components and curvilinearity.

In the fourth chapter, the methodology part consists of the problem statement with the research question and hypotheses. Method of the study, instruments and procedures are provided within the context of methodology.

In the fifth chapter, findings are stated according to the result of the experiments. The sixth chapter consists of discussion and conclusion, where the major findings of this study is compared with the previous research findings and suggestions for further research are composed. Visual and written materials related to the research are included in the appendices.

CHAPTER 2

PERCEIVED SPACIOUSNESS OF BOUNDARIES

This chapter presents a review of literature with the main focus being on the spaciousness of the environment and physical properties of the space boundary. Spaciousness with respect to the specific properties and the environmental properties are the two components that determine the specific properties of the boundary.

2.1. Spaciousness in the Environment

Why have many researches been investigating spaciousness in the environment? Theory provides possible answers to this question. Spaciousness first emerged as a major design determinant in zoos (Hediger, 1950, 1955). Hediger's theory suggests that, the main motivation that any animal has in any environment is simply staying alive by avoiding, identifying or fighting enemies and other situations (Stamps, 2009, 2007). There are

many animals in zoos that are part of the nature but are exposed to captivity and enclosure. Even though animals are taken well care of in zoos, they die prematurely, as they cannot properly complete the stages of their physical and psychological development, like they would in their natural environment. Therefore, lack of spaciousness in zoos proves to be a lethal mistake in terms of zoo design.

According to the theory of evolution, human beings are species of animals, and therefore they share similar instincts with other animals. Restricting closure, spaciousness and freedom affect their attitudes and their life comforts, as well. In case of the lack of adequate space, animals, including humans, feel threatened (Graziano & Cooke, 2006; Hediger, 1955; Stamp, 2010a). Environments that do not provide sufficient space are ambient stressors and, thus they should be avoided, and if they are unavoidable, their effects should be mitigated as much as possible (Stamp, 2011).

Humans also spend approximately 90% of their time indoors with enclosure and they interact intimately with these spaces (Klepeis, Nelson, Ott, Robinson, Tsang, Switzer, Behar, Hern & Engelmann, 2001; Vartanian et al., 2013). Main components of a space are perceived, evaluated and evoke emotional responses for human (Gifford, 2002). Space has both psychological and physiological influences on and interactions with people.

Spaciousness has also been investigated with respect to human behavior in both built and natural environment. This study is mainly focused on the built

environment and literature was investigated within this framework. Bharucha-Reid and Kiak (1982), reported findings for 86 respondents, who evaluated the ratings of the physical room effect (spacious, adequate, well-arranged) for rooms that varied in floor area (4.7 and 22 m^2). It was suggested that, the larger room was evaluated more positively than the smaller room. Research on environmental feeling has confirmed that people prefer larger or more open spaces to smaller or more constricted ones (Ozdemir, 2010).

This explanation is a general assessment of spaciousness. However, in some cases, people can also prefer smaller or more private spaces according to their needs. Perception and measurements of the environmental properties have a variable factor (Nasar, 2008). For spaciousness, physical measures might gauge the length, width, and height of a space, but holistic judgments of spaciousness may occur more to one of these measures than to the others (Thiel, 1997; Stamp, 2011).

One of the fundamental human needs is having enough space for living and spacious atmosphere for both physical and psychological order (Stamps, 2009). Several physical properties of the space affect human perception of spaciousness in many ways. One of the effective aspects of the physical properties is the boundary of space and their properties. The space boundary is a spatial enclosure which is surrounded with walls in order to prevent free ingress or egress (Stamp, 2010a; Stamp & Krishan, 2006). Spaciousness then becomes the apparent size of the region within the boundary.

The investigation of literature determines how the perception of spaciousness within the spatial space boundaries occurs and provides an analysis of the physical properties of the boundary which consist of specific and environmental properties.

2.2. Physical Properties of the Boundary

The physical characteristics of the environment, the human and the activities (Canter, 1977; Relph, 1976; Sack, 1997; Stokols & Schumaker, 1981; Stedman, 2002) are the three main categories that are defined by people-place relationship (Dazkır, 2009). As an environmental characteristic, physical properties of the boundary are related to the sense of spaciousness. The spatial perception can change according to the boundary properties. These changes occur, like an illusion conducted by the architects, according to the situation of the space and human needs (Sadalla & Oxley, 1984).

Accordingly, a series of experiments were carried out to find out how various physical properties of a boundary influence the impressions of spaciousness. Specific properties and environmental properties that affect perceived spaciousness are the two main aspects of physical properties of the spaces (Stamp, 2010a). This study contains people-place and environment focused research, specific properties of the environment and environmental properties of human focus schemas as depicted in Table1.

Table 1. Physical Properties for Spaciousness

Physical Properties	
(1) Specific Properties (environment)	(2) Environmental Properties (human)
-Distance -Gaps -Height -Horizontal Area -Light -Location -Material -Permeability -Shape -Solid Walls	-Boundary Roughness -Height -Horizontal Area -Light -Occlusion -Shape

2.2.1. Spaciousness with Respect to Specific Properties

Specific properties of the environment that affect specific properties on perceived spaciousness have been reported include the following: (a) distance (Stamps, 2005b, 2005c; Stamps & Krishnan, 2004; Stamps & Smith, 2002), (b) gaps (Stamps, 2005c), (c) height (Hayward & Franklin, 1974; Stamps, 2003, 2005c; Stamps & Krishnan, 2004), (d) horizontal area (Hayward & Franklin, 1974; Stamps, 2003, 2005a, 2005b; Stamps & Smith, 2002), (e) light (Stamps, 2005b; Stamps & Smith, 2002), (f) location with respect to observer (Stamp & Krishan 2006; Thiel, Harrison, & Alden, 1986), (g) material (Stamps, 2005a, 2005c, 2006), (h) permeability (Stamps, 2003, 2005c), (i) shape (Stamps, 2005a), and (j) solid walls (Hayward & Franklin, 1974; Stamps, 2005b; Stamps & Smith, 2002).

One extension of those studies is the specific character of the boundary which consists of; size, light, texture and color. These four specific properties are indicated to understand how the boundary properties affect perception of spaciousness.

2.2.1.1. Size

The size of a form consists of three main elements, which are physical dimensions of the length, width and depth. These physical dimensions are the determinants of the form of proportions, and also the scale of the form is determined by its size according to other forms in its context (Ching, 2015). One of the specific properties of the boundary in the perception of spaciousness is the size of the space. Figure 1 depicts Ching's (2015) size variations.

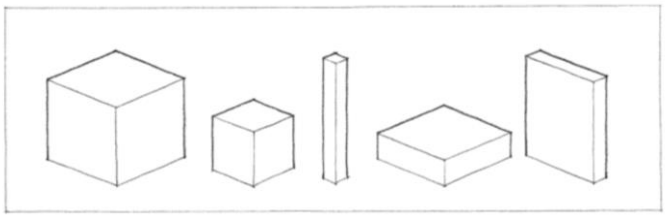


Figure 1. Size Variations (Ching, 2007: 34)

Sadalla and Oxley (1984) explored different geometric shapes of the areas with the same square meter, same size, and emphasized that perceived sizes of the spaces differed from one person to another. Size and form establish a relationship with each other that affects spaciousness at the same time.

Many previous experiments determined the premise that, two rooms of the same objective size may have distinct perceived sizes depending on their shapes. For instance, compared to a space with less rectangles, the area with more rectangles was perceived to be wider as a perception of size. Specifically, the effect of rectangularity (the ratio of length and width) was evaluated. Based on the studies on human perceptual abilities, physical sizes of the space affect the perception of the spaciousness, in particular, the length of the space increases the horizontal distance. Hence, in geometric terminology, rectangular form of a space appears to be larger and more spacious than a square geometric space form in the same objective size (Benedikt & Burnham, 1985; Bokharaei & Nasar, 2016; Franz, Von der Heyde, & Bülthoff, 2005; Franz & Wiener, 2005; Garling, 1970a, 1970b; Hayward & Franklin, 1974; Inui & Miyata, 1973; Stamps, 2007, 2009, 2010a). Based on the previous researches, the findings could be schematized as seen in Figure 2.

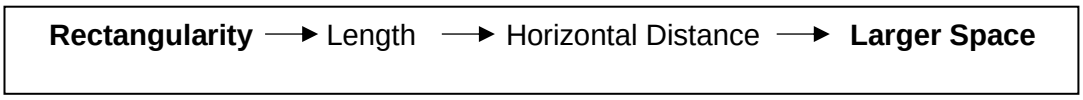


Figure 2. Spaciousness of Size

2.2.1.2. Light

One of the specific properties of boundary in the perception of spaciousness is the light in the space. Natural or artificial light are significant physical factors that affect people's psychology, thereby have influences on the perception of a space (Bokharaei & Nasar, 2016; Knez, 2001; Küller, Ballal,

Laike, Mikellide & Tonello, 2006; Mc-Cloughan, Aspinall & Webb, 1999; Odabaşioğlu & Olguntürk, 2015). Figure 3 depicts Ching's (2015) light variations.

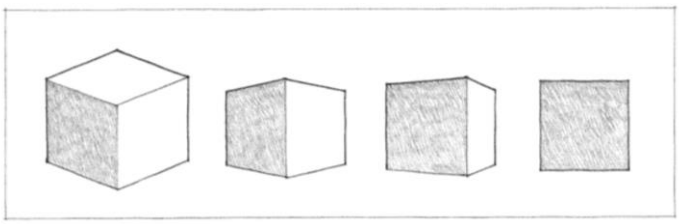


Figure 3. Light Variations (Ching, 2007: 34)

Many investigations were conducted according to the specific properties of lighting, and studies indicated that various judgements of spaciousness were related to the amount of light in a space (Kirschbaum & Tonello, 1997). Martyniuk, Flynn, Spencer and Hendrick (1973) had 96 participants who rated 6 rooms with different lighting schemes on several criteria including spaciousness and found that bright light level was affect human perception positively. Inui and Miyata (1973) also collected data on lighting as well as room size. A correlation between light level and perceived spaciousness was calculated for 13 stimuli and it was found out to have a strong correlation. Oberfeld and Hecht (2011) investigated the impact of surface lightness and perception of height and width of interior spaces. Findings showed that lighting of the ceiling and lighting of the walls make a room appear larger.

Other studies, as Acking and Küller (1972), Baum and Davis (1976), Oldham and Rotchford (1991), Küller (1986), and Oldham and Fried (1987) suggested that light level and perception of spaciousness are positively

corelated. High lighting level was preferred with the perception of spaciousness (Durak, Olguntürk, Yener, Güvenç & Gürçınar, 2007; Odabaşioğlu & Olguntürk, 2015; Stamps, 2007). People judge a space with bright light as more spacious than a space with dim light (Inui & Miyata, 1973; Kirschbaum & Tonello, 1997; Martyniuk et all., 1973; Ozdemir, 2010; Stamps, 2010a). Based on the previous researches, the findings could be schematized as seen in Figure 4.

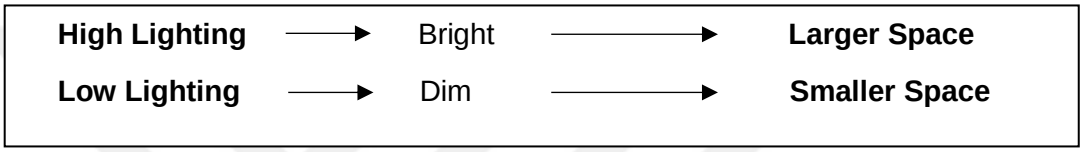


Figure 4. Spaciousness of Light

2.2.1.3. Texture

Another specific property of boundary regarding the perception of spaciousness is texture. The visual tactile quality is given to a surface by the shape, arrangement of the model and proportion of the paths. Texture creates a degree of reflection or absorption on the surface that results in differences in perception (Ching, 2015). Figure 5 depicts Ching's (2015) texture variations.

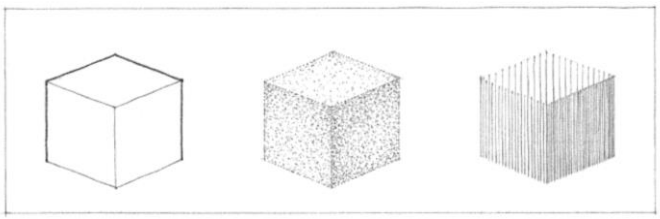


Figure 5. Texture Variations (Ching, 2007: 34)

Horizontal and vertical patterns on the boundary are tested to demonstrate the effect of illusion on perceived spaciousness in the literature. It was assumed that the horizontal pattern was related to depth, while the vertical pattern was associated with height (Bokharaei & Nasar, 2016). For instance, when the depth of the space increased with the horizontal texture, perception of spaciousness scaled up and made the space appear larger (Ishikawa, Okabe, Sadahiro & Kakumoto, 1998; Sadalla & Oxley, 1984). In contrast to this, there is a negative correlation between height and spaciousness (Stamps, 2011); when the height increases, the space looks narrower because of change in the space proportion. Hence, spaces appear smaller in a vertical pattern. Based on the previous researches, the findings could be schematized as seen in Figure 6.

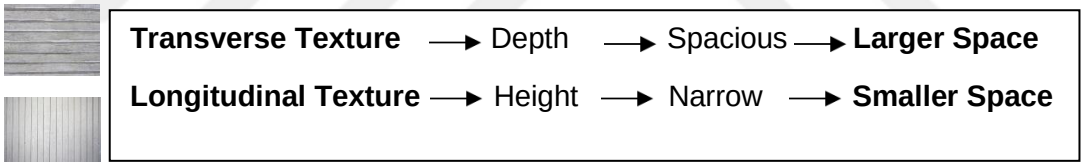


Figure 6. Spaciousness of Texture

2.2.1.4. Color

Color of the space is another specific property of boundary that affects the perception of spaciousness. Visual perception and phenomenon of light are described in terms of hue, saturation and tonal value that create the perception of color. Color is one of the distinguished features of the environment and it affects the visual level of a form (Ching, 2015). Figure 7 depicts Ching's (2015) color variations.

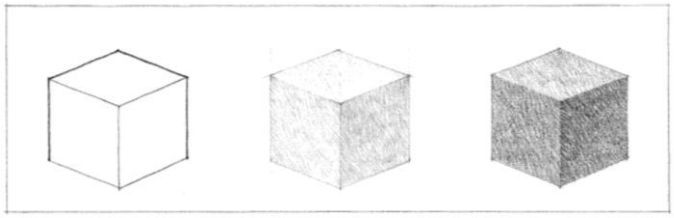


Figure 7. Color Variations (Ching, 2007: 34)

Yıldırım, Akalın-Başkaya, and Hidayetoğlu (2012) showed that interior spaces with cool colors, as blue or green, were perceived larger than the spaces with warm colors, such as red or orange. While the use of cool color schema and desaturated colors increase the perception of spaciousness, using warm and saturated color schema decrease the perception of spaciousness (Franz, 2006; Odabaşioğlu & Olguntürk, 2015). Based on the previous researches, the findings could be schematized as seen in Figure 8.

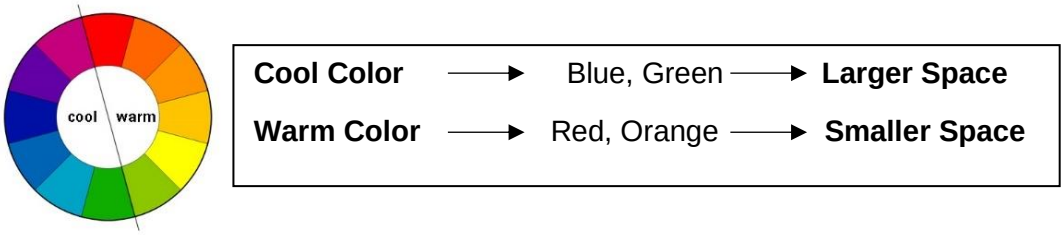


Figure 8. Spaciousness of Color

2.2.1.5. Multi Physical Variables

In the literature, there are many investigations separately conducted about the specific properties of spaces. Only Bokharaei and Nasar (2016) analyzed perceived spaciousness and preference in relation to six attributes (size, lighting, window size, texture, wall mural, and amount of furniture) and investigated these attributes in the same study. They investigated, 12 for

perception and 12 for preference, a total of 24 virtual reality (VR) walks between each attribute. Each of the six attributes contained pair of two levels; ‘small-large’ for size, ‘dim-bright’ for lighting, ‘vertical-horizontal’ for texture, ‘skyline-nature’ for wall mural, ‘small-large’ for window size and ‘a lot- not much’ for furniture. For each space, 13 males and 18 females with a total of 31 students rated the level of perception of spaciousness, and 16 males 14 females with a total of 30 students rated the level of space preference. As a result, the space with the larger, brighter, larger window and less furniture was perceived as more spacious. These features of the space also increased preference level of participants. They conclude that, while perception of spaciousness is related with size, lightness, window size, and amount of furniture; perception rate also depends on the previous experiences of space.

2.2.2. Spaciousness with Respect to Environmental Properties

The literature was investigated to identify the physical features of an environment that have an effect on the perception of spaciousness. For this aspect, articles review were written by Duval and Veitch (2002), Stamp and Krishan (2006) and Stamp (2009, 2010a).

Environmental properties, for which effect sizes on perceived spaciousness have been reported, include the following: (a) boundary roughness; breaks of surface, irregularities, uneven from projections and not smooth (Stamps & Krishnan, 2006), (b) height (Stamps, 2007, 2009, 2010a, 2011, 2012), (c) horizontal area (Benedikt & Burnham, 1985; Franz, Von der Heyde, & Bülthoff, 2005; Franz & Wiener 2005; Garling, 1970a, 1970b; Inui & Miyata,

1973; Sadalla & Oxley, 1976; Stamps, 2007, 2008; Stamps & Krishnan, 2006), (d) light (Inui & Miyata, 1973; Kirschbaum & Tonello, 1997; Martyniuk et all., 1973; Stamps, 2007; Stamps & Krishnan, 2006), (e) occlusion (Imamoglu, 1973; Stamps, 2007), and (f) shape (Ishikawa et all., 1998; Sadalla & Oxley, 1976, 1984; Stamps, 2007, 2009, 2010a, 2011, 2012).

One limitation of those studies is the form (shape) of the boundary. Therefore, this research aims to analyze the spaciousness of the space with the curvilinear boundary connections. This environmental property is indicated to understand how the boundary properties affect perception of spaciousness.

2.2.2.1. Form (Shape) of the Curvilinearity

Although there is no standard description existings for form or shape in general aspect, form and shape have two different meanings in architecture design (Banaei, Ahmadi & Yazdanfar, 2017a). The Oxford Dictionary defines ‘form’ as “the visible shape or configuration of something” and ‘shape’ as “the external form, contours, or outline of someone or something” (OED; 2018). Ching (2010) and Ching and Binggeli (2012) described form as point, line, plane, volume that differ according to the related proportion and scale, and shape as the differentiation of one form from another that can refer to the contour of line, the outline of plane, or the 3D boundary mass (Ching & Binggeli, 2012). Although they have different definitions, they are used interchangeably in many studies (Banaei, Ahmadi & Yazdanfar, 2017a).

Different forms are generally analyzed to reflect the different effects they have on human perception (Vartanian et al., 2013; Hobbs et all., 2015; Shemesh et all., 2016; Banaei et all., 2017b). The literature on the curvilinear geometry is examined in psychology, architecture, fine arts, neuroscience and many other areas because of their effective structures.

The term of curvature refers to smooth transition between contours, as opposed to sudden changes. Many studies investigated human responses to curvilinear forms in the environment (Alexander, 1977; Hesselgren, 1987; Hopkins, Kagan, Brachfeld, Hans, & Linn, 1976; Küller, 1980; Madani Nejad, 2007; Papanek, 1995; Pearson, 2001; Salingaros, 1998; Shepley, 1981; Vartanian et al., 2013) and it shows that how the curvilinear forms affect human perception in many ways.

Pearson (2001) emphasized that curves, which are also known in the philosophy of architecture as organic/green architecture, are more coherent to the human mind/ perception and are associated with the body. Salingaros (1998) inferred that buildings which have natural and biological forms, appear more psychologically appropriate and perceived differently than other standard forms. Alexander (1977) concluded that in the modern architecture, linear forms lack spatial sense for people’s perception. Papanek (1995) identified that curved forms of internal spaces invoke emotions of joy, harmony and well-being.

According to the literature, curved shapes are more pleasant and safer, more preferred and theorized to elicit positive emotions in people as compared to the straight ones (Hesselgren, 1987; Küller, 1980; Madani Nejad, 2007; Papanek, 1995; Shepley, 1981; Silvia & Barona, 2009). Natural forms, like curves, are more appealing to human beings, because they are parts of the nature, and organic forms attract people's interest more than the linear forms (Vartanian et al., 2013). While linear forms are continuously repeated in built environment, the dominant presence of curvilinear forms in nature makes the curved forms more aesthetical and emotional.

Furthermore, the preference of the curvature originates from a negative response to angular objects (Bar & Neta, 2006). Neuropsychological investigations explain that curvature of the contour enables rapid impression for the formation, whereas angularity triggers a sense of threat and feelings of insecurity (Bar & Neta, 2007). Corners are perceived as dangerous, because they are not found in natural environment as frequently as the curvilinear forms are (Bertamini, Palumbo, Gheorghes, & Galatsidas, 2015).

2.2.2.2. Curvilinear Form of the Boundary

Various boundary forms are recently investigated and implemented by many architects. Different forms are related with the technological advances and digital fabrication system that offers non-rectilinear, unusual and non-standard forms for spaces boundaries. The architectural design forms changes in this response accordingly (Hobbs et all., 2015).

A few studies investigated the form of space with curvilinear and various space boundaries that provide a relationship with this study. Hobbs et all., (2015) analyzed the preference levels of four different architectural geometries in a semi-open virtual environment. Curved, rectilinear, angled and mixed spaces are tested with 19 females and 46 males with a total of 65 participants. The results showed that higher preference level was rated for curved buildings because of the pleasant, relaxing and friendly atmosphere.

Banaei, Ahmadi and Yazdanfar (2017a) presented methodology for categorizing of various forms of interior spaces. Study proposed 25 different form clusters which consist of 343 various interior images of a living space belonging to different architectural style and approaches. Cluster groups are divided as 8 different types, 13 geometries, 6 scales, 5 locations and 6 angles for the interior space.

Banaei et all., (2017b) investigated the neurophysiological correlations between different interior forms on perception and brain activities. The three-dimensional (3D) architectural forms were examined with 8 females and 7 males with a total of 15 participants. Researchers investigated human brain activities with mobile brain/body imaging (MoMI) machine during the perceiver actively explores a 3D architectural space. The result showed that curved geometries affect human perception and brain activities strongly with higher pleasure and arousal ratings.

The physical properties of the space that consist of specific character and form of the boundary were examined with respect to the perception of spaciousness in this chapter. Following chapter is related to the people-place relationship; including aesthetic judgement and emotional responses. Chapter three was analyzed in order to reveal how spaciousness related with the aesthetic judgement and emotional responses.

CHAPTER 3

AESTHETIC AND EMOTIONS

This chapter deals with the influences of form/shape of the curvilinear space boundary types as a visual characteristic of the environment on our aesthetic judgement and emotional responses to interior spaces, and with their effects on human perception of spaciousness.

3.1. Aesthetic

In the late 18th century Immanuel Kant proposed an aesthetic model and according to Kant's (2005) theory, aesthetic experience is defined as disinterested pleasure and it varies according to the observer and the context (Kant, 2005, as cited in Goldman, 2006; Hekkert, 2006; Stamps, 2010b). Aesthetic value, aesthetic emotion, aesthetic understanding, aesthetic attitude and aesthetic judgement are the many aspects of the experience of

artwork. All these components are considered as the aesthetic experience (Hekkert, 2006).

Additionally, aesthetic experience is related to the appreciation of the qualities of the artifact's beauty; it is not shaped by the appraisal of the artifact's ability to satisfy a person's bodily needs, his/her current goals or plans or his/her social values (Scherer, 2005; Dazkır, 2009; Stamps, 2010b). According to the many investigations, aesthetic experience does not include pragmatic concerns because of the disinterested pleasure considerations (Kant, 2005; Scherer, 2005; Dazkır, 2009). Therefore, aesthetic judgements contain feelings (Stamps, 2010b). According to Kant's theory, feelings are purely subjective elements in the representation of aesthetic judgements.

3.1.1. Aesthetic Judgements

There are various researches conducted in order to demonstrate aesthetic judgements and its components. Alben (1996) created a model that identified aesthetics as an attribute contributing to the quality of experience. Goldman (2006) and Hekkert (2006) identified aesthetic value as being depended on the observer and the related context. According to this idea, aesthetic judgements do not only consist of purely sensory terms, but also they equate aesthetic experience with disinterested pleasure. "The idea of disinterested pleasure from passive contemplation derived in turn from exclusive focus on beauty as the only aesthetic property" (Goldman, 2006: 337).

Leder, Belke, Oeberst, and Augustin (2004) described the combination of aesthetic judgment components as the main elements of perception, artwork, and aesthetics. Figure 9 shows the schematic model of aesthetic judgements.

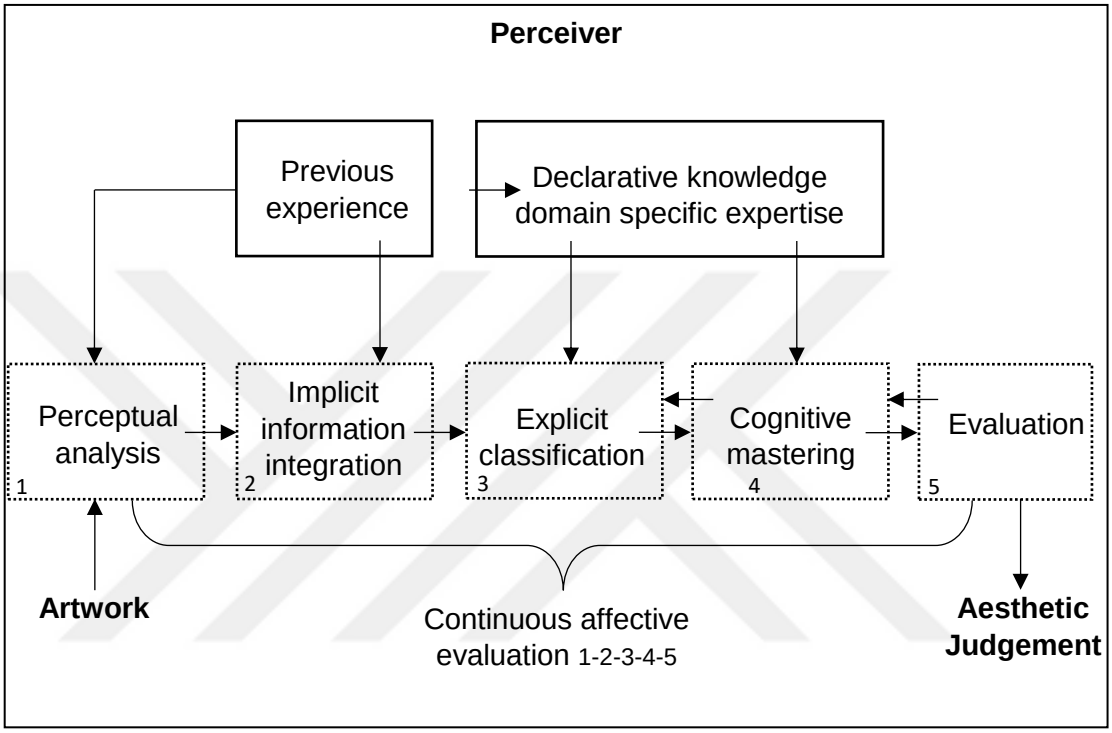


Figure 9. Schematic model of aesthetic judgements

(adapted from Leder et all., 2004: 492)

Leder et al., (2004) created a model for aesthetic judgement and this continuous affective evaluation consists of five principles: perceptual analysis of the work (1), comparison between new and previous work (2), classification of the work with related category (3), interpretation (4) and evaluation of the work (5).

Hekkert (2006) stated that aesthetic judgements can differ due to interpretational differences. Also, Hekkert (2006) identified four general principles for aesthetic pleasure: the preference, unity in variety, familiarity or newest version and consistency of impressions.

Based on this study, Hekkert (2006) suggested that, continuous affective evaluation could be divided into two main parts as automatic stage (stage 1-2-3) and cognitive/ emotional process (stage 3-4-5). Stage 3 is related with both part between automatic stage and cognitive/ emotional process. Environmental aesthetics is related to the automatic stage that is generated.

3.1.2. Environmental Aesthetics

Physical properties of the environment could affect aesthetic value that is generated as a response to the environment. Many studies assess people and environment relationships in terms of aesthetic judgements.

Devlin and Nasar (1989) emphasized that architectural assessments are divided into two forms which are called affective and interpretive. The emotional reactions of the respondents and the physical characteristics of the building create the combination in architectural approach. Devlin and Nasar (1989) tested the direct predictor of aesthetic appraisal with the variables of complexity, mystery, femininity and safety as an interpretive assessment. Prior research conducted by Hesselgren (1987), Heath, Smith and Lim (2000) and Scott (1993) about the aesthetic components.

Lang (1992) explained aesthetic experience between people and built environment in three stages: Affective, Formal and Symbolic interactions. Affective aesthetics is related to how pleasurable the feelings received from the environment are, and how arousable the environmental properties that affected people's perception in the environment are. Lang (1992) identified formal aesthetics in architecture as the complexities, rhythms, shapes and sequences of visual words. The final stage of the aesthetic experience is the symbolic aesthetics which is defined by the Lang (1992) as the appreciation of the associational meanings of the environment that give people pleasure. Table 2 demonstrates the environmental aesthetic judgement components.

Table 2. Environmental Aesthetic Judgements

Aesthetic Judgement	Lang (1992)	**Affective**	Arousal-Pleasantness (Excitement-Relaxing)	Russell (1992)
		Formal	Complexity-Coherence	
		Symbolic (Interpretive)	Safety Complexity-Mystery-Femininity	Delvin&Nasar (1989)

After Lang's (1992) description of the components of aesthetic judgement in terms of built environment, Russell (1992) grouped affective variables under two main headings which are *arousal* and *pleasantness*; and subheadings which consist of *excitement* and *relaxing*. Those variables, which are related to the affective variable of the environmental aesthetic, were analyzed in various research (Cetintahra & Cubukcu, 2014; Hanyu 1997, 2000; Nasar 1983, 1992a, 1992b, 1992c, 1992d; Nasar, Julian, Buchman, Humphreys, & Mrohaly, 1992; Russell 1992; Ulrich 1983; Ward & Russell 1981; Wells &

Evans, 2003). Researchers created two main semantic scales that are *complexity* and *coherence* for formal variables (Nasar, 1998). Many researchers analyzed the influence of complexity and coherence on environmental aesthetic evaluations (Canter 1969; Cetintahra & Cubukcu, 2014; Hanyu 1997, 2000; Kaplan 1992; Nasar 1992a, 1992c). In many studies *safety* was considered as a symbolic variable (Cetintahra & Cubukcu, 2014; Hanyu 1997, 2000; Kaplan & Kaplan 1989; Nasar et al., 1992; Nasar 1992c; Stamps 2005b; Ulrich 1983).

Rafaeli and Vilnai-Yavetz (2004) emphasized that there is a strong relationship between aesthetic judgement and physical environment. They investigated how a person's description of an interior environment will depend on its functionality, its aesthetic qualities, and how people attach meaning to this environment.

3.2. Emotion

Although the term of emotion is a commonly used word in everyday language, many investigators and scholars have difficulty in finding out the common operational definition (Izard, 2010; Kleinginna & Kleinginna, 1981; Scherer, 2005). Izard (2010) surveyed how the scientists define the term "emotion". The collected data showed that it cannot be defined as a unitary concept. Izard's analysis of the responses of the scientists resulted in the following description:

"Emotion consists of neural circuits (that are at least partially dedicated), response system, and feeling state/ process that motivates and organizes

cognition and action. Emotion also provides information to the person experiencing it, and may include antecedent cognitive appraisals and ongoing cognition including an interpretation of its feeling state, expressions or social-communicative signals, and may motivate approach or avoidant behavior, exercise control/ regulation or responses, and be social or relational in nature" (Izard, 2010: 367).

Emotion is a one of the strongest components of "feeling". Confusion about the definition of "emotion" is due to the similar or related attributes of each phenomenon. It is difficult to isolate one's emotional states from his/her sentiments, interpersonal stances, emotional trades, and etc (Dazkır, 2009).

Emotion is an internal short-term physiological reaction to an external stimulus that combines subjective feeling with appraisal and expression (Scherer, 2005). Many scholars evaluated emotional state as a short-term state which consist of seconds, not minutes or hours (Desmet, 2002; Ekman, 1992; Trabasso, Stein, Rodkin, Munger & Baughn, 1992). Ekman (1992) emphasized that people cannot decide when to experience which emotion, but one can choose to put themselves in a situation where an emotion is likely to occur (Dazkır, 2009).

3.2.1. Emotional Responses

There are many studies on emotional responses and their components (Izard, 2010; Scherer, 2005). Scherer (2005) explained the relationship between the components of emotions and the related function in five stages:

1. Cognitive component-appraisal (evaluating objects and events); 2. Neuro-physiological component-bodily symptoms (system regulation); 3. Motivational component (preparation and direction of action); 4. Motor expression component-facial and vocal expression (communication of reaction and behavioral intention); 5. Subjective feeling component-emotional experience (monitoring of internal state and organism-environment interaction).

These components of emotion clarify which emotion are found in each component, how they happen and how they are experienced. Each of the components are divided and analyzed separately because of their multidimensional and complex concept (Dazkır, 2009; Scherer, 2005). Studies on emotional responses focused on the specific components related to the research. As an example, appraisal mechanism, which is related to perception is measured by the researchers in order to identify the features of an environment that are desirable for the inhabitants (see Figure 10).

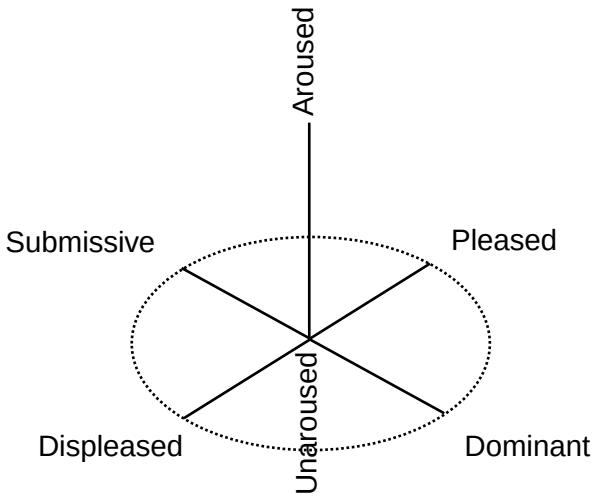


Figure 10. Feeling Wheel (Stamps, 2010: 79)

According to the cognitive components, there are three appraisals of feelings: pleasure, arousal and dominance. Figure 10 shows the coordinate system which demonstrated as a “feeling wheel” (Stamps, 2010b).

Appraisal of feelings can be represented in terms of the degree of pleasure, arousal and dominance. Although pleasure and dominance have both positive and negative extensions, arousal has only positive extension which begins at zero and increase. The opposite of arousal is defined as the lack of arousal (Stamps, 2010b).

3.2.2. Environmental Emotions

Physical properties of an environment could evoke an emotion generated towards the environment. Many studies evaluate people and environment relationships with respect to emotional responses (Franz, Von der Heyde & Bülthoff, 2005) and many studies evaluate built environment in terms of how it affects human emotional responses (Desmet, 2002; Hull & Harvey, 1989; Kaltcheva & Weitz, 2006; Küller & Mikellides, 1993; Mehrabian & Russell, 1974; Russell, 1992; Russell & Mehrabian, 1977; Russell & Pratt, 1980; Russell, Ward, & Pratt, 1981).

Many researchers investigated taxonomies of feeling while using empirical protocols (Mehrabian, 1995; Mehrabian & Russell, 1974; Osgood, Suci &Tannenbaum, 1957; Osgood, May & Miron, 1975). Russell and Mehrabian (1974) defined three dimensions of emotions, which are pleasure (pleasant-unpleasant), arousal, and dominance, that summarize the emotional

responses to all types of environment. Table 3 demonstrates the components of environmental emotional responses components.

Table 3. Environmental Emotional Responses

Emotional Responses	Russell & Mehrabian (1974,1977)	**Pleasure**	Annoyed-Pleased, Unhappy-Happy, Bored-Relaxed, Unsatisfied-Satisfied, Melancholic-Contended, Despairing-Hopeful
		Arousal	Unaroused-Aroused, Calm-Excited, Sluggish-Frenzied, Dull-Jittery, Sleepy-Wide awake, Relaxed-Stimulated
		Dominance	Control-Cared

Mehrabian and Russell (1974) explained that a feeling is described as projection of pleasure, arousal and dominance. According to their theory, pleasure is demonstrated through facial gestures (such as smiling and frowning) and by scales (such as annoyed-pleased, and happy-unhappy, bored-relaxed, unsatisfied-satisfied, melancholic-contended, despairing-hopeful). Arousal is indicated by human activities and alertness (such as skin responses) and by scale (such as unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wideawake, relaxed-stimulated). Dominance is indicated by scales (such as in control-cared for and autonomous-guided (Mehrabian & O'Reilly, 1980; Stamps, 2010b).

Russell and Mehrabian (1977) conducted a research using verbal reports and they concluded that the emotion-eliciting quality of an environment affects people's approach toward that environment. Russell (1992) created

affective appraisal in order to measure how people evaluate their built environments. According to the Russell's (1992) theory, affective quality is the determinant of human response to environment.

3.3. Aesthetic and Emotion versus Curvilinearity

Several studies focused on curvilinearity of forms with the related feeling components. Aesthetic judgements and emotional responses are the main components of feeling that provide a relationship with this study.

Firstly, Alp (1993) conducted an experimental study with different geometric configurations for architectural spaces and analyzed the aesthetic-emotional effects. The geometrical organization was the independent and the aesthetic-emotional values were the dependent variables for the study. Rectangular, triangular and circular (curvilinear) 1/20 scale space models were used as an experimental design study and 26 related aesthetic-emotion adjective scales were analyzed. Eight female and twenty-six male, total of thirty-four graduate students participated in this study. The result of the study showed that all three geometric models elicited highly significant aesthetic responses. Especially circular (curvilinear) space had higher ratings than rectangular and triangular spaces. Study concluded that different geometric configurations of space play a significant role in the identification of their aesthetic-emotion judgement.

Secondly, Madani Nejad's (2007) doctoral dissertation study ranked two modified interior residential views, where the architectural forms gradually

changed from being fully rectilinear to fully curvilinear in a card-sorting task. The aim of the study was to investigate the emotional effect of curvilinear forms in interior space settings. The research consisted of qualitative and quantitative methodologies. In this study, 50% of subjects was male and 50% was female total of 61 architects and 54.66% male and 45.34% female total of 236 non-architects participated research study. The results demonstrated that, curvilinear form tends to make the observers feel safer, and perceive the space to be more private and pleasant, and less stressful.

Thirdly, Dazkır's (2009) master thesis and Dazkır and Read's (2012) research study focused on pleasure and approach reactions towards rectilinear and curvilinear stimulated interior settings. Their study is related to furniture forms and their influence on people's emotional responses towards created 3D interior settings. As a result of the study, curvilinear forms were found to be significantly stronger and more pleasurable than rectilinear forms. With regard to emotional judgement, the study indicated that curvilinear settings showed higher amounts of pleasant-unarousing emotions that contains the feelings of relaxation, peacefulness, and calmness.

Fourthly, Vartanian et al., (2013) analyzed three architectural variables, which were curved versus rectilinear contours, openness and ceiling height in beauty-judgement and approach-avoidance. This research suggested that, people were more likely to judge curvilinear spaces as more beautiful than rectilinear spaces, and that judgment of beauty for curvilinear spaces was supported by emotion, human behavior and brain functions. The authors

inferred their results to indicate that, in architecture, sharp contour might not serve as an early warning signal for potential dangers, as it might elsewhere.

Fifthly, Shemesh et all., (2016) investigated the human reaction to spaces with different geometric forms. Square, round (domed), sharp-edged and curved spaces were investigated with qualitative and quantitative methods. In the first part, the participants analyzed spaces with different geometric forms in a virtual reality (VR) environment and filled out a questionnaire regarding their experience. In the second part, the researchers analyzed the differences in people's mental reactions with electroencephalogram in spaces with different geometric forms. Twenty-one design students and twenty-one non-design students, total of forty-two students, participated in this study. This study showed that participants had different types of responses and preferences towards spaces with different geometric forms. The findings of the first part revealed that, non-design students had a tendency to prefer curvy shaped spaces and design student had a tendency to prefer sharp-angled spaces. Initial findings from the second part of the research showed that, participants perceived symmetrical space differently from asymmetrical space with unconscious brain ability. The results pointed to a difference in people's mental reactions towards different geometric forms of space.

The aesthetic judgement and emotional responses were examined with in this chapter. Following chapter is related to the methodology of the study.

CHAPTER 4

METHODOLOGY

This chapter includes the problem statement along with the related research questions and hypotheses to be investigated. In addition, methodology is explained through the method of the study and the conceptual framework. Furthermore, the three stages of the study are explained in detail. Also, the instrument of the study and procedure of the study are introduced.

4.1. Problem Statement

The aim of this research is to examine the relationship between the perception of spaciousness and curvilinear boundaries related to different specific properties of the environment such as size, light, texture and color. This relationship is identified by the aesthetic judgements and emotional responses of the participants through a virtual environment.

4.1.1. Research Questions

Research questions were formulated to reach the aim of the study. Thesis aims to answer the following questions:

Q1: How do the horizontal and vertical curved boundaries influence peoples' perceptions of spaciousness with aesthetic judgements and emotional responses under specific properties of space (size/ light/ texture/ color)?

Q2: Does horizontal or vertical curvilinear boundaries have a more influence on the perceived spaciousness?

Q3: How does this perceived spaciousness affect human's emotional responses and aesthetic judgements?

The dependent variable being the "perceived spaciousness" and two independent variables, curved Vertical Boundary (VB) and Horizontal Boundary (HB), generate the main hypothesis of the thesis.

4.1.2. Hypotheses

The hypotheses that are formulated in response to the research questions are as follows:

H1: There is a spaciousness difference between the four settings in terms of each specific property (size/ light/ texture/ color).

H2: The interaction of the boundary type (horizontal/ vertical) and the specific property (size/ light/ texture/ color) has an impact on spaciousness.

H3a: Aesthetic judgements based on the boundary type (horizontal/ vertical) are a function of spaciousness.

H3b: Aesthetic judgements based on the specific properties (size/ light/ texture/ color) are a function of spaciousness.

H4a: Emotional responses based on the boundary type (horizontal/ vertical) are a function of spaciousness.

H4b: Emotional responses based on the specific properties (size/ light/ texture/ color) are a function of spaciousness.

H5: The behavioral intentions (approach-avoidance behaviors) are different in the four settings in terms of specific properties (size/ light/ texture/ color).

4.2 Methodology

In this research, two different manipulated curve rectangular boundary type are investigated to analyze the perceived spaciousness level; curved Horizontal Boundary (HB) and curved Vertical Boundary (VB).

Curved Horizontal Boundary (HB) rectangular space is bounded by four walls and the boundaries of each wall are connected to each other with horizontal concave connections. Aa seen in Figure 11, there is no 90-degree edge in horizontal plane of the space as there are in standard room connections.

Curved Vertical Boundary (VB) rectangular space is bounded by four walls and the boundaries of each wall are connected to ceiling as vertically

concave links. As seen in Figure 11, there is no 90-degree connection of vertical walls and ceiling as standard space connections.

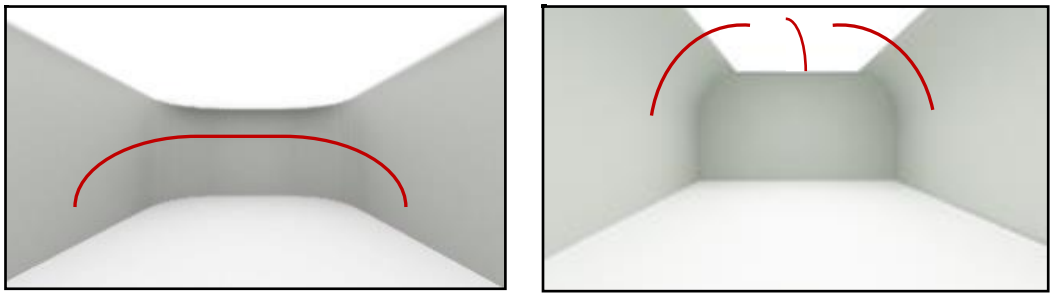


Figure 11. Curved Horizontal Boundary (HB) and Vertical Boundary (VB)

The radius degree of horizontal and vertical spaces are adapted from Hopkins et al., (1976). Hopkins et al, (1976) created four-line segment categories based on the curve radius form in order to judge the amount of curvature (see Appendix A). Both spaces have the same floor area (m^2) (see Figure 12).

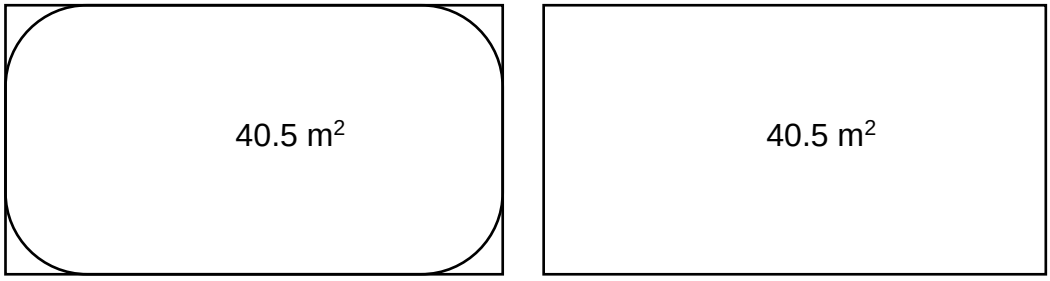


Figure 12. Floor Area of HB (m^2) and VB (m^2) Spaces

Analyzing two independent space boundaries demonstrate that the direction of the curvilinear boundary connections was perceived to be more spacious. Connections of the curved boundary directions, which are curved Horizontal Boundary (HB) and curved Vertical Boundary (VB), are the determinant factors of this investigation.

Dependent variable, which is perceived spaciousness, includes four boundary type and each boundary type involves two opposite properties: Size; small-large, Light; dim-bright, Texture; longitudinal-transverse, Color; cool-warm. These specific properties are the effective factors of the determinants. Table 4 demonstrates the study variables and Figure 13 shows the visual study variables (Appendix B and C)

Table 4. Study Variables

	Specific Property	**Boundary Type**	
		Horizontal Boundary	**Vertical Boundary**
Perceived Spaciousness	**Size**	small/large	small/large
	Light	dim/bright	dim/bright
	Texture	longitudinal/transverse	longitudinal/transverse
	Color	cool/warm	cool/warm

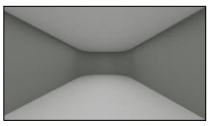
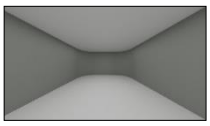
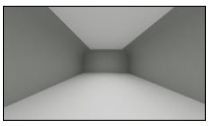
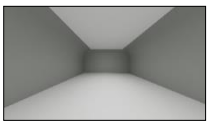
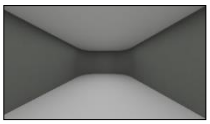
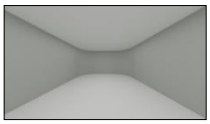
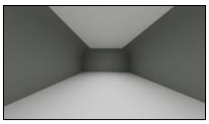
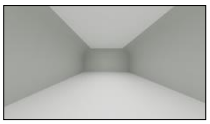
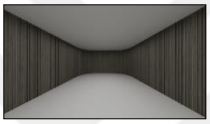
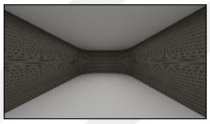
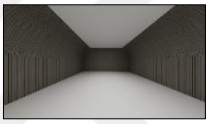
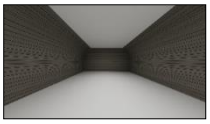
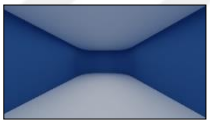
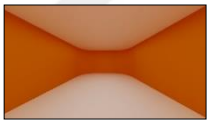
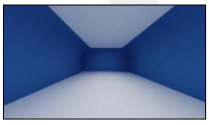
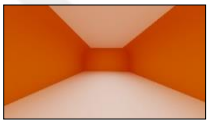
	Horizontal Boundary		Vertical Boundary	
Size	 Small	 Large	 Small	 Large
Light	 Dim	 Bright	 Dim	 Bright
Texture	 Longitudinal	 Transverse	 Longitudinal	 Transverse
Color	 Cool	 Warm	 Cool	 Warm

Figure 13. Visual Study Variables

Figure 14 3S Model created to show the relationship of the spaciousness, specific properties and spatial enclosure (boundary type).

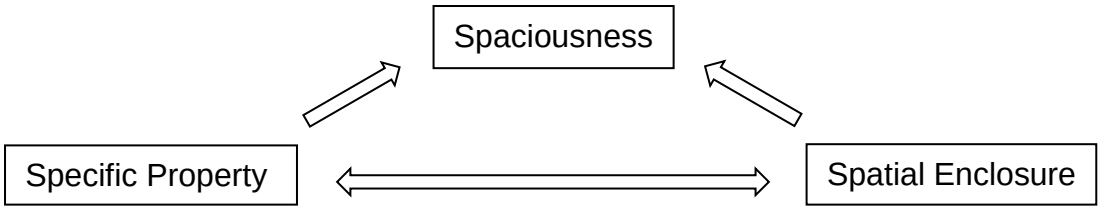


Figure 14. 3S Model

4.2.1. Stages of the Study and the Conceptual Framework

This study involves three main stages (see Figure 15). In the first stage, perception of the spaciousness level was identified by each participant. According to the data order, spaciousness of the specific property and direction of the curved connections of the boundary type was analyzed in the first stage. All boundaries (horizontal boundary and vertical boundary in size/ light/ texture or color) and accordingly all the settings (for size: small-large, for light: dim-bright, for texture: longitudinal-transverse or for color: cool-warm) were analyzed in the first stage.

The second stage is related to assessment of the conducted aesthetic judgements of the spaces. Perceived spacious levels were evaluated and associated with the relevant aesthetic judgments adjectives in the second stage.

In the third stage, the emotional responses to the spaces were investigated for each setting in order to make a clear judgement with relevant adjectives. The three stages of the study aim to make a relationship between perception of space spaciousness, aesthetic judgements and emotional responses.

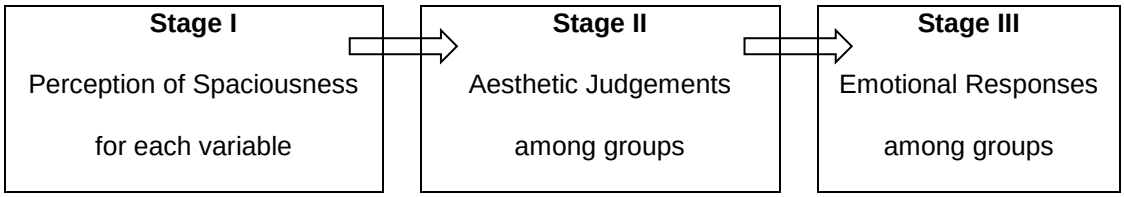


Figure 15. The Stages of the Study

4.2.2. Instrument of the Study

A Consent Form is given to each participant that involves the relevant information about the purpose, procedure, benefits, risk, and confidentiality of the research. The participants are selected by random sampling method and the researcher immediately informs them before the experiment with the Consent Form. Participants are given enough time given to read and sign the form to fulfill the procedure. The researcher keeps one copy of the signed Consent Form and the other copy is delivered to the participants. At this point, the researcher answers any question that the participants have about the study and the procedure. The study protocol was approved by the Ethics Committee of Bilkent University (NO: 2018_01_18_04). All participants provided written informed consent form (see Appendix D).

Firstly, it is confirmed that the participants do not have a vision and virtual reality cybersickness problem. Participants who have any cybersickness problem are excluded from the research study in order prevent any adverse effects. Also, the participants who have any neurological disease history are also excluded from the research study.

Secondly, Ishihara electronic color blindness test is used (Color-blindness.com, 2018) with the Gear VR equipment before the experiment. In this way, the participant are allowed to get used to the Gear VR equipment before the space analysis approximately five minutes (Appendix E). The test is used to analyze whether the participants have an appropriate color perception or not (Appendix F). According to the Marey, Semary and

Mandour (2015) research, the results of the traditional Ishihara test and electronic based test are similar. Then the demographic information of the participants are collected. Their age, gender, education level and major area of study are recorded (Appendix G).

Each participant is given one set of survey, which consists of four space settings with different curvilinear boundaries, and virtual reality simulations are shown according to the data order (Appendix H). The spaciousness level of four 360-degree spaces is determined by using a Gear VR equipment. After the analysis of each space setting simulations, a survey consisting of perception of spaciousness, aesthetic judgements and emotional responses of the participants is conducted with survey set (see Appendix G). At the end of the 360-degree simulation experiences for each space setting, participants are given 5 minutes to answer the relevant questions. The survey set is conducted in the electronic environment and it is filled with a touch screen computer by the participants.

4.2.2.1. Virtual Reality Simulations with Gear VR

Virtual Environment (VE) enables the researcher to change variables of interest, while keeping design feature stable (Meagher & Marsh, 2015; Shemesh et al., 2016). In a VE, all different specific property, such as shape, size, light, texture and color of given space, could be controlled.

The experiment consists of two independent types of VE that could affect the perceived spaciousness; curved horizontal boundary and curved vertical

boundary were designed to be free of object. Visual stimuli were showed, with the same layouts, that there were no materials and openings in the created space in order not to affect the perception of specific property with boundary type.

Spaces were designed to have the same medium-size (4.5 m wide by 9 m long by 3 m high), like a normal sized room, and the lighting was non-directional and created equal illumination in all parts of the space in general. Movements were based on egocentric frame of reference (i.e. one's body) during simulations in virtual environments (Sancaktar & Demirkan, 2008).

In this study, 3D Max and Gear VR 3D plug-in were used to create 360-degree realistic virtual environment simulations. The space simulations were drafted with 3D modeling software (3ds Max) and then they were recorded as a 2D 360-degree images (Appendix B). These 2D photos were transformed into 3D version by using a special web program (360.vizor.io, 2018) (Appendix C). The created 3D 360-degree simulations were experienced using Gear VR by participants.

The spaces were shown in Samsung SM-R325 Gear VR with the dimensions (HxWxD) 98.6 x 207.1 x 120.7 mm and 345 g weight (Controller, 2017) (Appendix E). This product was compatible with Samsung Galaxy Note 8 and after creating video simulations in 3ds max plug-in, created spaces projected to SM-R325 Gear VR with Samsung Galaxy Note 8.

The participants put on those 3D glasses and adjusted the glasses' angle to get the clearest view. While the participants were watching the created environments, the head belt kept the Gear VR securely on and the foam cushioning helped to decrease light transmittance. A width of 101° field of view was obtained through the large lenses to provide stable and precise head tracking via the built-in gyro sensor, and accelerometer was used for smooth expeditions.

4.2.2.2. Survey Set

The survey set included ranking questions related to perception of spaciousness, aesthetic judgements and emotional responses. The survey has included both ranking and open-ended questions.

Each participant was responsible for only one specific property (size, light, texture or color) and responsible for related four different settings (for size: small-large, for light: dim-bright, for texture: longitudinal-transverse or for color: cool-warm) (see Figure 13). Data order are demonstrated by the investigator. One of the main goal of the study is to compare the responses to the detect any significant differences among four setting for each specific property.

4.2.2.3. Sample Group

Gender, age, education level and participants' majors were analyzed before the space experimentation. The sample group was chosen from Bilkent University, Ankara; Turkey. At the beginning of the experiment 132

participant involved and four of them are excluded because of the vision and virtual reality cybersickness problem. Total of 128 graduate and undergraduate students, 64 males and 64 females participated in the experiment voluntarily from the social science and design departments. The age range of the participants was 19 to 29 years.

In order to ensure gender equality between participants, as total number thirty-two for each specific property; four female and four male participants took part in this study for each four settings. While education level was divided into two categories, graduate and undergraduate, participants majors was separated between social science and design.

4.2.2.4. Quantitative Data

Perception of Spaciousness

The first stage of the quantitative data contains “Perception of Spaciousness”. This part consists of 5-point Likert scale to identify immediate responses of participants’ perceptions on four settings as a first goal of the quantitative data. One refers to the lowest level (extremely negative) and five shows the highest level (extremely positive) of perceived spaciousness. The multi-item scale is reliable in attempts to quantify emotions, feeling, opinions, personalities and descriptions of people’s environment (Diamantopoulos, Sarstedt, Fuchs, Wilczynski & Kaiser, 2012; Gliem & Gliem 2003; Shemesh et al., 2016).

Aesthetic Judgements

In the second stage, “Aesthetic Judgements”, participants are asked to characterize the space and describe their thoughts and feelings towards each setting. Centering on the more specific impressions, the second stage of the study obtains the ratings of nine items of aesthetic judgements from five pairs of bipolar adjectives with semantic differentials with an added “neutral” between each pair. For the sets from one through five, negative preference is noted as the first set of words, while positive preference is the last word.

A second goal of the quantitative data is to make a relationship between the aesthetic judgements adjectives and perception of spaciousness in each four setting. The word sets are: sleepy-arousing, unpleasant-pleasant, gloomy-exciting, distressing-relaxing, simple-complex, incoherent-coherent, unsafe-safe, not mysterious-mysterious and masculine-feminine.

The selection of relevant adjectives ensures appropriate methods of measurement for the effect of curvilinear architectural form on human aesthetic judgements (Madani Nejad, 2007). The words chosen for aesthetic judgement set are adapted from Devlin and Nasar (1989), Hesselgren (1987), Heath, Smith and Lim (2000), Lang (1992), Madani Nejad (2007), Nasar (1998), Russell (1992) and Scott (1993). Table 5 demonstrates the quantitative data components of aesthetic judgements.

Table 5. Quantitative Data of Aesthetic Judgements

Environmental Aesthetic		
(1) Affective Variables	(2) Formal Variables	(3) Symbolic Variables
-Arousal (sleepy-arousing) **-Pleasantness** (unpleasant-pleasant) **-Excitement** (gloomy-exciting) **-Relaxing** (distressing-relaxing)	**-Complexity** (simple-complex) **-Coherence** (incoherent-coherent)	**-Safety** (unsafe-safe)
-Mystery (not mysterious-mysterious) **-Femininity** (masculine-feminine)		

Devlin and Nasar (1989) and Lang (1992) explained aesthetic experience between people and built environment and scale used as a word set. (see Appendix G for scales and see chapter three for more information of aesthetic).

A few researcher was used the emotional responses model. The Lang (1992) scales were approved and were used and found to provide strongly reliable data by researchers (Arnowitz, 2017; Cetintahra & Cubukcu, 2014).

Emotional Responses

In the third stage, “Emotional Responses”, participants are asked to evaluate the space and describe their emotions towards each setting. This final stage of the study is to measure emotional reactions of the participant elicited by each setting using five semantic differential scales with twelve items.

A third goal of the quantitative data of the study is to make a relationship between the emotional responses adjectives and perception of spaciousness in each specific four setting. The word sets are: annoyed-pleased, unaroused-aroused, unhappy-happy, bored-relaxed, unsatisfied-satisfied, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake, melancholic-contended, relaxed-stimulated, despairing-hopeful. The words chosen for emotional responses set are adapted from Mehrabian and Russell (1974) and Dazkır (2009). Table 6 demonstrates the quantitative data components of emotional responses.

Table 6. Quantitative Data of Emotional Responses

Environmental Emotion	
Semantic differential measures of emotional state	
(1) Pleasure	**(2) Arousal**
-Annoyed-Pleased	**-**Unaroused-Aroused
-Unhappy-Happy	**-**Calm-Excited
-Bored-Relaxed	**-**Sluggish-Frenzied
-Unsatisfied-Satisfied	**-**Dull-Jittery
-Melancholic-Contended	**-**Sleepy-Wide awake
-Despairing-Hopeful	**-**Relaxed-Stimulated

Mehrabian and Russell's (1974) "semantic differential measures of emotional state or characteristic emotions" scale (pleasure and arousal) used as a word set. Study utilized circumplex model of emotions (Russell, 1980), which derived from Mehrabian and Russell (1974) (see Appendix G for scales and see chapter three for more information on circumplex model of emotions).

Many researchers was used the circumplex model of emotions. The Mehrabian and Russell's (1974) scales were approved and were found to provide strongly reliable data by many researchers and it was tested many times (Barrett & Russell, 1998; Holbrook, Chestnut, Oliva, & Greenleaf, 1984; Kaltcheva & Weitz, 2006; Russell, 1980; Russell & Pratt, 1980; Russell et al., 1981; Wirtz, Mattila & Tan, 2000).

Mehrabian and Russell's (1974) "semantic differential measures of emotional state or characteristic emotions" scale analyzed to clarify reliability and validity score by using Kuder-Richardson reliability coefficient test. The pleasure reliability was 0.81, with a retest value of 0.71 and the arousal reliability was 0.50, with a retest value of 0.69 (Mehrabian & Russell, 1974). Additionally, Russell (1980) tested reliability of Mehrabian and Russell's (1974) "semantic differential measures of emotional state or characteristic emotions" arousal and pleasure scales. Results demonstrated alpha level reliability of 0.84 for pleasure and an alpha level of reliability of 0.74 for arousal.

4.2.2.5. Qualitative Data

Two open-ended questions aim to provide a better understanding on aesthetic judgements and emotional responses. The questions are as follows:

1. Are there any other feelings/ emotions that you would like to describe about related space setting?

2.What have you liked/ disliked about this room? Please explain**.**

Qualitative data aim to demonstrate approach-avoidance behavior of participants. Three questions that consist of verbal measures of Likert scale are as follows:

1. How much time would you like to spend in this room?
2. Once in this room, how much would you enjoy exploring around?
3. To what extent does this place make you feel friendly and talkative to a stranger who happens to be near you?

4.2.3. Procedure of the Study

Each participant is responsible for only one specific property of survey that consists of four setting with different curvilinear boundary types. The spaciousness of four 360-degree spaces is determined using a Gear VR (Samsung SM-R325 Gear VR). After the analysis of each space setting, a survey consisting of perception of spaciousness, aesthetic judgements and emotional responses of the participants are completed.

This study is conducted with 4 group of participants who are completing one survey set related to one specific property of space either size, light, texture or color. Apart from this, each specific property involves 4 starting order in order to analyze order effect (see Table 7). The study has obtained independent ratings on four settings to eliminate the bias of one kind of rating affecting the other for each specific property. Research consists of approximately 128 undergraduate or graduate students at Bilkent University. The participation is on voluntary basis. All participants are over 18 years old.

Table 7. Specific Property of Participant

Spaciousness			
Size (n=32)	**Light** (n=32)	**Texture** (n=32)	**Color** (n=32)
1-S (n=8)	**1-L** (n=8)	**1-T** (n=8)	**1-C** (n=8)
2-S (n=8)	**2-L** (n=8)	**2-T** (n=8)	**2-C** (n=8)
3-S (n=8)	**3-L** (n=8)	**3-T** (n=8)	**3-C** (n=8)
4-S (n=8)	**4-L** (n=8)	**4-T** (n=8)	**4-C** (n=8)
128 participants			

The experiment consists of four specific property (size/ light/ texture/ color), which include four setting for each (for size: HB-S, HB-L, VB-S, VB-L, for light: HB-D, HB-B, VB-D, VB-B, for texture: HB-L, HB-T, VB-L, VB-T, for color: HB-C, HB-W, VB-C, VB-W) and these settings start experimentation with different for each 8 participant (Appendix H). The group of thirty-two (8×4) participant are responsible for each specific property. Figure 16 demonstrates the experiment order consisting of 4 specific properties and 4 setting for each. The procedure of the study are as follows:

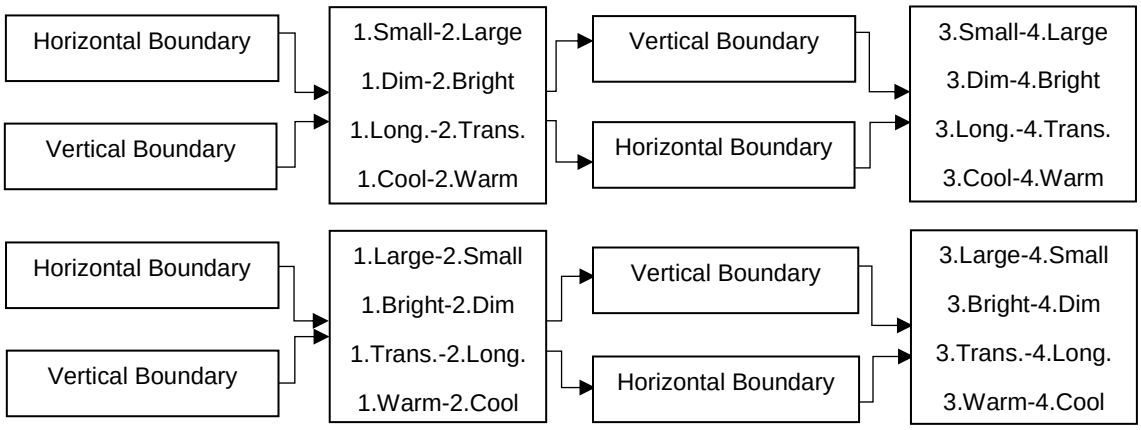


Figure 16. Data Gathering Order

1- S/ L/ T/ C; Each eight participants start the experiment with small/ dim/ longitudinal or cool horizontal boundary space and then continue with large/ bright/ transverse or warm horizontal boundary space. The same participants move to the small/ dim/ longitudinal or cool vertical boundary space and then to large/ bright/ transverse or warm vertical boundary space to experience both of the boundaries depend on the related boundary type

2- S/ L/ T/ C; Each eight participants begin the experiment with small/ dim/ longitudinal or cool vertical boundary space and then large/ bright/ transverse or warm vertical boundary space. The same participants proceed to experience the small/ dim/ longitudinal or cool horizontal boundary space and then large/ bright/ transverse or warm horizontal boundary space in order to analyze these boundaries depend on the related boundary type

3- S/ L/ T/ C; Each eight participants begin the experiment by the analyzing the large/ bright/ transverse or warm horizontal boundary space and then the small/ dim/ longitudinal or cool horizontal boundary space. The same participants continue with the large/ bright/ transverse or warm vertical boundary space and then small/ dim/ longitudinal or cool vertical boundary space to understand both boundaries depend on the related boundary type

4- S/ L/ T/ C; Each eight participants proceed the experiment with large/ bright/ transverse or warm vertical boundary space and then small/ dim/ longitudinal or cool vertical boundary space. Then, the same participants start to experience the large/ bright/ transverse or warm horizontal boundary space and then small/ dim/ longitudinal or cool horizontal boundary space in order to analyze both of the boundaries depend on the related boundary type.

Appendix H showed the all procedure of the study in detail and Appendix I showed the summarized all specific property and boundary types procedures. The methodology of the study was examined in this chapter in detail. The following chapter is related to the findings of the relevant methodology.

CHAPTER 5

FINDINGS

The purpose of this chapter is to demonstrate the findings of the data analysis that was gathered through 360-degree VR simulation tasks conducted by the test subjects. The data were analyzed using Statistical Package for the Social Science (SPSS) software version 24.0 (SPSS, IBM Crop, Statistics for research: with a guide to SPSS).

Firstly, demographic backgrounds of the participants were analyzed. The findings of the study conducted according to the 5 hypotheses of the study.

Secondly, for each specific property (size, light, texture and color) perception of spaciousness level was analyzed for each four settings. Then, the multiple comparison test was done in order to determine the relationship in the perception of spaciousness in the four settings of boundaries.

Thirdly, each specific property was followed by the descriptive analysis of aesthetic judgements that were composed of affective, formal and symbolic variables**.** The descriptive analysis of emotional responses that was composed of pleasure and arousal groups was done.

Fourthly, variance analysis conducted to analyzed interaction of the boundary type and specific property. Fifthly, group of regression test was conducted to determine the relationship between the perception of spaciousness and nine aesthetic judgement. Sixthly, group of regression test was conducted to determine the relationship between the perception of spaciousness and twelve emotional responses items.

Finally, each specific property and boundary type groups of qualitative comments on space setting was analyzed. Behavioral intention that were focused on time span, enjoyment and feel friendly level analyzed as an approach-avoidance behavior of the individuals.

5.1. Demographic Characteristics

The “Perceive Spaciousness” survey is composed of four specific property that are size, light, texture and color and each property is analyzed separately. The survey, with four specific property consisted of 128 participants (64 male and 64 female) who were the graduate and undergraduate students from the social science and design department at Bilkent University. The age range of the participant was 18-29 years. Data were collected through a virtual reality field study approach, since the

subjects experienced the created space with a SM-R325 Gear VR. Participation was on voluntary basis and no reward incentive was provided. Table 8 summarizes the demographic profile of the participants.

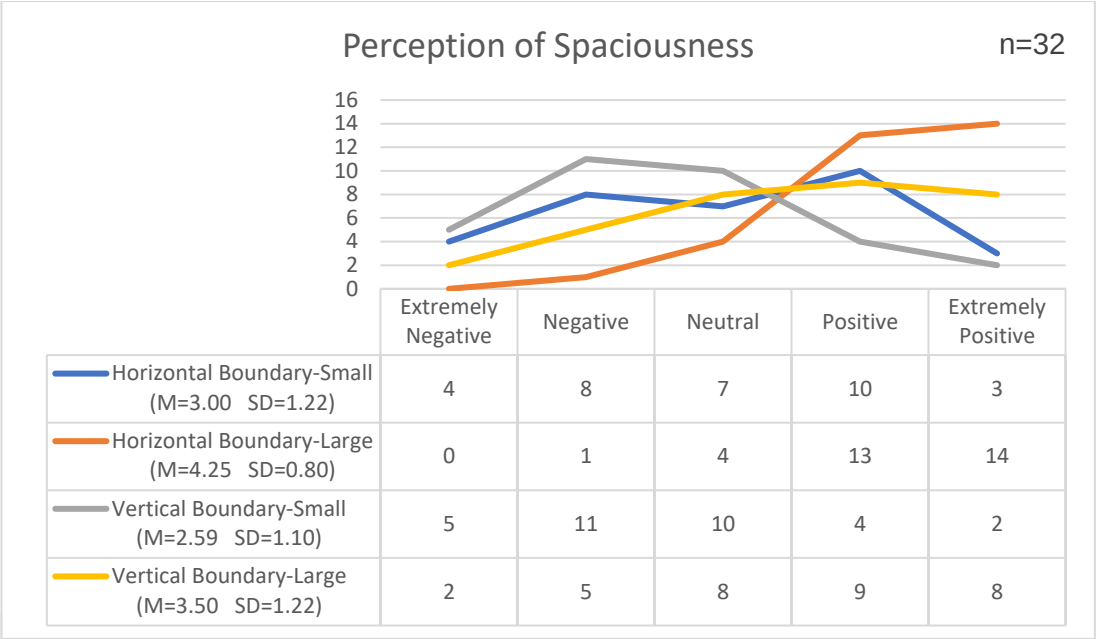
Table 8. Demographic Characteristics of the Participants of the Study

		Perceive Spaciousness			
		Size	**Light**	**Texture**	**Color**
Characteristics	**Category**	**Freq./Perct.**	**Freq./Perct.**	**Freq./Perct.**	**Freq./Perct.**
Gender	Male	16/ 50.0	16/ 50.0	16 / 50.0	16/ 50.0
	Female	16/ 50.0	16/ 50.0	16 / 50.0	16/ 50.0
Age	18-27	30 / 93.7	29 / 90.6	31 / 96.9	29 / 90.6
	27-more	2 / 6.3	3 / 9.4	1 / 3.1	3 / 9.4
Education Level	Undergraduate	23 / 71.9	20 / 62.5	21 / 65.6	21 / 65.6
	Graduate	9 / 28.1	12 / 37.5	11 / 34.4	11 / 34.4
Major	Social Science	10 / 31.3	13 / 40.6	9 / 28.1	10 / 31.3
	Design	22 /68.8	19 / 59.4	23 / 71.9	22 / 68.8

5.2. Perception of Spaciousness in Terms of Specific Properties

5.2.1. Size Property

In Figure 17, Statistical results showed that the highest spaciousness level was perceived in the HB-L space (M=4.25, SD=0.80) and it was followed by the VB-L space (M=3.50, SD=1.22). While the HB-S space was perceived as the third spacious space (M=3.00, SD=1.22) and the VB-S space was the least spacious space (M=2.59, SD=1.10).



	Extremely Negative	Negative	Neutral	Positive	Extremely Positive
Horizontal Boundary-Small (M=3.00 SD=1.22)	4	8	7	10	3
Horizontal Boundary-Large (M=4.25 SD=0.80)	0	1	4	13	14
Vertical Boundary-Small (M=2.59 SD=1.10)	5	11	10	4	2
Vertical Boundary-Large (M=3.50 SD=1.22)	2	5	8	9	8

Figure 17. Rating Scale for Perception of Spaciousness in Size

Multiple comparison test was done in order to determine the perception of spaciousness differences in the four-size boundaries. The sample size was equal in each group and ANOVA Scheffe test was conducted. The results showed that there are statistical significant mean differences in size property with value of $F(3,124) = 13.48$ $p < .0001$ with subset for alpha level = 0.05.

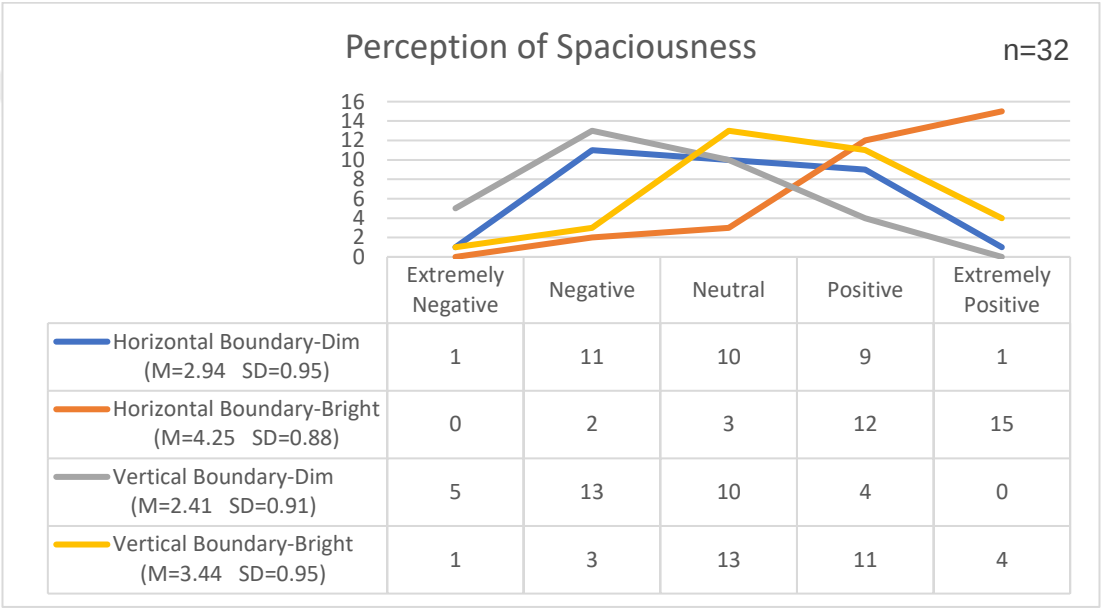
There are significant differences between HB-S and HB-L; between HB-L and VB-S; and between VB-S and VB-L. There are three homogenous subsets that means which do not differ significantly from each other as seen in Table 9.

Table 9. Groups of Perception of Spaciousness in Size

	Subset for alpha = 0.05		
	1	2	3
Vertical Boundary-Small	2.59		
Horizontal Boundary-Small	3.00	3.00	
Vertical Boundary-Large		3.50	3.50
Horizontal Boundary-Large			4.25

5.2.2. Light Property

In Figure 18, Statistical results showed that the highest spaciousness level was perceived in the HB-B space (M=4.25, SD=0.88) and it was followed by the VB-B space (M=3.44, SD=0.95). While the HB-D space was perceived as the third spacious space (M=2.94, SD=0.95) and the VB-D space was the least spacious space (M=2.41, SD=0.91).



	Extremely Negative	Negative	Neutral	Positive	Extremely Positive
Horizontal Boundary-Dim (M=2.94 SD=0.95)	1	11	10	9	1
Horizontal Boundary-Bright (M=4.25 SD=0.88)	0	2	3	12	15
Vertical Boundary-Dim (M=2.41 SD=0.91)	5	13	10	4	0
Vertical Boundary-Bright (M=3.44 SD=0.95)	1	3	13	11	4

Figure 18. Rating Scale for Perception of Spaciousness in Light

Multiple comparison test was done in order to determine the perception of spaciousness differences in the four-light boundaries. The sample size was equal in each group and ANOVA Scheffe test was conducted. The results showed that there are statistical significant mean differences in light property with value of $F(3,124) = 23.13$ $p < .0001$ with subset for alpha level = 0.05.

There are significant differences between HB-D and HB-B; between HB-B and VB-D; between HB-B and VB-B; and between VB-D and VB-B. There

are three homogenous subsets that means which do not differ significantly from each other as seen in Table 10.

Table 10. Groups of Perception of Spaciousness in Light

Subset for alpha = 0.05

	1	2	3
Vertical Boundary-Dim	2.41		
Horizontal Boundary-Dim	2.94	2.94	
Vertical Boundary-Bright		3.44	
Horizontal Boundary-Bright			4.25

5.2.3. Texture Property

In Figure 19, Statistical results showed that the highest spaciousness level was perceived in the HB-T space (M=3.97, SD=1.03) and it was followed by the VB-T space (M=3.50, SD=1.11). While the HB-L space was perceived as the third spacious space (M=2.72, SD=1.11) and the VB-L space was the least spacious space (M=2.66, SD=1.10).

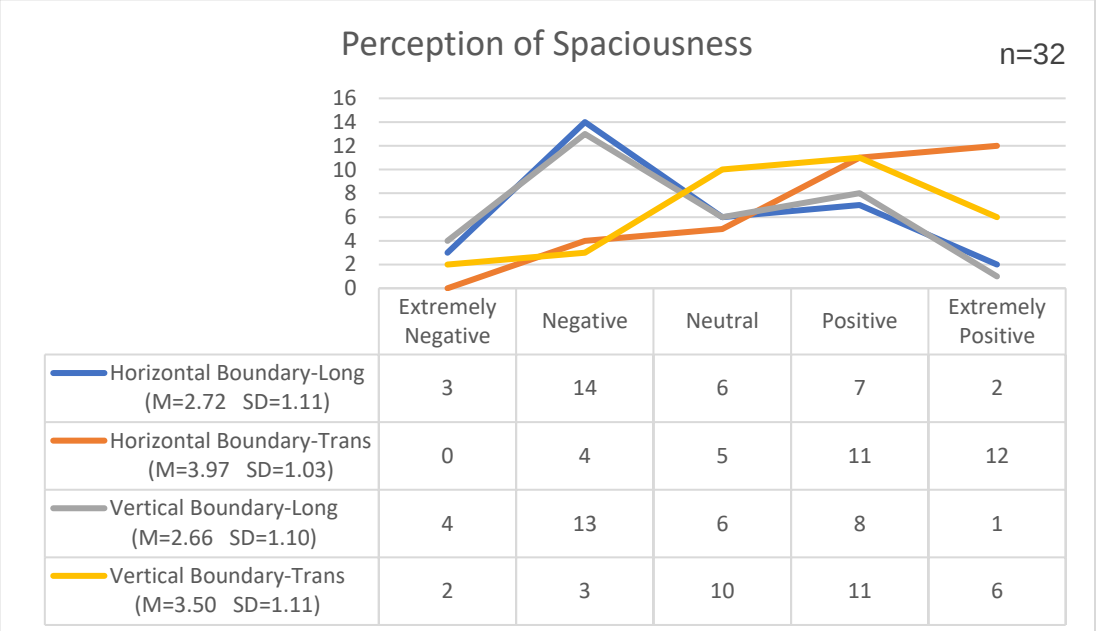


Figure 19. Rating Scale for Perception of Spaciousness in Texture

Multiple comparison test was done in order to determine the perception of spaciousness differences in the four-texture boundaries. The sample size was equal in each group and ANOVA Scheffe test was conducted. The results showed that there are statistical significant mean differences in texture property with value of $F(3,124) = 10.89$ $p < .0001$ with subset for alpha level = 0.05.

There are significant differences between HB-L and HB-T; between HB-L and VB-T; between HB-T and VB-L; and between VB-L and VB-T. There are two homogenous subsets that means which do not differ significantly from each other as seen in Table 11.

Table 11. Groups of Perception of Spaciousness in Texture

	Subset for alpha = 0.05	
	1	2
Vertical Boundary-Longitudinal	2.66	
Horizontal Boundary-Longitudinal	2.72	
Vertical Boundary-Transverse		3.50
Horizontal Boundary-Transverse		3.97

5.2.4. Color Property

In Figure 20, Statistical results showed that the highest spaciousness level was perceived in the HB-C space (M=4.09, SD=0.89) and it was followed by the VB-C space (M=3.66, SD=0.90). While the HB-W space was perceived as the third spacious space (M=2.84, SD=0.77) and the VB-W space was the least spacious space (M=2.28, SD=0.92).

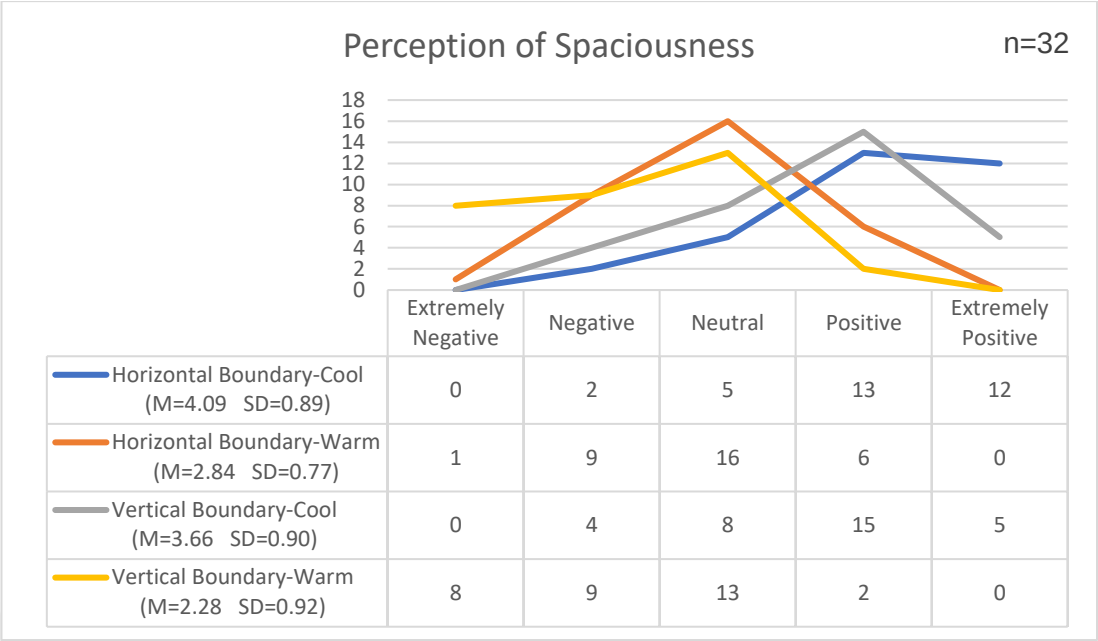


Figure 20. Rating Scale for Perception of Spaciousness in Color

Multiple comparison test was done in order to determine the perception of spaciousness differences in the four-color boundaries. The sample size was equal in each group and ANOVA Scheffe test was conducted. The results showed that there are statistical significant mean differences in color property with value of $F(3,124) = 27.63$ $p < .0001$ with subset for alpha level = 0.05.

There are significant differences between HB-C and HB-W; between HB-C and VB-W; between HB-W and VB-C; and between VB-C and VB-W. There are two homogenous subsets that means which do not differ significantly from each other as seen in Table 12.

Table 12. Groups of Perception of Spaciousness in Color

	Subset for alpha = 0.05	
	1	2
Vertical Boundary-Warm	2.28	
Horizontal Boundary-Warm	2.84	
Vertical Boundary-Cool		3.66
Horizontal Boundary-Cool		4.09

5.3. Aesthetic Judgements and Emotional Responses in Specific Properties

Aesthetic judgement is composed of three variable groups; namely as affective, formal and symbolic variables. The mean scores for the aesthetic judgements of the participants related to the four space boundaries are presented. In the following section, for each space boundary, the lowest and the highest mean scores for each variable group is specified. Furthermore, the rating level of each item in each variable group is stated. Also, the related Cronbach's Alpha level for each space is indicated.

Emotional response is composed of two groups; namely as pleasure and arousal. The mean score for the emotional responses of the participants related to four space boundaries are presented. In the following section, for the space boundary, the lowest and the highest mean scores for each group is specified. Furthermore, the rating level of each item in each group is stated. Also, the related Cronbach's Alpha level for each space is indicated.

This section presents the outcomes of the descriptive analysis findings related to the aesthetic judgements and emotional responses of the subjects that provides a basis for the further analysis of the previous stated hypothesis.

5.3.1. Size Property

*Among the items of Horizontal Boundary – Small (HB-S) space; a*s seen in Figure 21, the mean score for the items of aesthetic judgements dimension ranged from 2.94 (neutral) ('simple-complex' item in formal variables) to 4.00 (positive) ('unsafe-safe' item in symbolic variables). Among four items of *affective variables,* three items were rated as 'neutral' (unpleasant-pleasant, gloomy-exciting and distressing-relaxing) and one item was rated as 'positive' (sleepy-arousing). All two items of *formal variables* were rated as 'neutral' (simple-complex and incoherent-coherent). For three items of s*ymbolic variables,* one item was rated as 'neutral' (not mysterious-mysterious) and two items were rated as 'positive' (unsafe-safe and masculine-feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.74.

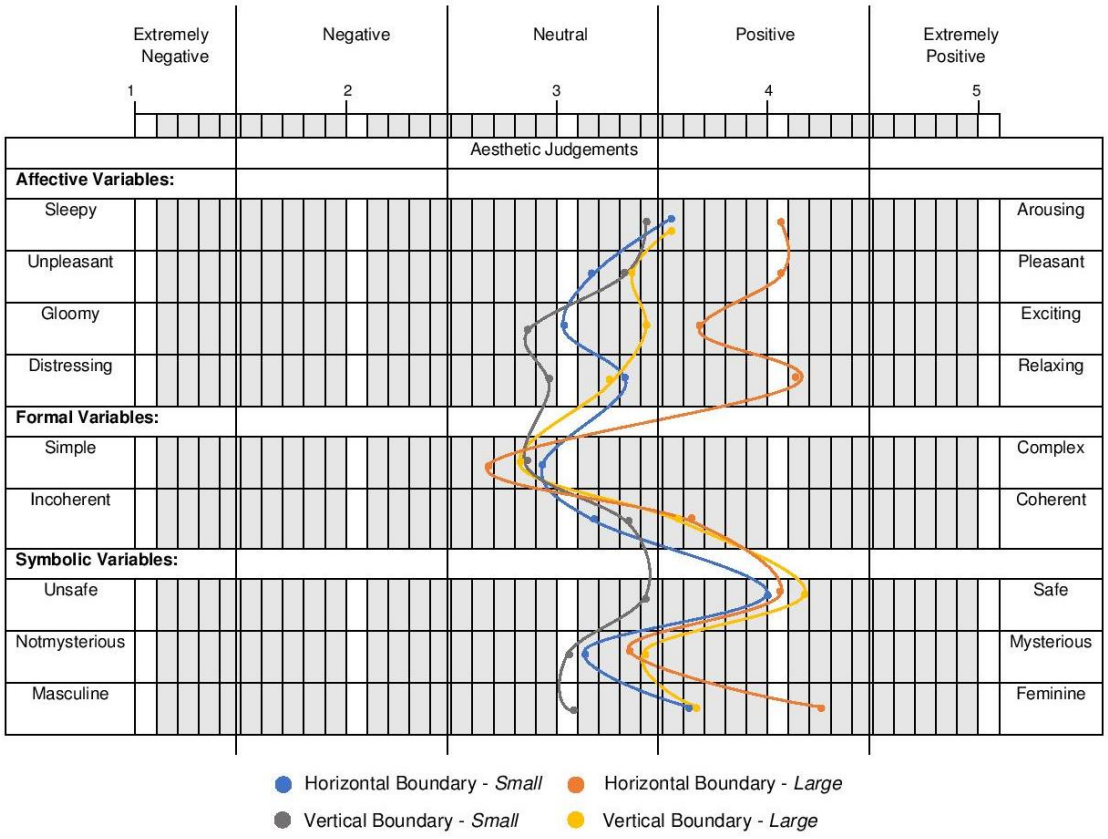


Figure 21. Rating Scale for Aesthetic Judgements in Size

*Among the items of Horizontal Boundary – Large (HB-L) space; a*s seen in Figure 21, the mean score for the items of aesthetic judgements dimension ranged from 2.69 (neutral) ('simple-complex' item in formal variables) to 4.25 (positive) ('masculine-feminine' item in symbolic variables). All four items of *affective variables* were rated as 'positive' (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). Among two items of *formal variables,* one item was rated as 'neutral' (simple-complex) and the other as 'positive' (incoherent-coherent). For three items of s*ymbolic variables,* one item was rated as 'neutral' (not mysterious-mysterious) and two items were rated as 'positive' (unsafe-safe and masculine feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.78.

*Among the items of Vertical Boundary – Small (VB-S) space; a*s seen in Figure 21, the mean score for the items of aesthetic judgements dimension ranged from 2.88 (neutral) ('gloomy-exciting' item in affective variables and 'simple-complex' item in formal variables) to 3.41 (positive) ('sleepy-arousing' item in affective variables and 'unsafe-safe' item in symbolic variables). All four items of *affective variables* were rated as 'neutral' (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). All two items of *formal variables* were rated as 'neutral' (simple-complex and incoherent-coherent). All three items of s*ymbolic variables* were rated as 'neutral' (unsafe-safe, not mysterious-mysterious and masculine feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.26.

*Among the items of Vertical Boundary – Large (VB-L) space; a*s seen in Figure 21, the mean score for the items of aesthetic judgements dimension ranged from 2.84 (neutral) (‘simple-complex’ item in formal variables) to 4.19 (positive) (‘unsafe-safe’ item in symbolic variables). Among four items of *affective variables*, three items were rated as ‘neutral’ (unpleasant-pleasant, gloomy-exciting and distressing-relaxing) and one item was rated as ‘positive’ (sleepy-arousing). Among two items of *formal variables,* one item was rated as ‘neutral’ (simple-complex) and the other as ‘positive’ (incoherent-coherent). For three items of s*ymbolic variables,* one item was rated as ‘neutral’ (not mysterious-mysterious) and two items were rated as ‘positive’ (unsafe-safe and masculine feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.79.

*Among the items of Horizontal Boundary – Small (HB-S) space; a*s seen in Figure 22, the mean score for the items of emotional responses dimension ranged from 2.88 (neutral) (‘calm-excited’ item in arousal group) to 3.28 (neutral) (‘unhappy-happy’ item in pleasure group). All six items of *pleasure group* were felt as ‘neutral’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.89.

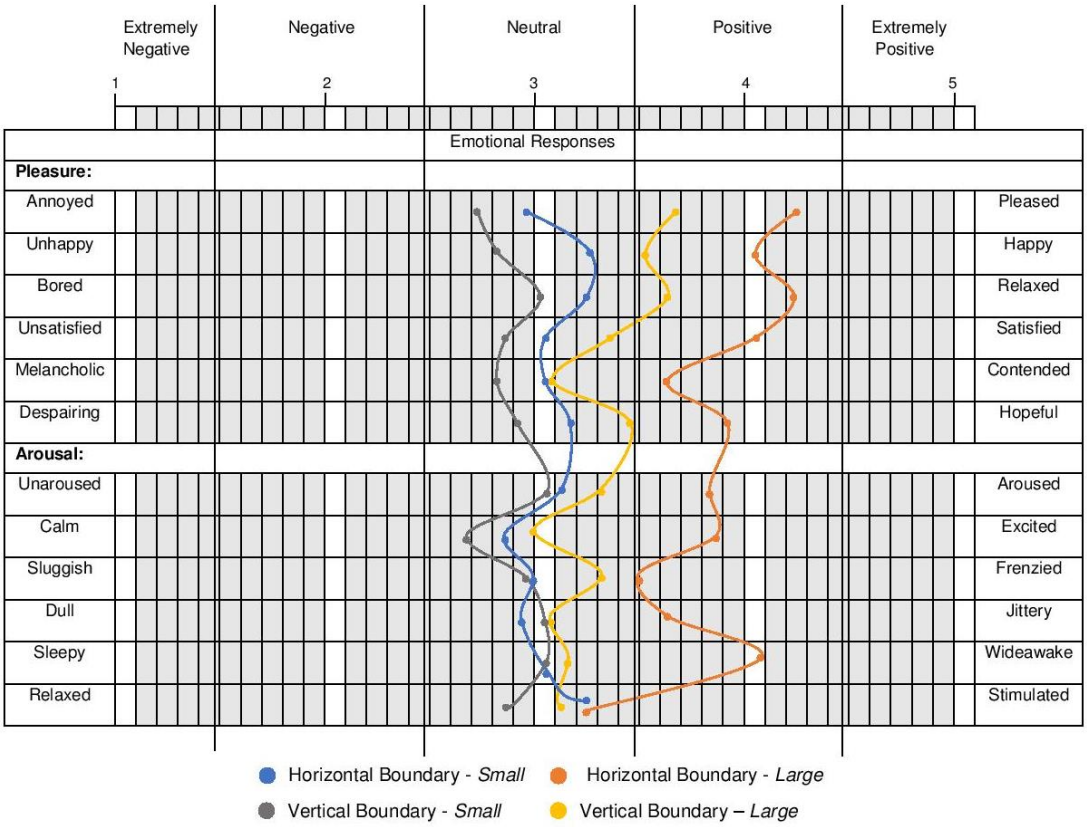


Figure 22. Rating Scale for Emotional Responses in Size

*Among the items of Horizontal Boundary – Large (HB-L) space; a*s seen in Figure 22, the mean score for the items of emotional responses dimension ranged from 3.25 (neutral) (‘relaxed-stimulated’ item in arousal group) to 4.25 (positive) (‘annoyed-pleased’ item in pleasure group). All six items of *pleasure group* were felt as ‘positive’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). Among six items of *arousal group*, one item was thought as ‘neutral’ (relaxed-stimulated) and five items were thought as ‘positive’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery and sleepy-wide awake). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.86.

*Among the items of Vertical Boundary – Small (VB-S) space; a*s seen in Figure 22, the mean score for the items of emotional responses dimension ranged from 2.69 (neutral) (‘calm-excited’ item in arousal group) to 3.06 (neutral) (‘unaroused-aroused’, ‘dull-jittery’ and ‘sleepy-wide-awake’ items in arousal group). All six items of *pleasure group* were felt as ‘positive’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.79.

*Among the items of Vertical Boundary – Large (VB-L) space; a*s seen in Figure 22, the mean score for the items of emotional responses dimension ranged from 3.00 (neutral) (calm-excited’ item in arousal group) to 3.69 (positive) (‘annoyed-pleased’ and ‘bored-relaxed’ items in pleasure group). Among six items of *pleasure group,* three items were felt as ‘neutral’ unsatisfied-satisfied, melancholic-contended and despairing-hopeful) and three as ‘positive’ (annoyed-pleased, unhappy-happy and bored-relaxed). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.95.

5.3.2. Light Property

*Among the items of Horizontal Boundary – Dim (HB-D) space; a*s seen in Figure 23, the mean score for the items of aesthetic judgements dimension ranged from 2.03 (negative) (‘masculine-feminine’ item in symbolic variables) to 4.09 (positive) (‘unsafe-safe’ item in symbolic variables). All four items of *affective variables* were rated as ‘neutral’ (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). Among two items of *formal variables,* one item was rated as ‘neutral’ (simple-complex) and the other as ‘positive’ (incoherent-coherent). For three items of s*ymbolic variables,* one item was rated as ‘negative’ (masculine-feminine), one as ‘neutral’ (not mysterious-mysterious) and other as ‘positive’ (unsafe-safe). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.63.

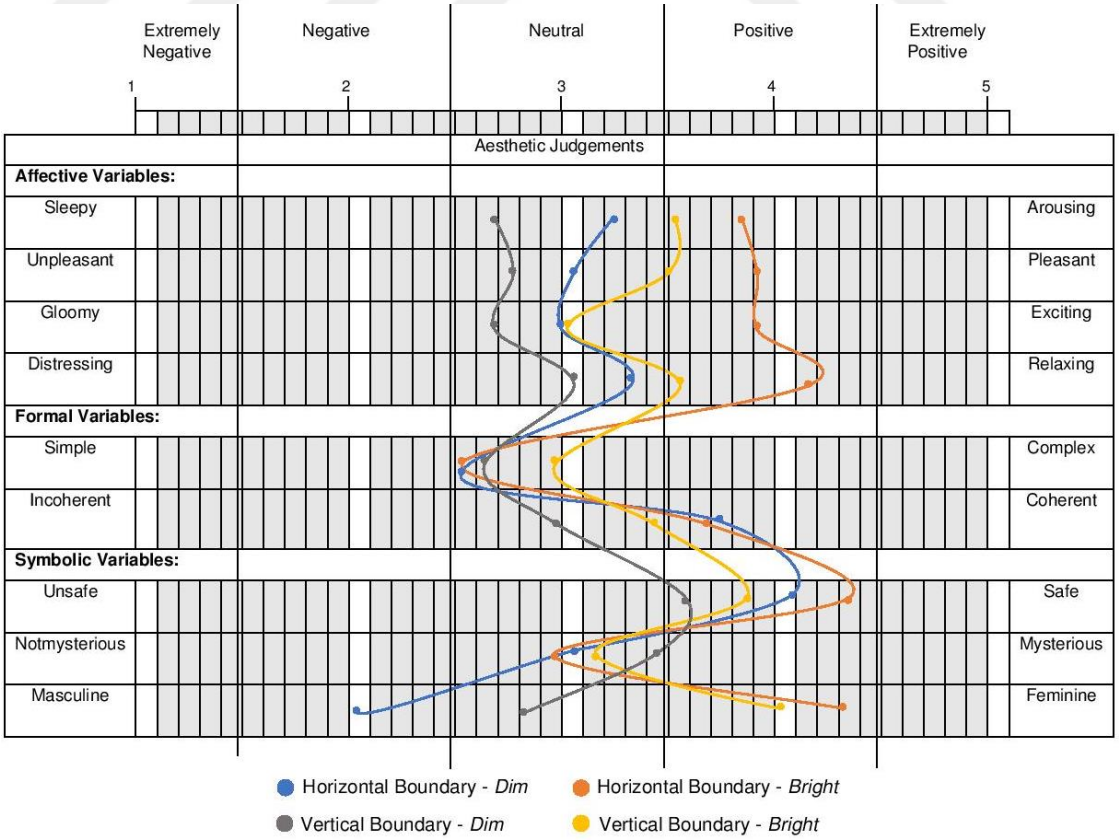


Figure 23. Rating Scale for Aesthetic Judgements in Light

*Among the items of Horizontal Boundary – Bright (HB-B) space; a*s seen in Figure 23, the mean score for the items of aesthetic judgements dimension ranged from 2.53 (neutral) ('simple-complex' item in formal variables) to 4.34 (positive) ('unsafe-safe' item in symbolic variables). All four items of *affective variables* were rated as 'positive' (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). Among two items of *formal variables,* one item was rated as 'neutral' (simple-complex) and the other as 'positive' (incoherent-coherent). For three items of s*ymbolic variables,* one item was rated as 'neutral' (not mysterious-mysterious) and two items were rated as 'positive' (unsafe-safe and masculine feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.75.

*Among the items of Vertical Boundary – Dim (VB-D) space; a*s seen in Figure 23, the mean score for the items of aesthetic judgements dimension ranged from 2.63 (neutral) ('simple-complex' item in formal variables) to 3.59 (positive) ('unsafe-safe' item in symbolic variables). All four items of *affective variables* were rated as 'neutral' (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). All two items of *formal variables* were rated as 'neutral' (simple-complex and incoherent-coherent). For three items of s*ymbolic variables,* two items were rated as 'neutral' (not mysterious-mysterious and masculine feminine) and one item was rated as 'positive' (unsafe-safe). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.27.

*Among the items of Vertical Boundary – Bright (VB-B) space; a*s seen in Figure 23, the mean score for the items of aesthetic judgements dimension ranged from 2.97 (neutral) (‘simple-complex’ item in formal variables) to 4.03 (positive) (‘masculine-feminine’ item in symbolic variables). Among four items of *affective variables*, one item was rated as ‘neutral’ (gloomy-exciting) and three items were rated as ‘positive’ (unpleasant-pleasant, distressing-relaxing and sleepy-arousing). All two items of *formal variables* were rated as ‘neutral’ (simple-complex and incoherent-coherent). For three items of s*ymbolic variables,* one item was rated as ‘neutral’ (not mysterious-mysterious) and two items were rated as ‘positive’ (unsafe-safe and masculine feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.85.

*Among the items of Horizontal Boundary – Dim (HB-D) space; a*s seen in Figure 24, the mean score for the items of emotional responses dimension ranged from 2.50 (neutral) (‘calm-excited’ item in arousal group) to 3.13 (neutral) (annoyed-pleased’ item in pleasure group). All six items of *pleasure group* were felt as ‘neutral’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.81.

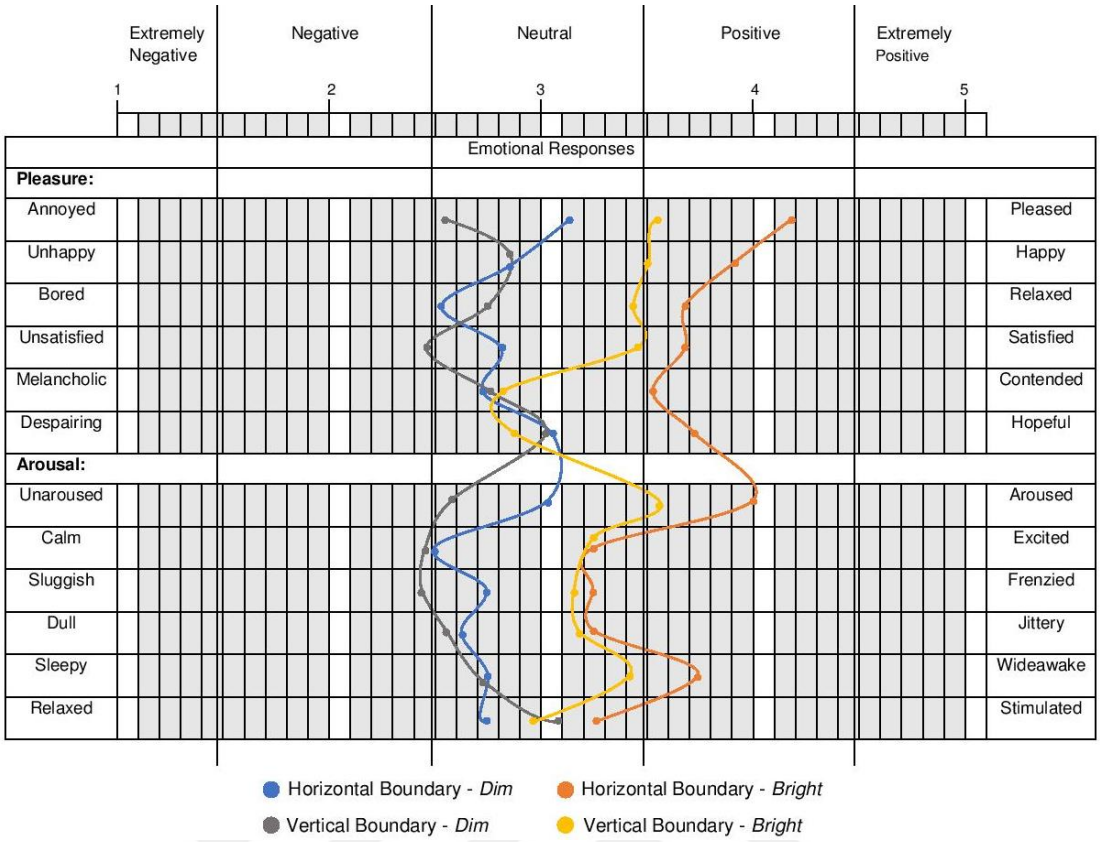


Figure 24. Rating Scale for Emotional Responses in Light

*Among the items of Horizontal Boundary – Bright (HB-B) space; a*s seen in Figure 24, the mean score for the items of emotional responses dimension ranged from 3.25 (neutral) (‘calm-excited’, ‘sluggish-frenzied’, ‘dull-jittery’ and ‘relaxed-stimulated’ items in arousal group) to 4.19 (positive) (‘annoyed-pleased’ item in pleasure group). All six items of *pleasure group* were felt as ‘positive’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). Among six items of *arousal group*, four items were thought as ‘neutral’ (calm-excited, sluggish-frenzied, dull-jittery and relaxed-stimulated) and two as ‘positive’ (unaroused-aroused and sleepy-wide awake) The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.90.

*Among the items of Vertical Boundary – Dim (VB-D) space; a*s seen in Figure 24, the mean score for the items of emotional responses dimension ranged from 2.47 (negative) (‘unsatisfied-satisfied’ item in pleasure group and ‘calm-excited’ item in arousal group) to 3.09 (neutral) (‘relaxed-stimulated’ item in arousal group). Among six items of *pleasure group*, five items were felt as ‘neutral’ (annoyed-pleased, unhappy-happy, bored-relaxed, melancholic-contended and despairing-hopeful) and one item was felt as ‘positive’ (unsatisfied-satisfied). For six items of *arousal group*, two items were thought as ‘negative’ (calm-excited and sluggish-frenzied) and four as ‘neutral’ (unaroused-aroused, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.85.

*Among the items of Vertical Boundary – Bright (VB-B) space; a*s seen in Figure 24, the mean score for the items of emotional responses dimension ranged from 2.81 (neutral) (‘melancholic-contended’ item in pleasure group) to 3.56 (positive) (‘annoyed-pleased’ item in pleasure group and ‘unaroused-aroused’ item in arousal group). Among six items of *pleasure group,* four items were felt as ‘neutral’ (bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful) and two as ‘positive’ (annoyed-pleased and unhappy-happy). For six items of *arousal group*, five items were thought as ‘neutral’ (calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated) and one item was thought as ‘positive’ (unaroused-aroused). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.88.

5.3.3. Texture Property

Among the items of Horizontal Boundary – Longitudinal (HB-L) space; as seen in Figure 25, the mean score for the items of aesthetic judgements dimension ranged from 2.97 (neutral) ('simple-complex' item in formal variables and 'gloomy-exciting' item in affective variables) to 4.00 (positive) ('unsafe-safe' item in symbolic variables). All four items of *affective variables* were rated as 'neutral' (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). Among two items of *formal variables,* one item was rated as 'neutral' (simple-complex) and the other as 'positive' (incoherent-coherent). For three items of s*ymbolic variables,* two items were rated as 'neutral' (not mysterious-mysterious and masculine feminine) and one item was rated as 'positive' (unsafe-safe). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.68.

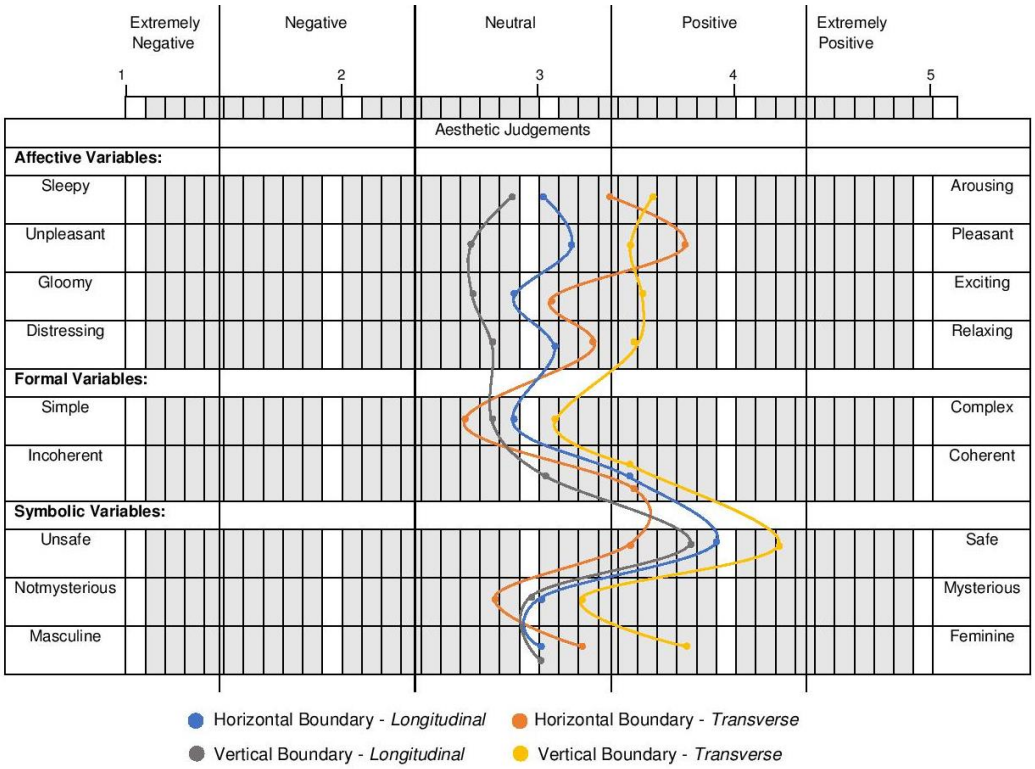


Figure 25. Rating Scale for Aesthetic Judgements in Texture

*Among the items of Horizontal Boundary – Transverse (HB-T) space; a*s seen in Figure 25, the mean score for the items of aesthetic judgements dimension ranged from 2.72 (neutral) (‘simple-complex’ item in formal variables) to 3.59 (positive) (‘incoherent-coherent’ item in formal variables). Among four items of *affective variables*, three items were rated as ‘neutral’ (sleepy-arousing, gloomy-exciting and distressing-relaxing) and one item was rated as ‘positive’ (unpleasant-pleasant). For two items of *formal variables,* one item was rated as ‘neutral’ (simple-complex) and the other as ‘positive’ (incoherent-coherent). For three items of s*ymbolic variables,* two items were rated as ‘neutral’ (not mysterious-mysterious and masculine feminine) and one item was rated as ‘positive’ (unsafe-safe). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.82.

*Among the items of Vertical Boundary – Longitudinal (VB-L) space; a*s seen in Figure 25, the mean score for the items of aesthetic judgements dimension ranged from 2.75 (neutral) (‘unpleasant-pleasant’ item in affective variables) to 3.88 (positive) (‘unsafe-safe’ item in symbolic variables). All four items of *affective variables* were rated as ‘neutral’ (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). All two items of *formal variables* were rated as ‘neutral’ (simple-complex and incoherent-coherent). For the three items of s*ymbolic variables,* two items were rated ‘neutral’ (not mysterious-mysterious and masculine feminine) and one item was rated as ‘positive’ (unsafe-safe). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.73.

*Among the items of Vertical Boundary – Transverse (VB-T) space; a*s seen in Figure 25, the mean score for the items of aesthetic judgements dimension ranged from 3.19 (neutral) ('simple-complex' item in formal variables) to 4.31 (positive) ('unsafe-safe' item in symbolic variables). All four items of *affective variables* were rated as 'positive' (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). Among two items of *formal variables,* one item was rated as 'neutral' (simple-complex) and the other as 'positive' (incoherent-coherent). For the three items of s*ymbolic variables,* one item was rated as 'neutral' (not mysterious-mysterious) and two items were rated as 'positive' (unsafe-safe and masculine feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.87.

*Among the items of Horizontal Boundary – Longitudinal (HB-L) space; a*s seen in Figure 26, the mean score for the items of emotional responses dimension ranged from 2.59 (neutral) ('calm-excited' item in arousal group) to 3.44 (neutral) ('despairing-hopeful' item in pleasure group). All six items of *pleasure group* were felt as 'neutral' (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as 'neutral' (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.88.

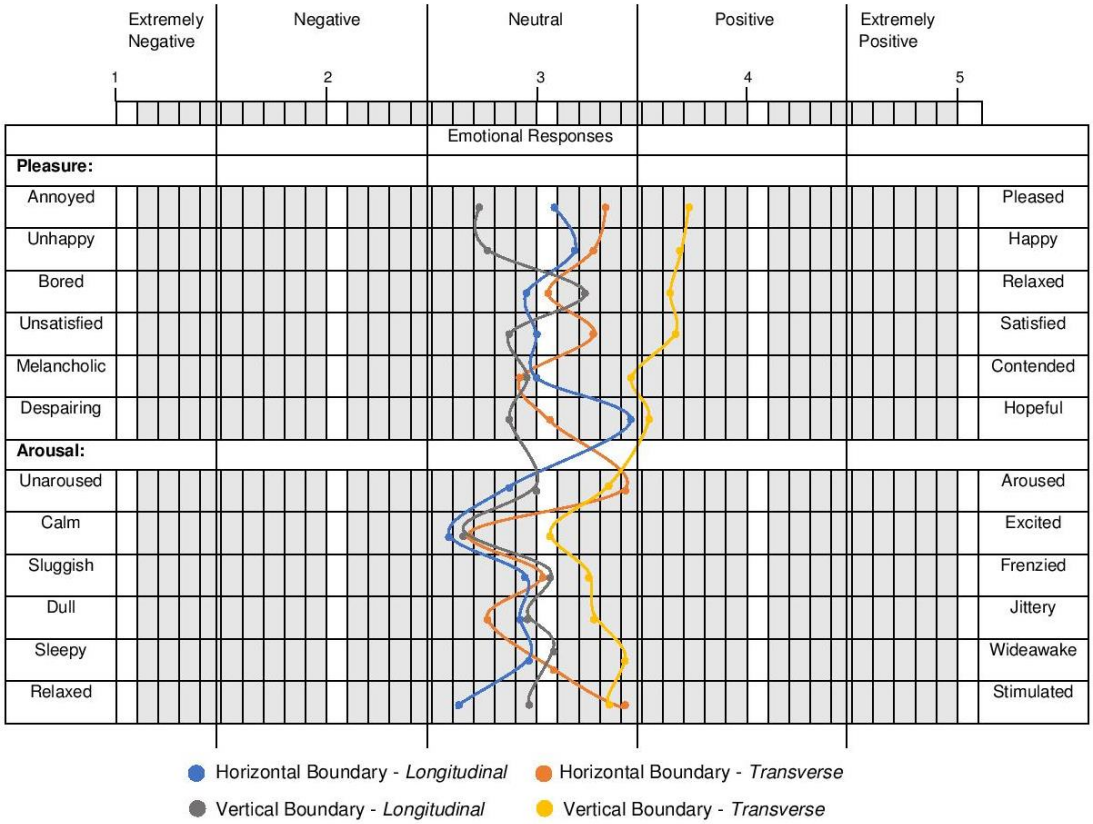


Figure 26. Rating Scale for Emotional Responses in Texture

*Among the items of Horizontal Boundary – Transverse (HB-T) space; a*s seen in Figure 26, the mean score for the items of emotional responses dimension ranged from 2.69 (neutral) (‘calm-excited’ item in arousal group) to 3.41 (neutral) (‘relaxed-stimulated’ and ‘unaroused-aroused’ items in arousal group). All six items of *pleasure group* were felt as ‘neutral’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.79.

*Among the items of Vertical Boundary – Longitudinal (VB-L) space; a*s seen in Figure 26, the mean score for the items of emotional responses dimension ranged from 2.66 (neutral) (‘calm-excited’ item in arousal group) to 3.13 (neutral) (‘bored-relaxed’ item inpleasure group). All six items of *pleasure group* were felt as ‘neutral’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.86.

*Among the items of Vertical Boundary – Transverse (VB-T) space; a*s seen in Figure 26, the mean score for the items of emotional responses dimension ranged from 3.06 (neutral) (‘calm-excited’ item in arousal group) to 3.72 (neutral) (‘annoyed-pleased’ item in pleasure group). Among six items of *pleasure group,* one item was felt as ‘neutral’ (melancholic-contended) and five items were felt as ‘positive’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, despairing-hopeful). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake, relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.91.

5.3.4. Color Property

*Among the items of Horizontal Boundary – Cool (HB-C) space; a*s seen in Figure 27, the mean score for the items of aesthetic judgements dimension ranged from 2.06 (negative) (‘masculine-feminine’ item in symbolic variables) to 4.22 (positive) (‘unsafe-safe’ item in symbolic variables). Among four items of *affective variables,* one item was rated as ‘neutral’ (gloomy-exciting) and three items were rated as ‘positive’ (sleepy-arousing, unpleasant-pleasant and distressing-relaxing). All two items of *formal variables* were rated as ‘neutral’ (simple-complex and incoherent-coherent). For the three items of s*ymbolic variables,* two items were rated as ‘neutral’ (not mysterious-mysterious and masculine-feminine) and one item was rated as ‘positive’ (unsafe-safe). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.81.

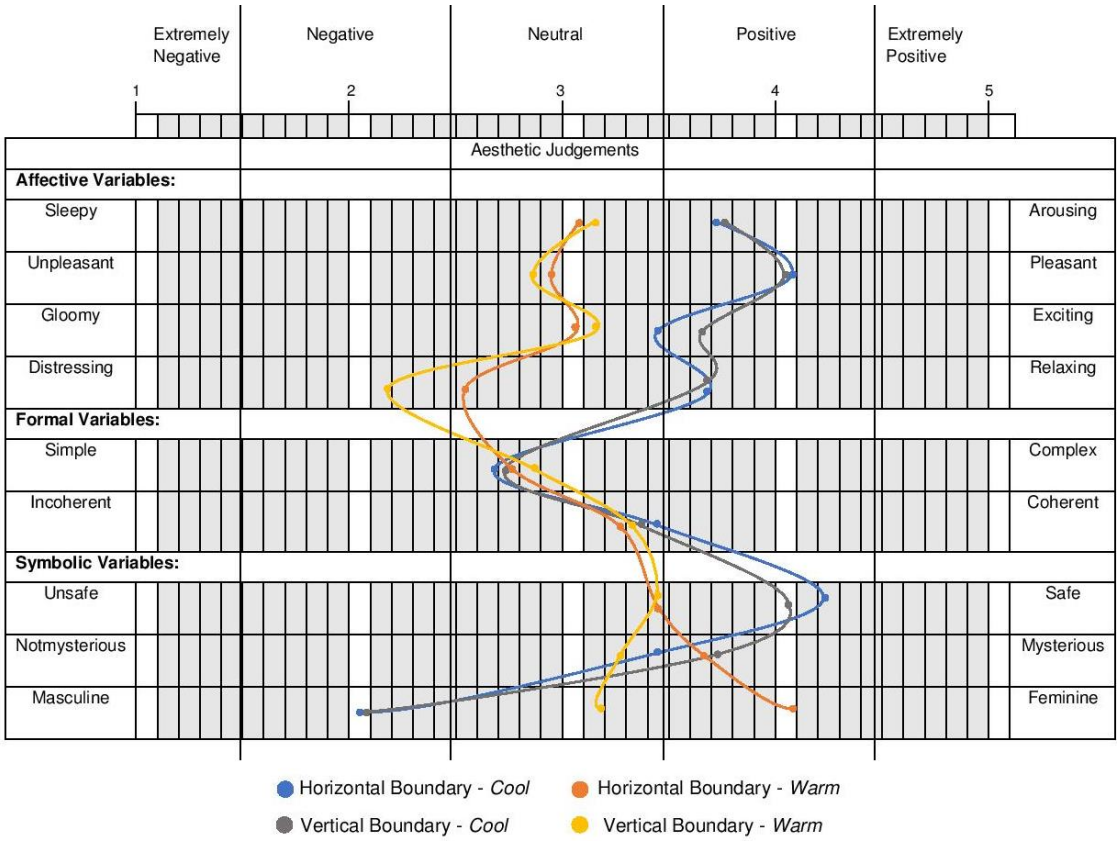


Figure 27. Rating Scale for Aesthetic Judgements in Color

*Among the items of Horizontal Boundary – Warm (HB-W) space; a*s seen in Figure 27, the mean score for the items of aesthetic judgements dimension ranged from 2.56 (neutral) (‘distressing-relaxing’ item in affective variables) to 4.09 (positive) (‘masculine-feminine’ item in symbolic variables). All four items of *affective variables* were rated as ‘neutral’ (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). All two items of *formal variables* were rated as ‘neutral’ (simple-complex and incoherent-coherent). For three items of s*ymbolic variables,* one item was rated as ‘neutral’(unsafe-safe) and two items were rated as ‘positive’ (not mysterious-mysterious and masculine feminine). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.62.

*Among the items of Vertical Boundary – Cool (VB-C) space; a*s seen in Figure 27, the mean score for the items of aesthetic judgements dimension ranged from 2.09 (negative) (‘masculine-feminine’ item in symbolic variables) to 4.06 (positive) (‘unpleasant-pleasant’ item in affective variables and ‘unsafe-safe’ item in symbolic variables). All four items of *affective variables* were rated as ‘positive’ (sleepy-arousing, unpleasant-pleasant, gloomy-exciting and distressing-relaxing). All two items of *formal variables* were rated as ‘neutral’ (simple-complex and incoherent-coherent). For three items of s*ymbolic variables,* one item was rated ‘negative’ (masculine feminine) and two items were rated as ‘positive’ (unsafe-safe and not mysterious-mysterious). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.75.

*Among the items of Vertical Boundary – Warm (VB-W) space; a*s seen in Figure 27, the mean score for the items of aesthetic judgements dimension ranged from 2.19 (negative) (‘distressing-relaxing’ item in affective variables) to 3.44 (neutral) (‘unsafe-safe’ item in symbolic variables). Among four items of *affective variables*, one item was rated as ‘negative’ (distressing-relaxing) and three items were rated as ‘neutral’ (sleepy-arousing, unpleasant-pleasant and gloomy-exciting). All two items of *formal variables* were rated as ‘neutral’ (simple-complex and incoherent-coherent). All three items of s*ymbolic variables* were rated as ‘neutral’ (unsafe-safe, masculine feminine and not mysterious-mysterious). The Cronbach's Alpha reliability of the nine items of aesthetic judgement for the thirty-two cases is 0.77.

*Among the items of Horizontal Boundary – Cool (HB-C) space; a*s seen in Figure 28, the mean score for the items of emotional responses dimension ranged from 2.75 (neutral) (‘relaxed-stimulated’ item in arousal group) to 4.00 (positive) (‘annoyed-pleased’ item in pleasure group). Among six items of *pleasure group*, two items were felt as ‘neutral’ (melancholic-contended and despairing-hopeful) and four as ‘positive’ (annoyed-pleased, unhappy-happy, bored-relaxed and unsatisfied-satisfied). For six items of *arousal group*, five items were thought as ‘neutral’ (calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated) and one item was thought as ‘positive’ (unaroused-aroused). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.88.

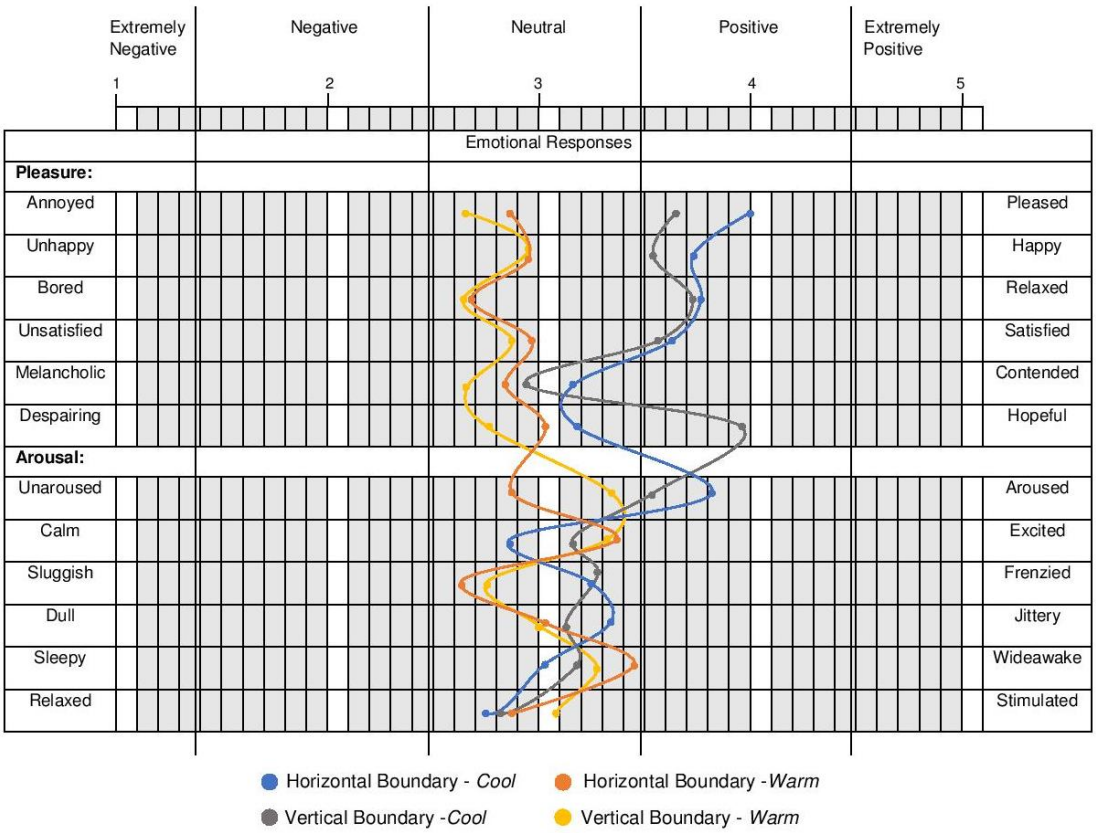


Figure 28. Rating Scale for Emotional Responses in Color

Among the items of Horizontal Boundary – Warm (HB-W) space; as seen in Figure 28, the mean score for the items of emotional responses dimension ranged from 2.63 (neutral) ('sluggish-frenzied' item in arousal group) to 3.44 (neutral) ('sleepy-wide awake' item in arousal group). All six items of *pleasure group* were felt as 'neutral' (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as 'neutral' (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.88.

*Among the items of Vertical Boundary – Cool (VB-C) space; a*s seen in Figure 28, the mean score for the items of emotional responses dimension ranged from 2.81 (neutral) (‘relaxed-stimulated’ item in arousal group) to 3.97 (positive) (‘despairing-hopeful’ item in pleasure group). Among six items of *pleasure group*, one item was felt as ‘neutral’ (melancholic-contended) and five items were felt as ‘positive’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied and despairing-hopeful). For six items of *arousal group*, five items were thought as ‘neutral’ (calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated) and one item was thought as ‘positive’ (unaroused-aroused). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.87.

*Among the items of Vertical Boundary –Warm (VB-W) space; a*s seen in Figure 28, the mean score for the items of emotional responses dimension ranged from 2.66 (neutral) (‘annoyed-pleased’, ‘bored-relaxed’ and ‘melancholic-contended’ items in pleasure group) to 3.34 (neutral) (‘unaroused-aroused’ item in arousal group). All six items of *pleasure group* were felt as ‘neutral’ (annoyed-pleased, unhappy-happy, bored-relaxed, unsatisfied-satisfied, melancholic-contended and despairing-hopeful). All six items of *arousal group* were thought as ‘neutral’ (unaroused-aroused, calm-excited, sluggish-frenzied, dull-jittery, sleepy-wide awake and relaxed-stimulated). The Cronbach's Alpha reliability of the twelve items of emotional responses for the thirty-two cases is 0.88.

5.4. Interaction of the Boundary Type and Specific Properties

5.4.1. Size Property

In Table 13, A two-way unrelated ANOVA showed that significant effects were obtained for boundary, $F(1,124)=8.86$, $p= 0.004$, partial $\eta^2 = 0.067$, and size, $F(1,124)=30.81$, $p < 0.0001$, partial $\eta^2 = 0.199$, but not for their interaction, $F(1,124)=0.78$, $p=0.378$, partial $\eta^2 = 0.006$ (see Figure 29).

Table 13. Analysis of Variance Summary in Size

Source of Variation	Sums of squares	Degrees of freedom	Mean square	F-ratio	Probability
Boundary	10.695	1	10.695	8.858	0.004
Size	37.195	1	37.195	30.806	0.0001
Boundary with Size	0.945	1	0.945	0.783	0.378
Error	149.719	124	1.207		

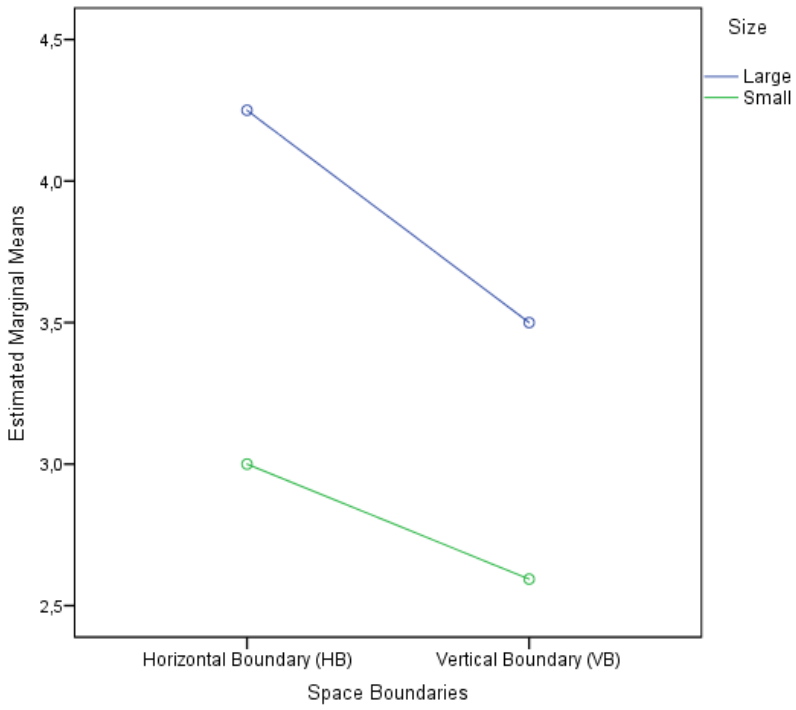


Figure 29. Estimated Marginal Means of Spaciousness in Terms of Size

5.4.2. Light Property

In Table 14, A two-way unrelated ANOVA showed that significant effects were obtained for boundary, $F(1,124)=16.98$, $p < 0.0001$, partial $\eta^2 = 0.120$, and light, $F(1,124)=51.67$, $p < 0.0001$, partial $\eta^2 = 0.294$, but not for their interaction, $F(1,124)=0.74$, $p=0.390$, partial $\eta^2 = 0.006$ (see Figure 30).

Table 14. Analysis of Variance Summary in Light

Source of Variation	Sums of squares	Degrees of freedom	Mean square	F-ratio	Probability
Boundary	14.445	1	14.445	16.983	0.0001
Light	43.945	1	43.945	51.667	0.0001
Boundary with Light	0.633	1	0.633	0.744	0.390
Error	105.469	124	0.851		

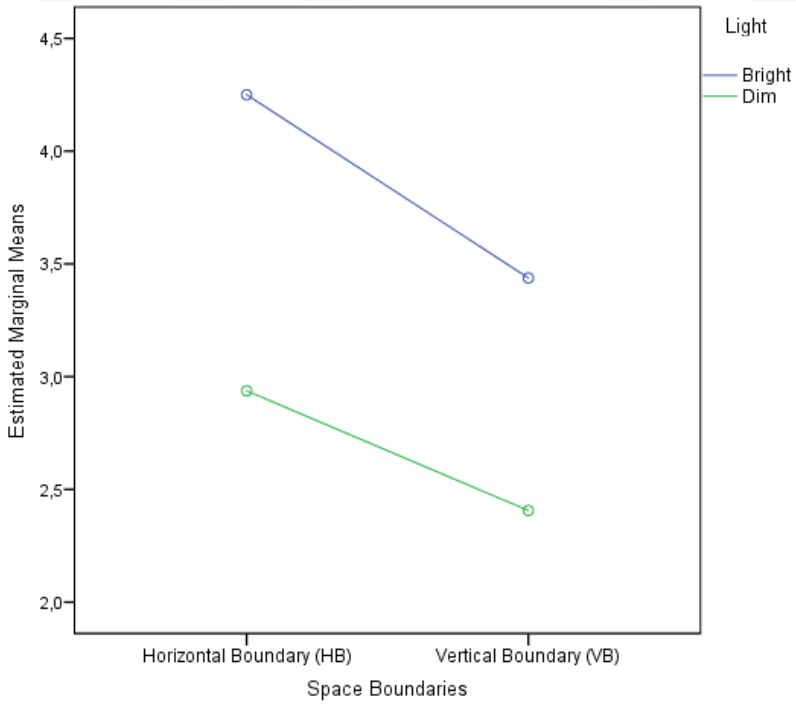


Figure 30. Estimated Marginal Means of Spaciousness in Terms of Light

5.4.3. Texture Property

In Table 15, A two-way unrelated ANOVA showed that significant effects were obtained for boundary, $F(1,124)=1.91$, $p= 0.170$, partial $\eta^2 = 0.015$, and texture, $F(1,124)=29.65$, $p < 0.0001$, partial $\eta^2 = 0.193$, but not for their interaction, $F(1,124)=1.116$, $p=0.290$, partial $\eta^2 = 0.009$ (see Figure 31).

Table 15. Analysis of Variance Summary in Texture

Source of Variation	Sums of squares	Degrees of freedom	Mean square	F-ratio	Probability
Boundary	2.258	1	2.258	1.909	0.170
Texture	35.070	1	35.070	29.652	0.0001
Boundary with Texture	1.320	1	1.320	1.116	0.293
Error	146.656	124	1.183		

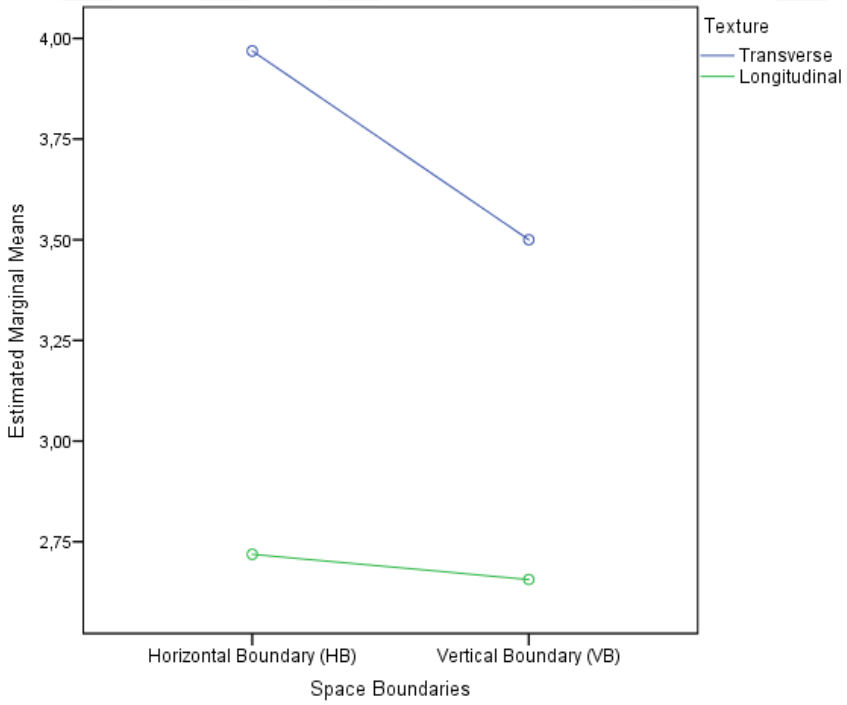


Figure 31. Estimated Marginal Means of Spaciousness in Terms of Texture

5.4.4. Color Property

In Table 16, A two-way unrelated ANOVA showed that significant effects were obtained for boundary, $F(1,124)=10.48$, $p= 0.002$, partial $\eta^2 = 0.078$, and color, $F(1,124)=72.24$, $p < 0.0001$, partial $\eta^2 = 0.368$, but not for their interaction, $F(1,124)=0.164$, $p=0.686$, partial $\eta^2 = 0.001$ (see Figure 32).

Table 16. Analysis of Variance Summary in Color

Source of Variation	Sums of squares	Degrees of freedom	Mean square	F-ratio	Probability
Boundary	8.000	1	8.000	10.483	0.002
Color	55.125	1	55.125	72.238	0.0001
Boundary with Color	0.125	1	0.125	0.164	0.686
Error	94.625	124	0.763		

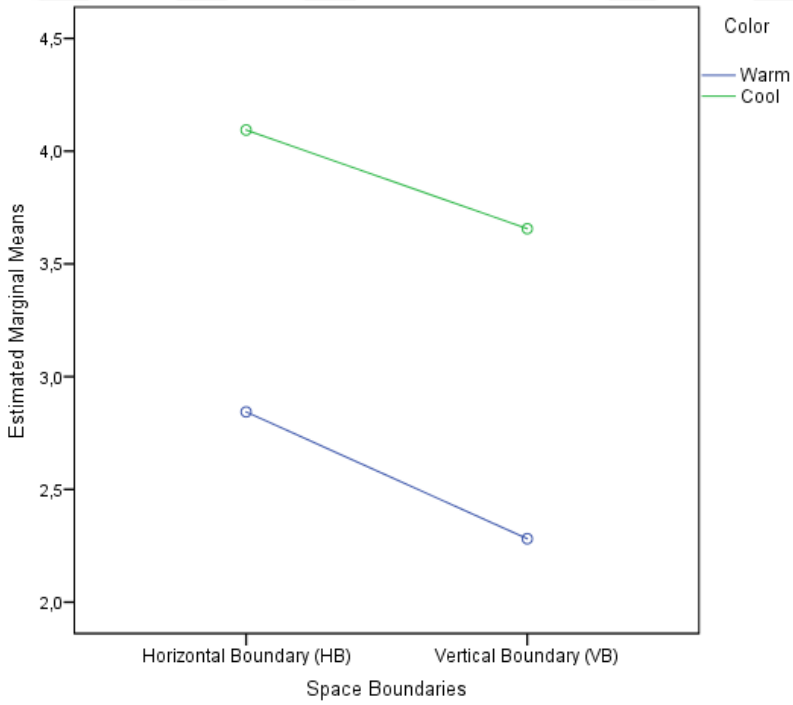


Figure 32. Estimated Marginal Means of Spaciousness in Terms of Color

5.5. Spaciousness and Aesthetic Judgements

The multiple regression analysis is conducted in order to analyze the relationship between the independent and dependent variables of the study. The items of the aesthetic judgements dimensions are the independent variables where the group of perception of spaciousness is the dependent variable. Table 17 - 20 present the data obtained from Constant Regression Coefficients (Const. B), Regression Coefficients (B), Standardized Coefficient (β), t-Ratio and Significant Ratio (Sig.) of each positively related independent dimension to the dependent dimension (Argyrous, 2011).

5.5.1. Size Property

Table 17 indicates that in aesthetic judgement dimension, the ‘unpleasant-pleasant’ item as an *affective variable* is positively, the ‘simple-complex’ item as a *formal variable* is negatively, the ‘unsafe-safe’ and ‘not mysterious-mysterious’ items as a *symbolic variable* are positively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when ‘pleasant’ (β=0.490), ‘simple’ (β=0.177), ‘safe’ (β=0.219) and ‘mysterious’ (β=0.189) levels increase. Spaciousness HB= -0.015 + 0.408 (pleasant) - 0.160 (simple) + 0.246 (safe) + 0.195 (mysterious). Coefficient of Multiple Determination= 0.711.

Table 17. Coefficients for Aesthetic Judgements in Size (n=64)

	Constant		Const.B	B	β	t-Ratio	Sig.
BOUNDARY	*Horizontal Boundary*	Unpleasant-Pleasant	-0.015	0.408	0.490	2.992	0.004
		Simple-Complex		-0.160	-0.177	-2.170	0.034
		Unsafe-Safe		0.246	0.219	2.356	0.022
		Not Mysterious-Mysterious		0.195	0.189	2.505	0.015
	Vertical Boundary	Sleepy-Arousing	-0.031	-0.335	-0.297	-2.012	0.049
		Unpleasant-Pleasant		0.381	0.338	2.413	0.019
		Gloomy-Exciting		0.452	0.449	4.157	0.0001
		Incoherent-Coherent		-0.314	-0.243	-2.255	0.028
		Unsafe-Safe		0.376	0.383	3.845	0.0001
		Masculine-Feminine		0.278	0.267	3.097	0.003
SIZE	*Small*	Sleepy-Arousing	1.498	-0.381	-0.338	-2.153	0.036
		Unpleasant-Pleasant		0.412	0.438	2.810	0.007
		Gloomy-Exciting		0.337	0.361	2.986	0.004
		Incoherent-Coherent		-0.354	-0.276	-2.743	0.008
		Unsafe-Safe		0.328	0.348	3.250	0.002
	Large	Sleepy-Arousing	1.065	0.281	0.301	2.209	0.031
		Unpleasant-Pleasant		0.471	0.558	4.193	0.0001
		Gloomy-Exciting		0.263	0.268	2.817	0.007
		Distressing-Relaxing		-0.152	-0.168	-2.580	0.013

In aesthetic judgement dimension, the ‘sleepy-arousing’ item as an *affective variable* is negatively, the ‘unpleasant-pleasant’ and ‘gloomy-exciting’ items as an *affective variable* are positively, the ‘incoherent-coherent’ item as a *formal variable* is negatively, the ‘unsafe-safe’ and ‘masculine-feminine’ items as a *symbolic variable* are positively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB spaces increases when, ‘sleepy’ (β=0.297), ‘pleasant’ (β=0.338), ‘exciting’ (β =0.449), ‘incoherent’ (β =0.243), ‘safe’ (β =0.383) and ‘feminine’ (β =0.267) levels increase. Spaciousness VB= -0.031 - 0.335 (arousing) + 0.381 (pleasant) + 0.452 (exciting) – 0.314 (coherent) + 0.376 (safe) + 0.278 (feminine). Coefficient of Multiple Determination= 0.593.

In aesthetic judgement dimension, the ‘sleepy-arousing’ item as an *affective variable* is negatively, the ‘unpleasant-pleasant’ and ‘gloomy-exciting’ items as an *affective variable* is positively, the ‘incoherent-coherent’ item as a *formal variable* is negatively and the ‘unsafe-safe’ item as a *symbolic variable* is positively related with S (Small) spaces ($p < .05$). The perception of spaciousness rate in S spaces increases when ‘sleepy’ (β=0.338), ‘pleasant’ (β=0.438), ‘exciting’ (β=0.361), ‘incoherent’ (β=0.276) and ‘‘safe’ (β=0.348) levels increase. Spaciousness S= 1.498 - 0.381 (arousing) + 0.412 (pleasant) + 0.337 (exciting) - 0.354 (coherent) + 0.328 (safe). Coefficient of Multiple Determination= 0.503.

In aesthetic judgement dimension, the ‘sleepy-arousing’, ‘unpleasant-pleasant’, ‘gloomy-exciting’ items as an *affective variable* is positively and ‘distressing-stressing’ item as an *affective variable* is negatively related with L (Large) spaces ($p < .05$). The perception of spaciousness rate in L spaces increases when ‘arousing’ (β=0.301), ‘pleasant’ (β=0.558), ‘exciting’ (β=0.268) and ‘distressing’ (β=0.168) levels increase. Spaciousness L= 1.065 + 0.281 (arousing) + 0.471 (pleasant) + 0.263 (exciting) – 0.152 (relaxing). Coefficient of Multiple Determination= 0.803.

5.5.2. Light Property

Table 18 indicates that in aesthetic judgement dimension, the ‘sleepy-arousing’, ‘gloomy-exciting’ and distressing-relaxing’ items as an *affective variable* are positively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when

‘arousing’ (β=0.319), ‘exciting’ (β=0.251) and ‘relaxing’ (β=0.287) levels increase. Spaciousness HB= -0.054 + 0.291 (arousing) + 0.244 (exciting) + 0.279 (relaxing). Coefficient of Multiple Determination= 0.573.

Table 18. Coefficients for Aesthetic Judgements in Light (n=64)

	Constant		Const.B	B	β	t-Ratio	Sig.
BOUNDARY	*Horizontal Boundary*	Sleepy-Arousing	-0.054	0.291	0.319	2.576	0.013
		Gloomy-Exciting		0.244	0.251	2.164	0.035
		Distressing-Relaxing		0.279	0.287	2.470	0.017
	Vertical Boundary	Sleepy-Arousing	0.809	0.476	0.538	3.933	0.0001
		Distressing-Relaxing		-0.227	-0.256	-2.010	0.049
LIGHT	*Dim*	Sleepy-Arousing	1.025	0.229	0.282	2.758	0.008
		Not mysterious-Mysterious		0.182	0.213	2.262	0.028
		Masculine-Feminine		-0.285	-0.433	-4.774	0.0001
	Bright	Unsafe-Safe	1.048	0.341	0.400	3.242	0.002
		Not mysterious-Mysterious		0.200	0.234	2.500	0.016

In aesthetic judgement dimension, the ‘sleepy-arousing’ item as an *affective variable* is positively and the ‘distressing-relaxing’ item as an *affective variable* is negatively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB spaces increases when ‘arousing’ (β=0.538) and ‘distressing’ (β=0.256) levels increase. Spaciousness VB= 0.809 + 0.476 (arousing) - 0.227 (relaxing). Coefficient of Multiple Determination= 0.497.

In aesthetic judgement dimension, the ‘sleepy-arousing’ item as an *affective variable* and ‘not mysterious-mysterious’ item as a *symbolic variable* are positively and the ‘masculine-feminine’ item as a *symbolic variable* is negatively related with D (Dim) spaces ($p < .05$). The perception of

spaciousness rate in D spaces increases when ‘arousing’ (β=0.282), ‘mysterious’ (β=0.213) and ‘masculine’ (β=0.433) levels increase. Spaciousness D= 1.025 + 0.229 (arousing) + 0.182 (mysterious) – 0.285 (feminine). Coefficient of Multiple Determination= 0.607.

In aesthetic judgement dimension, the ‘unsafe-safe’ and ‘not mysterious-mysterious’ items as a *symbolic variable* are positively related with B (Bright) spaces ($p < .05$). The perception of spaciousness rate in B spaces increases when ‘safe’ (β=0.400) and ‘mysterious’ (β=0.234) levels increase. Spaciousness B= 1.048 + 0.341 (safe) + 0.200 (mysterious). Coefficient of Multiple Determination= 0.484.

5.5.3. Texture Property

Table 19 indicates that in aesthetic judgement dimension, the ‘unpleasant-pleasant’ items as an *affective variable* is positively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when ‘pleasant’ (β=0.536) level increase. Spaciousness HB= -0.121 + 0.589 (pleasant). Coefficient of Multiple Determination= 0.461.

Table 19. Coefficients for Aesthetic Judgements in Texture (n=64)

Constant			Const.B	B	β	t-Ratio	Sig.
BOUNDARY TEXTURE	*Horizontal Boundary*	Unpleasant-Pleasant	-0.121	0.589	0.536	3.746	0.0001
	Vertical Boundary	Gloomy-Exciting	1.033	0.391	0.426	2.916	0.005
	Longitudinal	Gloomy-Exciting	-0.395	0.507	0.511	3.568	0.001
	Transverse	Unpleasant-Pleasant	1.561	0.693	0.734	4.053	0.0001
		Simple-Complex		-0.260	-0.318	-2.429	0.018
		Not Mysterious-Mysterious		0.282	0.357	2.490	0.016

In aesthetic judgement dimension, the ‘gloomy-exciting’ item as an *affective variable* is positively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB spaces increases when ‘exciting’ (β=0.426) level increase. Spaciousness VB= 1.033 + 0.391 (exciting). Coefficient of Multiple Determination= 0.321.

In aesthetic judgement dimension, the ‘gloomy-exciting’ item as an *affective variable* is positively related with L (Longitudinal) spaces ($p < .05$). The perception of spaciousness rate in L spaces increases when ‘exciting’ (β=0.511) level increase. Spaciousness L= -0.395 - 0.507 (exciting). Coefficient of Multiple Determination= 0.383.

In aesthetic judgement dimension, the ‘unpleasant-pleasant’ item as an *affective variable*, ‘not mysterious-mysterious’ item as a *symbolic variable* is positively and ‘simple-complex’ item as a *formal variable* is negatively related with T (Transverse) spaces ($p < .05$). The perception of spaciousness rate in

T spaces increases when ‘pleasant’ (β=0.734), ‘simple’ (β=0.318) and ‘mysterious’ (β=0.357) levels increase. Spaciousness T= 1.561 + 0.693 (pleasant) - 0.260 (simple) + 0.282 (mysterious). Coefficient of Multiple Determination= 0.392.

5.5.4. Color Property

Table 20 indicates that in aesthetic judgement dimension, the ‘sleepy-arousing’ and ‘unpleasant-pleasant’ items as an *affective variable* are positively and ‘masculine-feminine’ item as a *symbolic variable* are negatively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when ‘arousing’ (β=0.220), ‘pleasant’ (β=0.479) and ‘masculine’ (β=0.347) levels increase. Spaciousness HB= 2.152 + 0.184 (arousing) + 0.331 (pleasant) - 0.260 (feminine). Coefficient of Multiple Determination= 0.630.

Table 20. Coefficients for Aesthetic Judgements in Color (n=64)

Constant			Const.B	B	β	t-Ratio	Sig.
BOUNDARY	*Horizontal Boundary*	Sleepy-Arousing	2.152	0.184	0.220	2.280	0.027
		Unpleasant-Pleasant		0.331	0.479	3.072	0.003
		Masculine-Feminine		-0.260	-0.347	-3.835	0.0001
	Vertical Boundary	Distressing-Relaxing	0.463	0.302	0.362	2.451	0.018
COLOR	*Cool*	Distressing-Relaxing	2.160	0.222	0.305	2.579	0.013
		Incoherent-Coherent		-0.274	-0.281	-2.867	0.006
		Unsafe-Safe		0.256	0.272	2.307	0.025
		Masculine-Feminine		-0.186	-0.196	-2.346	0.023
	Warm	Masculine-Feminine	0.234	0.295	0.433	3.337	0.002

In aesthetic judgement dimension, the ‘distressing-relaxing’ item as an *affective variable* is positively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB spaces increases when ‘relaxing’ ($\beta=0.362$) level increase. Spaciousness VB= 0.463 + 0.302 (relaxing). Coefficient of Multiple Determination= 0.530.

In aesthetic judgement dimension, the ‘distressing-relaxing’ item as an *affective variable* ‘unsafe-safe’ item as a symbolic variable are positively and ‘incoherent-coherent’ item as a *formal variable* and ‘masculine-feminine’ item as a *symbolic variable* are negatively related with C (Cool) spaces ($p < .05$). The perception of spaciousness rate in C spaces increases when ‘relaxing’ ($\beta=0.305$), ‘incoherent’ ($\beta=0.281$), ‘safe’ ($\beta=0.272$) and ‘masculine’ ($\beta=0.196$) levels increase. Spaciousness C= 2.160 + 0.222 (relaxing) - 0.274 (coherent) + 0.256 (safe) - 0.186 (feminine). Coefficient of Multiple Determination= 0.612.

In aesthetic judgement dimension, the ‘masculine-feminine’ item as a *symbolic variable* is positively related with W (Warm) spaces ($p < .05$). The perception of spaciousness rate in W spaces increases when ‘feminine’ ($\beta=0.433$) level increase. Spaciousness W= 0.234 + 0.295 (feminine). Coefficient of Multiple Determination= 0.339.

5.6. Spaciousness and Emotional Responses

The multiple regression analysis is conducted in order to analyze the relationship between the independent and dependent variables of the study. The items of the emotional responses dimensions are the independent variables where the group of perception of spaciousness is the dependent variable. Table 21 - 24 present the data obtained from Constant Regression Coefficients (Const. B), Regression Coefficients (B), Standardized Coefficient (β), t-Ratio and Significant Ratio (Sig.) of each positively related independent dimension to the dependent dimension (Argyrous, 2011).

5.6.1. Size Property

Table 21 indicates that in emotional responses dimension, the 'annoyed-pleased' item as a *pleasure group* is positively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when 'pleased' (β=0.413) level increase. Spaciousness HB= -0.350 + 0.391 (pleased). Coefficient of Multiple Determination= 0.788.

Table 21. Coefficients for Emotional Responses in Size (n=64)

	Constant		Const.B	B	β	t-Ratio	Sig.
BOUNDARY	*Horizontal Boundary*	Annoyed-Pleased	-0.350	0.391	0.413	2.756	0.008
	Vertical Boundary	Unhappy-Happy	-0.615	0.465	0.404	2.515	0.015
		Sluggish-Frenzied		0.254	0.206	2.368	0.022
		Dull-Jittery		-0.213	-0.172	-2.191	0.033
SIZE	*Small*	Unhappy-Happy	-0.771	0.323	0.297	2.028	0.048
		Unsatisfied-Satisfied		0.250	0.252	2.379	0.021
	Large	Unhappy-Happy	0.057	0.545	0.536	3.478	0.001
		Unaroused-Aroused		0.182	0.210	2.333	0.024

In emotional responses dimension, the ‘unhappy-happy’ item as a *pleasure group* is positively, the ‘sluggish-frenzied’ item as an *arousal group* is positively and the ‘dull-jittery’ item as an *arousal group* is negatively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB spaces increases when ‘happy’ (β=0.404), ‘frenzied’ (β=0.206) and ‘dull’ (β=0.172) levels increase. Spaciousness VB= -0.615 + 0.465 (happy) + 0.254 (frenzied) - 0.213 (jittery). Coefficient of Multiple Determination= 0.762.

In emotional responses dimension, the ‘unhappy-happy’ and ‘unsatisfied-satisfied’ items as a *pleasure group* is positively related with S (Small) spaces ($p < .05$). The perception of spaciousness rate in S spaces increases when ‘happy’ (β=0.297) and ‘satisfied’ (β=0.252) levels increase. Spaciousness S= -0.771 + 0.323 (happy) + 0.250 (satisfied). Coefficient of Multiple Determination= 0.687.

In emotional responses dimension, the ‘unhappy-happy’ item as a *pleasure group* is and the ‘unaroused-aroused’ item as an *arousal group* is positively related with L (Large) spaces ($p < .05$). The perception of spaciousness rate in L spaces increases when ‘happy’ (β=0.536) and ‘aroused’ (β=0.210) levels increase. Spaciousness L= 0.057 + 0.545 (happy) + 0.182 (aroused). Coefficient of Multiple Determination= 0.783.

5.6.2. Light Property

Table 22 indicates that in emotional responses dimension, the ‘annoyed-pleased’ and ‘unsatisfied-satisfied’ items as a *pleasure group* are positively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when ‘pleased’ (β=0.550) and ‘satisfied’ (β=0.297) levels increase. Spaciousness HB= 0.464 + 0.489 (pleased) + 0.296 (satisfied). Coefficient of Multiple Determination= 0.633.

Table 22. Coefficients for Emotional Responses in Light (n=64)

	Constant		Const.B	B	β	t-Ratio	Sig.
BOUNDARY	*Horizontal Boundary*	Annoyed-Pleased	0.464	0.489	0.550	3.707	0.001
		Unsatisfied-Satisfied		0.296	0.297	2.155	0.036
	Vertical Boundary	Bored-Relaxed	-0.369	0.475	0.540	3.086	0.003
		Relaxed-Stimulated		0.365	0.342	2.906	0.005
LIGHT	*Dim*	Annoyed-Pleased	0.407	0.356	0.459	2.643	0.011
		Bored-Relaxed		-0.272	-0.320	-2.880	0.006
		Unaroused-Aroused		0.240	0.271	2.093	0.041
		Relaxed-Stimulated		0.231	0.225	2.004	0.050
	Bright	Annoyed-Pleased	0.974	0.371	0.418	2.395	0.020
		Bored-Relaxed		0.428	0.530	2.807	0.007
		Relaxed-Stimulated		0.207	0.231	2.049	0.046

In emotional responses dimension, the ‘bored-relaxed’ item as a *pleasure group* and the ‘relaxed-stimulated’ item as an *arousal group* are positively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB spaces increases when ‘relaxed’ (β=0.540) and ‘stimulated’ (β=0.342) levels increase. Spaciousness VB= -0.369 + 0.475 (relaxed) + 0.365 (stimulated). Coefficient of Multiple Determination= 0.565.

In emotional responses dimension, the ‘annoyed-pleased’ item as a *pleasure group* is positively, the ‘bored-relaxed’ item as a *pleasure group* is negatively, the ‘unaroused-aroused’ and ‘relaxed-stimulated’ items as an *arousal group* are positively related with D (Dim) spaces ($p < .05$). The perception of spaciousness rate in D spaces increases when ‘pleased’ (β=0.459), ‘bored’ (β=0.320), ‘aroused’ (β=0.271) and ‘stimulated’ (β=0.225) levels increase. Spaciousness D= 0.407 + 0.356 (pleased) – 0.272 (relaxed) + 0.240 (aroused) + 0.231 (stimulated). Coefficient of Multiple Determination= 0.529.

In emotional responses dimension, the ‘annoyed-pleased’, ‘bored-relaxed’ items as a *pleasure group* and the ‘relaxed-stimulated’ item as an *arousal group* are positively related with B (Bright) *spaces* ($p < .05$). The perception of spaciousness rate in B spaces increases when ‘pleased’ (β=0.418), ‘relaxed’ (β=0.530) and ‘stimulated’ (β=0.231) levels increase. Spaciousness B= 0.974 + 0.371 (pleased) + 0.428 (relaxed) + 0.207 (stimulated). Coefficient of Multiple Determination= 0.484.

5.6.3. Texture Property

Table 23 indicates that in emotional responses dimension, the ‘annoyed-pleased’ and ‘unsatisfied-satisfied’ items as a *pleasure group* is positively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when ‘pleased’ (β=0.391) and ‘satisfied’ (β=0.528) levels increase. Spaciousness HB= -0.015 + 0.418 (pleased) + 0.525 (satisfied). Coefficient of Multiple Determination= 0.449.

Table 23. Coefficients for Emotional Responses in Texture (n=64)

Constant			Const.B	B	β	t-Ratio	Sig.
BOUNDARY	*Horizontal Boundary*	Annoyed-Pleased	-0.015	0.418	0.391	2.301	0.026
		Unsatisfied-Satisfied		0.525	0.528	3.196	0.002
	Vertical Boundary	Unhappy-Happy	2.329	0.631	0.709	2.985	0.004
TEXTURE	*Longitudinal*	Bored-Relaxed	1.153	-0.227	-0.273	-2.031	0.048
		Unsatisfied-Satisfied		0.436	0.549	2.919	0.005
	Transverse	Unhappy-Happy	2.701	0.440	0.489	2.127	0.038

In emotional responses dimension, the ‘unhappy-happy’ item as a *pleasure group* is positively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB spaces increases when ‘happy’ (β=0.709) level increase. Spaciousness VB= 2.329 + 0.631 (happy). Coefficient of Multiple Determination= 0.416.

In emotional responses dimension, the ‘bored-relaxed’ item as a *pleasure group* is negatively and ‘unsatisfied-satisfied’ item as a *pleasure group* is positively related with L (Longitudinal) space ($p < .05$). The perception of spaciousness rate in L spaces increases when ‘bored’ (β=0.273) and ‘satisfied’ (β=0.549) levels increase. Spaciousness L= 1.153 - 0.227 (relaxed) + 0.436 (satisfied). Coefficient of Multiple Determination= 0.446.

In emotional responses dimension, the ‘unhappy-happy’ item as a *pleasure group* is positively related with T (Transverse) spaces ($p < .05$). The perception of spaciousness rate in T spaces increases when ‘happy’

(β=0.489) level increase. Spaciousness T= 2.701 + 0.440 (happy). Coefficient of Multiple Determination= 0.249.

5.6.4. Color Property

Table 24 indicates that in emotional responses dimension, the 'annoyed-pleased' item as a *pleasure group* and 'sluggish-frenzied' item as an *arousal group* are positively related with HB (Horizontal Boundary) spaces ($p < .05$). The perception of spaciousness rate in HB spaces increases when 'pleased' (β=0.541) and 'frenzied' (β=0.337) levels increase. Spaciousness HB= 0.970 + 0.418 (pleased) + 0.359 (frenzied). Coefficient of Multiple Determination= 0.598.

Table 24. Coefficients for Emotional Responses in Color (n=64)

Constant			Const.B	B	β	t-Ratio	Sig.
BOUNDARY	*Horizontal Boundary*	Annoyed-Pleased	0.970	0.418	0.541	2.942	0.005
		Sluggish-Frenzied		0.359	0.337	3.212	0.002
	Vertical Boundary	Annoyed-Pleased	1.013	0.460	0.499	2.137	0.037
		Despairing-Hopeful		0.386	0.415	2.212	0.031
COLOR	*Cool*	Annoyed-Pleased	1.945	0.469	0.609	3.075	0.003
	Warm	Melancholic-Contended	1.336	0.271	0.361	2.488	0.016
		Unaroused-Aroused		-0.222	-0.275	-2.177	0.034

In emotional responses dimension, the 'annoyed-pleased' and 'despairing-hopeful' items as an *arousal group* are positively related with VB (Vertical Boundary) spaces ($p < .05$). The perception of spaciousness rate in VB

spaces increases when ‘pleased’ (β=0.499) and ‘hopeful’ (β=0.415) levels increase. Spaciousness VB= 1.013 + 0.460 (pleased) + 0.386 (hopeful). Coefficient of Multiple Determination= 0.374.

In emotional responses dimension, the ‘annoyed-pleased’ item as an *arousal group* is positively related with C(Cool) spaces ($p < .05$). The perception of spaciousness rate in C spaces increases when ‘pleased’ (β=0.609) level increase. Spaciousness C= 1.945 + 0.469 (pleased). Coefficient of Multiple Determination= 0.378.

In emotional responses dimension, the ‘melancholic-contended’ item as a *pleasure group* is positively and ‘unaroused-aroused’ item as an *arousal group* is negatively related with W (Warm) spaces ($p < .05$). The perception of spaciousness rate in W spaces increases when ‘contended’ (β=0.361) and ‘unaroused’ (β=0.275) levels increase. Spaciousness W= 1.336 + 0.271 (contended) – 0.222 (aroused). Coefficient of Multiple Determination= 0.319.

5.7. Behavioral Intentions

5.7.1. Size Property

Each virtual simulation had two open-ended questions. The open-ended questions were optional, and 25 (78.1%) out of 32 respondents answered those optional open-ended questions for at least one of the virtual spaces.

In the first open-ended question, participant was described their negative feeling/ emotions towards *boundary of space* as ‘emptiness-in unreality’ for

Horizontal Boundary (HB) and ‘nervous-scary-emptiness-in unreality’ for Vertical Boundary (VB) spaces; towards the *size of space* as ‘distracting-low-depressed’ for Small (S) and ‘lonely-unlimited’ for Large (L) spaces.

For positive aspect, participant was explained their feeling/ emotions towards *boundary of space* as ‘spacious-relax-pleased-attractive-happiness’ for HB and ‘interesting-different-attractive’ for VB spaces; towards the *size of space* as ‘integrated-safe-in personal space’ for S and ‘freedom-spacious-happiness-safe’ for L spaces.

In the second open-ended question, participant was expressed their dislike opinions towards *boundary of space* as ‘unusual form’ for HB and ‘unusual form-curvilinearity condition’ for VB spaces; towards the *size of space* as ‘limited environment’ for S and ‘emptiness’ for L spaces. One of the participant’s reflections:

> I don’t like the VB space because looking into the space like a fish eye. I don’t feel spaciousness because of the limited size of the space.

The like opinions was identified towards *boundary of space* as ‘boundary connection-no sharp edges-spaciousness-continuity-fluency-smoothness-safety’ for HB and ‘difference-no sharp edges-safety’ for VB spaces; towards the *size of space* as ‘different aspect-unusual form’ for S and ‘spaciousness-wide angle perception-unusual form’ L spaces. One of the participant’s reflections:

> I like the connections of the boundary and wide angle of the space.

Each four setting of the size had three multiple-choice questions in order to demonstrate approach-avoidance behavior. Firstly, how much time each participant would like to spend in this room is determined. Figure 33 shows the distributions of the intended time of each participant in each setting. While the highest score in the time spend from an hour to few hours is obtained in HB and Large size settings, the lowest score in the time spend from never to almost never is obtained in VB and Small size.

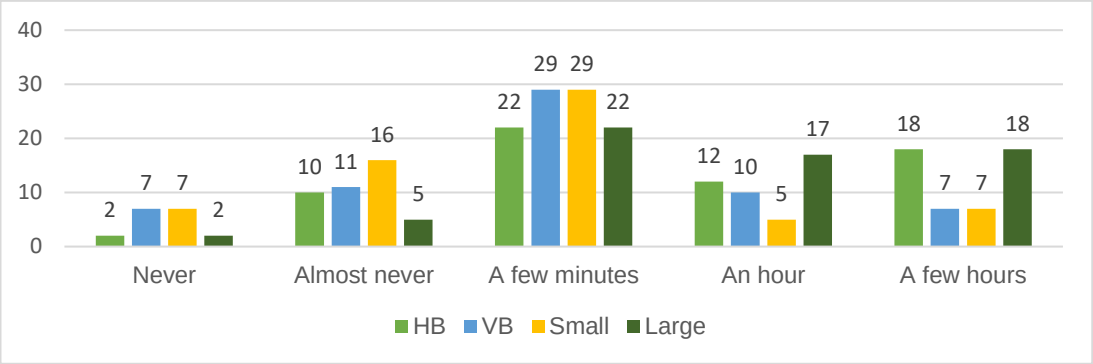


Figure 33. Distribution of the Intended Time in Each Size Setting

Secondly, how much each participant would enjoy exploring each setting is determined. Figure 34 shows the distribution of 'enjoyment' level in each setting. While the highest score in the enjoyment level from much to very much is obtained in HB and Large size settings, the lowest score in the enjoyment level from not at all to slightly is obtained in VB and Small size.

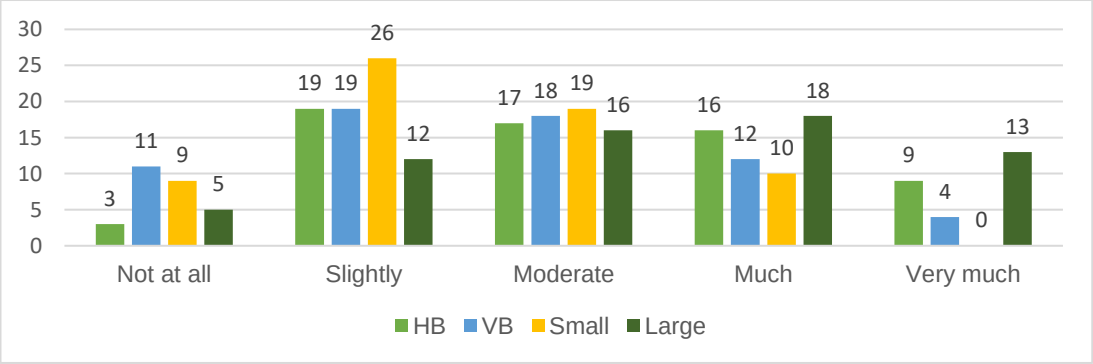


Figure 34. Distribution of the Enjoyment Level in Each Size Setting

Thirdly, to what extent each participant would feel friendly and talkative to participants. Figure 35 shows the distribution of 'feel friendly' level in each setting. While the highest score in the feel friendly level from much to very much is obtained from HB and Large size settings, the lowest score in the feel friendly level from not at all to slightly is obtained in VB and Small size.

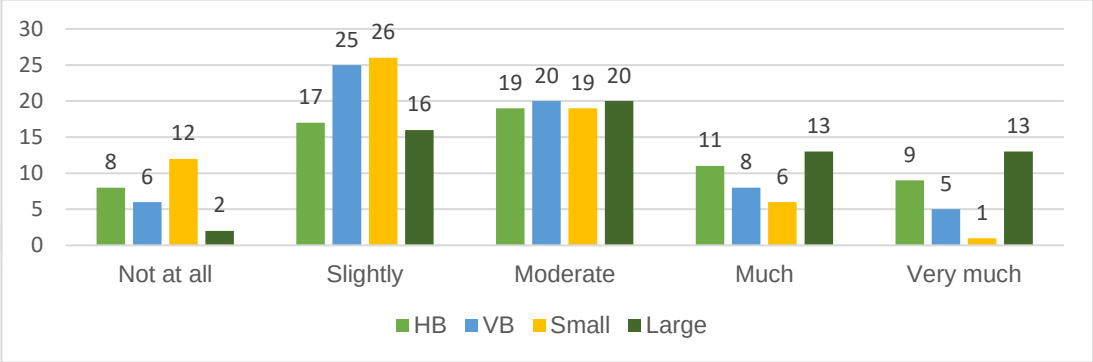


Figure 35. Distribution of the Feel Friendly Level in in Each Size Setting

5.7.2. Light Property

Each virtual simulation had two open-ended questions. The open-ended questions were optional, and 20 (62.5%) out of 32 respondents answered those optional open-ended questions for at least one of the virtual spaces.

In the first open-ended question, participant was described their negative feeling/ emotions towards *boundary of space* as 'oppressed' for Horizontal Boundary (HB) and 'annoyed-depressed-closed' for Vertical Boundary (VB) spaces; towards the *light of space* as 'anxious-unsafe-tired' for Dim (D) and 'fatigue' for Bright (B) spaces.

For positive aspect, participant was explained their feeling/ emotions towards *boundary of space* as 'relaxed-exciting-powerful-strong-safe' for HB and

‘relaxed-exciting-safe’ for VB spaces; towards the *light of space* as ‘comfortable-relax’ for D and ‘free-precision-relaxed’ for B spaces.

In the second open-ended question, participant was expressed their dislike opinions towards *boundary of space* as ‘unusual form-limited environment’ for HB and ‘way of border- closedness’ for VB spaces; towards the *light of space* as ‘color-low contrast’ for D and ‘glare’ for B spaces. One of the participant’s reflections:

> I don’t like the dim light because it affected the color of the space and my perception of spaciousness. I also dislike the wall color because it is mopy. Especially VB front wall looks like it’s blocking the space.

The like opinions was identified towards *boundary of space* as ‘different perspective-different experience-aesthetic appearance-simplicity-no sharpness-spaciousness-safety’ for HB and ‘smoothness-spaciousness-safety’ for VB spaces; towards the *light of space* as ‘dynamism’ for D and ‘effective color-refreshing appearance’ B spaces. One of the participant’s reflections:

> I liked the HB space because it shows a different perspective in terms of experiencing a space. Bright place looks bigger and I feel refresh.

Each four setting of the size had three multiple-choice questions in order to demonstrate approach-avoidance behavior. Firstly, how much time each participant would like to spend in this room is determined. Figure 36 shows the distributions of the intended time of each participant in each setting. While the highest score in the time spend from an hour to few hours is

obtained in HB and Bright light settings, the lowest score in the time spend from never to almost never is obtained in VB and Dim light.

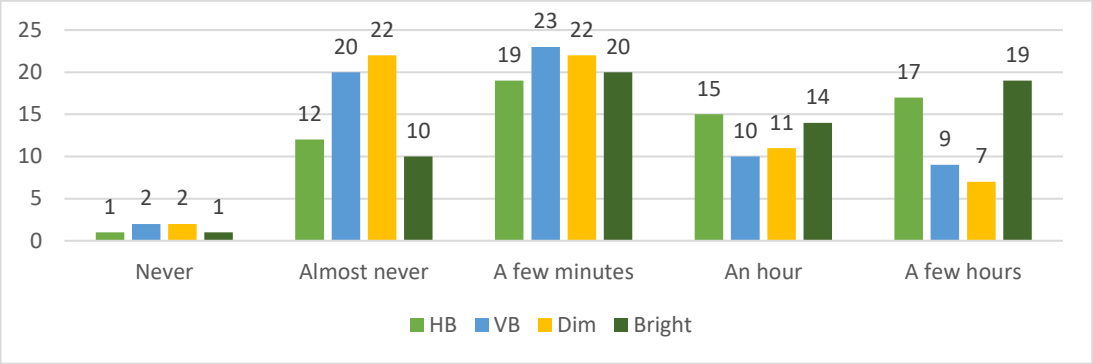


Figure 36. Distribution of the Intended Time in Each Light Setting

Secondly, how much each participant would enjoy exploring each setting is determined. Figure 37 shows the distribution of 'enjoyment' level in each setting. While the highest score in the enjoyment level from much to very much is obtained in HB and Bright light settings, the lowest score in the enjoyment level from not at all to slightly is obtained in VB and Dim light.

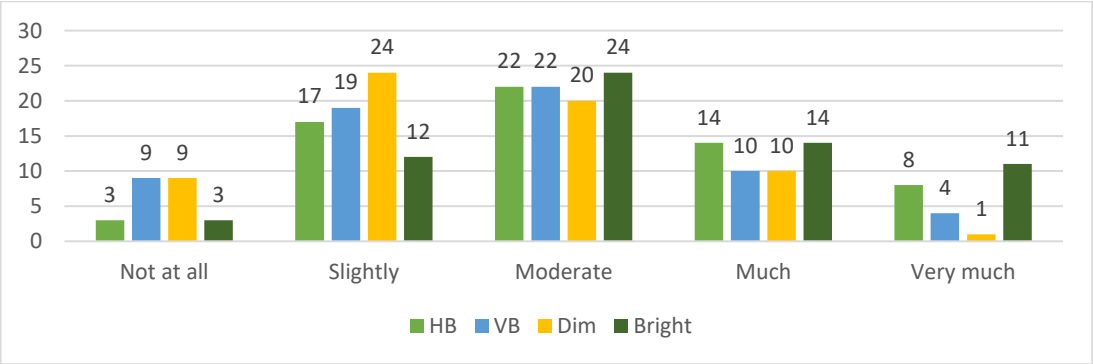


Figure 37. Distribution of the Enjoyment Level in Each Light Setting

Thirdly, to what extent each participant would feel friendly and talkative to participants. Figure 38 shows the distribution of 'feel friendly' level in each setting. While the highest score in the feel friendly level from much to very

much is obtained from HB and Bright light settings, the lowest score in the feel friendly level from not at all to slightly is obtained in VB and Dim light.

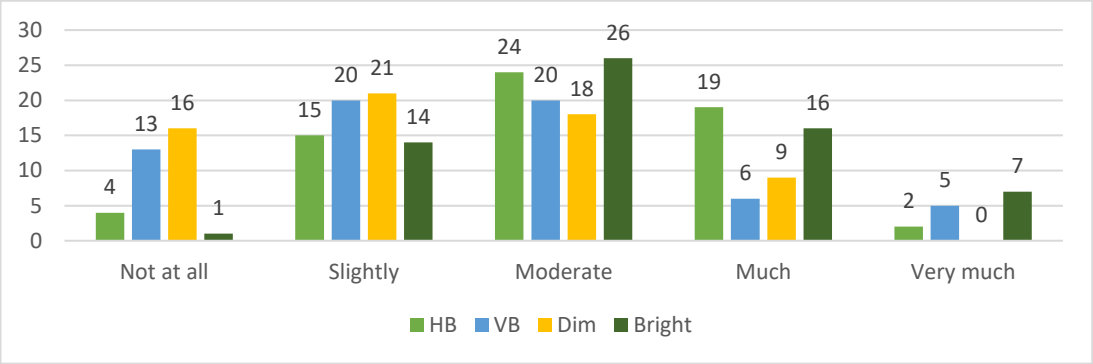


Figure 38. Distribution of the Feel Friendly Level in in Each Light Setting

5.7.3. Texture Property

Each virtual simulation had two open-ended questions. The open-ended questions were optional, and 19 (59.4%) out of 32 respondents answered those optional open-ended questions for at least one of the virtual spaces.

In the first open-ended question, participant was described their negative feeling/ emotions towards *boundary of space* as ‘empty’ for Horizontal Boundary (HB) and ‘unexcited-uncomfortable-distressing-nervous’ for Vertical Boundary (VB) spaces; towards the *texture of space* as ‘prison like’ for Longitudinal (L) and ‘limited’ for Transverse (T) spaces.

For positive aspect, participant was explained their feeling/ emotions towards *boundary of space* as ‘excited-calm-satisfy-refresh-sense of fulfilment-smoothness’ for HB and ‘curious-enjoy-like falling’ for VB spaces; towards

the *texture of space* as ‘spaciousness’ for L and ‘excited-comfortable-calm-smoothness’ for T spaces.

In the second open-ended question, participant was expressed their dislike opinions towards *boundary of space* as ‘clean-formal-curvilinearity.’ for HB and ‘intersections-curvilinearity-corners’ for VB spaces; towards the *texture of space* as ‘continuity-color-light-rotation of the texture’ for L and ‘continuity-color-light’ for T spaces. One of the participant’s reflections:

> I don’t like the corners of longitudinal texture and intersection of the VB corner. The sensation of being trapped was not nice because of the longitudinal texture.

The like opinions was identified towards *boundary of space* as ‘smooth corner-continuity-safety’ for HB and ‘smooth corner-ways of the curvilinearity-intersections’ for VB spaces; towards the *texture of space* as ‘higher ceiling-continuity-spaciousness’ for L and ‘spaciousness-ambiance’ T spaces. One of the participant’s reflections:

> I like continuity of transverse texture that made space more understandable also I like the curves and corners combinations.

Each four setting of the size had three multiple-choice questions in order to demonstrate approach-avoidance behavior. Firstly, how much time each participant would like to spend in this room is determined. Figure 39 shows the distributions of the intended time of each participant in each setting. While the highest score in the time spend from an hour to few hours is obtained in VB and Transverse texture settings, the lowest score in the time spend from never to almost never is obtained in HB and Longitudinal texture.

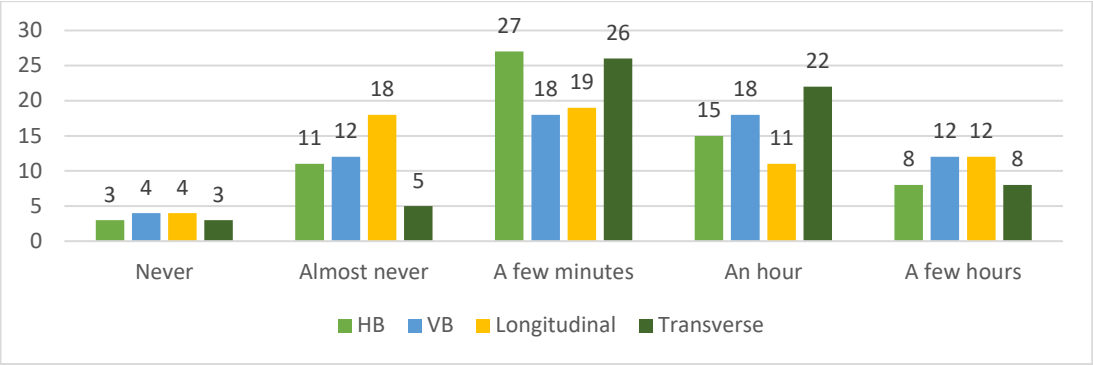


Figure 39. Distribution of the Intended Time in Each Texture Setting

Secondly, how much each participant would enjoy exploring each setting is determined. Figure 40 shows the distribution of 'enjoyment' level in each setting. While the highest score in the enjoyment level from much to very much is obtained in VB and Transverse texture settings, the lowest score in the enjoyment level from not at all to slightly is obtained in HB and Longitudinal texture.

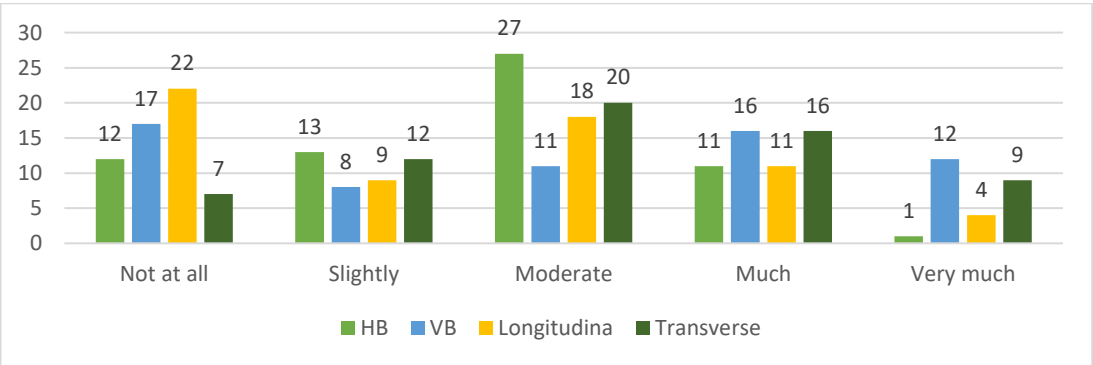


Figure 40. Distribution of the Enjoyment Level in Each Texture Setting

Thirdly, to what extent each participant would feel friendly and talkative to participants. Figure 41 shows the distribution of 'feel friendly' level in each setting. While the highest score in the feel friendly level from much to very much is obtained from VB and Transverse texture settings, the lowest score

in the feel friendly level from not at all to slightly is obtained in HB and Longitudinal texture.

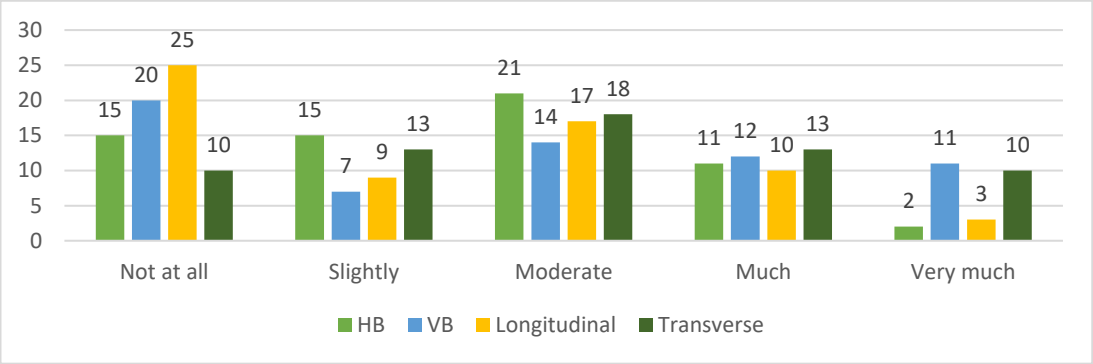


Figure 41. Distribution of the Feel Friendly Level in in Each Texture Setting

5.7.4. Color Property

Each virtual simulation had two open-ended questions. The open-ended questions were optional, and 23 (71.8%) out of 32 respondents answered those optional open-ended questions for at least one of the virtual spaces.

In the first open-ended question, participant was described their negative feeling/ emotions towards *boundary of space* as ‘alone’ for Horizontal Boundary (HB) and ‘stocked’ for Vertical Boundary (VB) spaces; towards the *color of space* as ‘anger’ for Cool (C) and ‘uncomfortable-annoyed-unsafe-tired’ for Warm (W) spaces.

For positive aspect, participant was explained their feeling/ emotions towards *boundary of space* as ‘fulfillment-borderless-safe’ for HB and ‘safe’ for VB spaces; towards the *color of space* as ‘fresh-pleasant’ for C and ‘awakening-cosines-enjoy’ for W spaces.

In the second open-ended question, participant was expressed their dislike opinions towards *boundary of space* as ‘emptiness’ for HB and ‘emptiness-formal form’ for VB spaces; towards the *color of space* as ‘natural-ordinary’ for C and ‘color-brightness-not mysterious’ for W spaces. One of the participant’s reflections:

> I don’t like warm color atmosphere because it prevents the fresh feeling. The warm color of space makes me stressed because of the brightness level.

The like opinions was identified towards *boundary of space* as ‘curve-mystery-infinite view-extraordinary-corners-different atmosphere’ for HB and ‘curve-mystery-usual/ordinal-connections’ for VB spaces; towards the *color of space* as ‘fresh’ for C and ‘attractive’ W spaces. One of the participant’s reflections:

> I like the feeling of freedom in cool color space and simplicity. Cool color increases the smooth transition of the corner in HB space.

Each four setting of the size had three multiple-choice questions in order to demonstrate approach-avoidance behavior. Firstly, how much time each participant would like to spend in this room is determined. Figure 42 shows the distributions of the intended time of each participant in each setting. While the highest score in the time spend from an hour to few hours is obtained in HB and Cool color settings, the lowest score in the time spend from never to almost never is obtained in VB and Warm color.

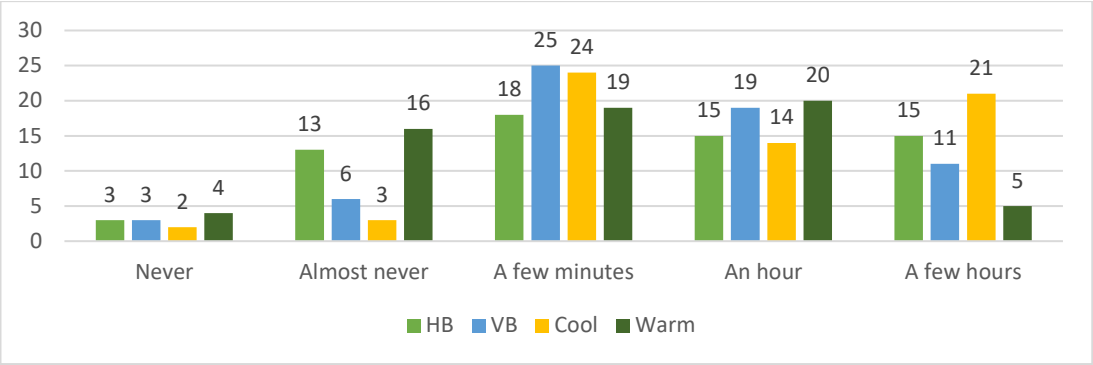


Figure 42. Distribution of the Intended Time in Each Color Setting

Secondly, how much each participant would enjoy exploring each setting is determined. Figure 43 shows the distribution of 'enjoyment' level in each setting. While the highest score in the enjoyment level from much to very much is obtained in HB and Cool color settings, the lowest score in the enjoyment level from not at all to slightly is obtained in VB and Warm color.

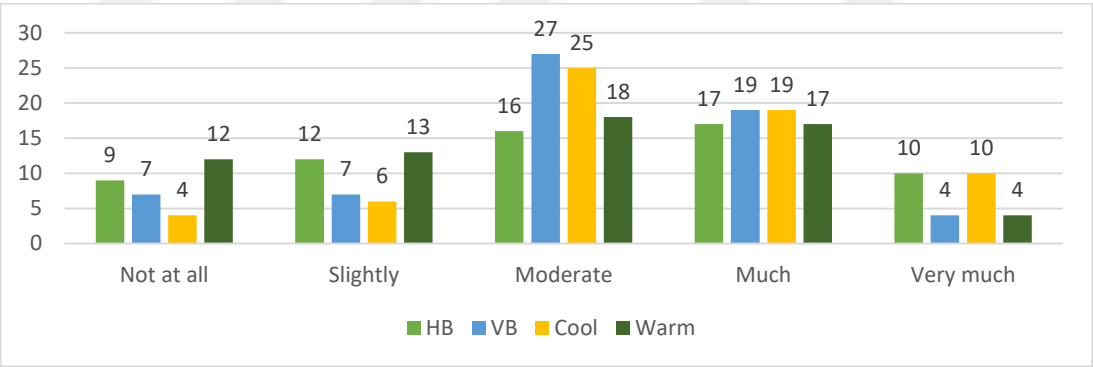


Figure 43. Distribution of the Enjoyment Level in Each Color Setting

Thirdly, to what extent each participant would feel friendly and talkative to participants. Figure 44 shows the distribution of 'feel friendly' level in each setting. While the highest score in the feel friendly level from much to very much is obtained from HB and Cool color, the lowest score in the feel friendly level from not at all to slightly is obtained in VB and Warm color.

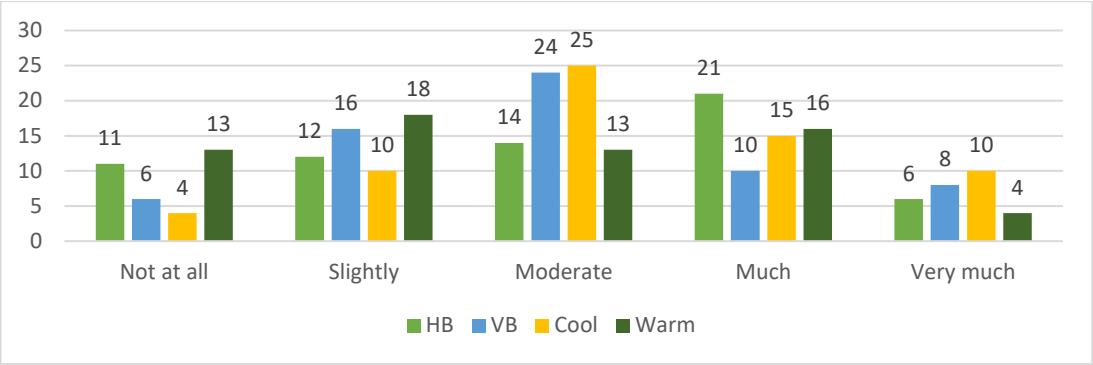


Figure 44. Distribution of the Feel Friendly Level in in Each Color Setting

According to the literature, emotional responses influence the approach-avoidance behavior of the individuals towards that setting (Mehrabian & Russell, 1977). The findings of the study were examined in this chapter in detail and summarized the research. The following chapter is related to the discussion and conclusion.

CHAPTER 6

DISCUSSION AND CONCLUSION

In this chapter, discussion of the findings that consist of related to perception of spaciousness in terms of specific properties, interaction of the boundary type and specific property, spaciousness and aesthetic judgement, spaciousness and emotional responses and behavioral intention were analyzed. The discussion of the study conducted according to the 5 hypotheses of the study. The conclusion, implication on interior architecture, limitations of the study and implication for further study are explained.

6.1. Discussion

The objective of this study was to demonstrate the effect of perception of spaciousness in curvilinear boundary types with four specific properties of the environment (size/ light/ texture/ color). The aim of this study also to find out the related aesthetic judgements and emotional responses of the

participants. The aesthetic judgement items (Delvin & Nasar, 1989; Lang, 1992; Russell, 1992) and emotional responses items (Russell & Mehrabian, 1977) are provided based on the related literature review. As, Hobbs et all., (2015) and Banaei et all., (2017b) stated that curve geometries in architectural spaces affect human perception positively, this study focused on horizontal and vertical boundary types.

Findings on perception of spaciousness curvilinear boundaries was supported with the findings of aesthetic judgements and emotional responses in each setting. In agreement with the previous findings that claimed that aesthetic judgements and emotional responses are related to perception (Alp, 1993; Dazkır, & Read, 2012; Madani Nejad, 2007; Shemesh et all., 2016; Vartanian et al., 2013).

In this study, the perceived spaciousness was determined as a function of the pecific properties and curved boundary types. Virtual environment simulations wearing Samsung SM-R325 Gear VR were used for each setting and a total of sixteen VEs were conducted in this study. The findings revealed that the curved boundary types have a significant impact on the perception of spaciousness. However, aesthetic judgements and emotional response items supported the perception of spaciousness while explaining with relevant adjectives.

6.1.1. On Perception of Spaciousness in Terms of Specific Properties

The perception of spaciousness is analyzed by descriptive analysis for each specific property (size/ light/ texture or color) with 32 participants. In this study, the perception of spaciousness of each specific property and curved boundary types were investigated together that was separately analyzed in the previous researches. It was hypothesed that there is a spaciousness difference between the four settings in terms of each specific property.

In this study, it was found that larger size and horizontal boundaries have a positive influence on the perception of spaciousness. In the four settings (HB-S, HB-L, VB-S, VB-L) related to size property were tested in order to understand the similar space groups. Three groups were determined; Group 1: VB-S (M=2.59) and HB-S (M=3.00), Group 2: HB-S (3.00) and VB-L (3.50) and Group 3: VB-L (M=3.50) and HB-L (4.25) (see Table 9). It was found that Group 3 had the highest mean value with large size.

Findings of the study is in agreement with the previous findings that claimed that perception of spaciousness increases with “large” size (Benedikt & Burnham, 1985; Bokharaei & Nasar, 2016; Franz, Von der Heyde, & Bülthoff, 2005; Franz & Wiener, 2005; Garling, 1970a, 1970b; Hayward & Franklin, 1974; Inui & Miyata, 1973; Stamps, 2007, 2009, 2010a).

In this study, it was found that bright light and horizontal boundaries have a positive influence on the perception of spaciousness. In the four settings (HB-D, HB-B, VB-D, VB-B) related to light property were tested in order to

understand the similar space groups. Three groups were determined; Group 1: VB-D (M=2.41) and HB-D (M=2.94), Group 2: HB-D (2.94) and VB-B (3.44) and Group 3: VB-B (M=3.44) and HB-B (4.25) (see Table 10). It was found that Group 3 had the highest mean value with bright light.

Findings of the study is in agreement with the previous findings that claimed that perception of spaciousness increases with “bright” light (Bokharaei & Nasar, 2016; Durak, Olguntürk, Yener, Güvenç & Gürçınar, 2007; Inui & Miyata, 1973; Kirschbaum & Tonello, 1997; Martyniuk et all., 1973; Odabaşioğlu & Olguntürk, 2015; Ozdemir, 2010; Stamps, 2007 Stamps, 2010a).

In this study, it was found that transverse texture and horizontal boundaries have a positive influence on the perception of spaciousness. In the four settings (HB-L, HB-T, VB-L, VB-T) related to texture property were tested in order to understand the similar space groups. Two groups were determined; Group 1: VB-L (M=2.66) and HB-L (M=2.72) and Group 2: VB-T (3.50) and HB-T (3.97) (see Table 11). It was found that Group 2 had the highest mean value with transverse texture.

Findings of the study is in agreement with the previous findings that claimed that perception of spaciousness increases with “transverse” texture (Bokharaei & Nasar, 2016; Ishikawa, Okabe, Sadahiro & Kakumoto, 1998; Sadalla & Oxley, 1984; Stamp, 2011).

In this study, it was found that cool color and horizontal boundaries have a positive influence on the perception of spaciousness. In the four settings (HB-C, HB-W, VB-C, VB-W) related to texture property were tested in order to understand the similar space groups. Two groups were determined; Group 1: VB-W (M=2.28) and HB-W (M=2.84), Group 2: VB-C (3.66) and HB-C (4.09) (see Table 12). It was found that Group 2 had the highest mean value with cool color.

Findings of the study is in agreement with the previous findings that claimed that perception of spaciousness increases with “cool” color (Franz, 2006; Martyniuk et al., 1973; Odabaşioğlu & Olguntürk, 2015; Yıldırım, Akalın-Başkaya, & Hidayetoğlu, 2012).

6.1.2. On the Interaction of the Boundary Type and Specific Properties

Variance analysis was conducted in order to understand the relationship between boundary type (horizontal/ vertical) and specific properties (size/ light/ texture/ color). It was hypothesed that the interaction of the boundary type and the specific property has an impact on perception of spaciousness. It was found that, there was no interaction between boundary type and specific property as an impact on spaciousness. Considering each specific property and the boundary type, it was found that there was a significant impact on spaciousness except in texture property the boundary type.

For the size property, it was hypothesed that there is an interaction between boundary type and size in terms of spaciousness. The findings revealed that

there is no interaction between the boundary and size (p=0.378) but the independently boundary (p=0.004) and size (p < 0.0001) have an impact on perceived spaciousness (see Table 13).

For the light property, it was hypothesed that there is an interaction between boundary type and light in terms of spaciousness. The findings revealed that there is no interaction between the boundary and light (p=0.390) but the independently boundary (p < 0.0001) and light (p < 0.0001) have an impact on perceived spaciousness (see Table 14).

For the texture property, it was hypothesed that there is an interaction between boundary type and texture in terms of spaciousness. The findings revealed that there is no interaction between the boundary and texture (p=0.290) also the independently boundary (p=0.170) not found as significant. Only the texture (p < 0.0001) have an impact on perceived spaciousness (see Table 15).

For the color property, it was hypothesed that there is an interaction between boundary type and color in terms of spaciousness. The findings revealed that there is no interaction between the boundary and color (p=0.686) but the independently boundary (p=0.002) and color (p < 0.0001) have an impact on perceived spaciousness (see Table 16).

According to the general variance analysis that showed each boundary type and specific property have significant effect on the perceived spaciousness

separately accept from texture boundary type. Result of 3S Model showed that there is no relationship between specific property and spatial enclosure (boundary type). Specific properties and Spatial enclosures are separately related with the spaciousness (see Figure 45). The statistical analysis later were conducted with the boundary type and specific property groups with 64 participants each.

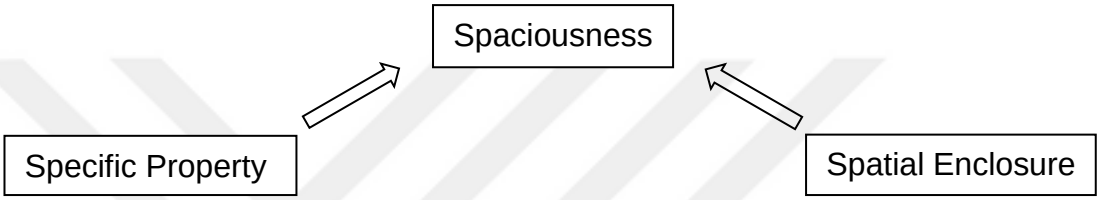


Figure 45. Revised of 3S Model

6.1.3. On Spaciousness and Aesthetic Judgements

Regression analysis for aesthetic judgements was conducted in two groups (boundary type and specific property). The aesthetic judgements consist of three components and these are showed as follows: Affective Variable (AV), Formal Variable (FV) and Symbolic Variable (SV). In agreement with the previous findings claimed that positive influence on aesthetic judgements in perception of spaciousness (see Table 17 for size, Table 18 for light, Table 19 for texture and Table 20 for color).

Boundary Type

It was hypothesed that aesthetic judgements were based on the boundary type (vertical/ horizontal) as a function of spaciousness. The results showed that for the size, the highest significant levels were found as ‘exciting’ (AV) and ‘safe’ (SV) items, for light as ‘arousing’ (AV) and items, for texture was found as ‘pleasant’ (AV) item and for color as ‘masculine’ item.

Specific Property

It was hypothesed that aesthetic judgements were based on the specific properties (size/ light/ texture/color) as a function of spaciousness. The results showed that for the size, the highest significant level were found as ‘safe’ (AV) and ‘pleasant’ (AV) items, for light as ‘masculine’ (SV) and ‘safe’ (SV) items, for texture as ‘exciting’ (AV) and ‘pleasant’ (AV) items with and for color was found as ‘feminine’ item. Table 25 shows all highest level of boundary type and specific properties for aesthetic judgement items.

Table 25. Aesthetic Judgement

		Aesthetic Judgement						
	Size		Light		Texture		Color	
BOUNDARY TYPE	HB	Pleasant (AV) Simple (FV) Safe (SV) Mysterious (SV)		Arousing (AV) Exciting (AV) Relaxing (AV)		Pleasant (AV)*		Arousing (AV) Pleasant (AV) Masculine (SV)*
	VB	Sleepy (AV) Pleasant (AV) Exciting (AV)* Incoherent (FV) Safe (SV)* Feminine (SV)		Arousing (AV)* Distressing (AV)		Exciting (AV)		Relaxing (AV)
SPECIFIC PROPERTY	S	Sleepy (AV) Pleasant (AV) Exciting (AV) Incoherent (FV) Safe (SV)**	D	Arousing (AV) Mysterious (SV) Masculine (SV)*	L	Exciting (AV)**	C	Relaxing (AV) Incoherent (FV) Safe (SV) Masculine (SV)
	L	Arousing (AV) Pleasant (AV)* Exciting (AV) Distressing (AV)	B	Safe (SV)** Mysterious (SV)	T	Pleasant (AV)* Simple (FV) Mysterious (SV)	W	Feminine (SV)**

* $p < 0.0001$

** $p < 0.002$

6.1.4. On Spaciousness and Emotional Responses

Regression analysis for emotional responses was conducted in two groups (boundary type and specific property). The emotional responses consist of two components and these are showed as follows: Pleasure (PL) and Arousal (AR). In agreement with the previous findings claimed that positive influence on emotional responses in perception of spaciousness (see Table 21 for size, Table 22 for light, Table 23 for texture and Table 24 for color).

Boundary Type

It was hypothesed that emotional responses were based on the boundary type (vertical/ horizontal) as a function of spaciousness. The results showed that for the size, the highest significant levels was felt as ‘pleased’ (PL) item, for light were felt as ‘pleased’ (PL), ‘relaxed’ (PL) and thought as ‘stimulated’ items, for texture felt as ‘pleased’ (PL), ‘satisfied’ (PL) and ‘happy’ (PL) items and for color as ‘pleased’ (PL), ‘hopeful’ and thought as ‘frenzied’ items.

Specific Property

It was hypothesed that emotional responses were based on the specific properties (size/ light/ texture/color) as a function of spaciousness. The results showed that for the size, the highest significant level was felt as ‘happy’ (PL) item, for light were felt as ‘bored’ (PL) and ‘relaxed’ items, for texture was felt as ‘satisfied’ (PL) item and for color as ‘Pleased’ item. Table 26 shows all the highest level of boundary type and specific property for emotional response items.

Table 26. Emotional Responses

	Emotional Response							
	Size		**Light**		**Texture**		**Color**	
BOUNDARY TYPE	**HB**	Pleased (PL)**		Pleased (PL)* Satisfied (PL)		Pleased (PL) Satisfied (PL)**		Pleased (PL)** Frenzied (AR)**
	VB	Happy (PL Frenzied (AR) Dull (AR)		Relaxed (PL)** Stimulated (AR)**		Happy (PL)**		Pleased (PL) Hopeful (PL)
SPECIFIC PROPERTY	**S**	Happy (PL) Satisfied (PL)	**D**	Pleased (PL) Bored (PL)** Aroused (AR) Stimulated (AR)	**L**	Bored (PL) Satisfied (PL)**	**C**	Pleased (PL)**
	L	Happy (PL)* Aroused (AR)	**B**	Pleased (PL) Relaxed (PL)** Stimulated (AR)	**T**	Happy (PL)	**W**	Contended (PL) Unaroused (AR)

* $p < 0.001$

** $p < 0.01$

6.1.5. On Behavioral Intention

Participants' qualitative comments on space settings were analyzed and grouped in order to support aesthetic judgements and emotional response items that provided further discussion on the findings.

Also, the behavioral intentions were analyzed to support the emotional responses of the participants. Three multiple-choice questions were provided in order to have an overall view of behavioral intention that were focused on time span, enjoyment and feel friendly level. The total score of three question for each specific property was determined to find out the behavioral intentions of each participant (see Figure 33-35 for size, Figure 36-38 for light, Figure 39-41 for texture and Figure 42-44 for color).

In this study, curved boundary type (horizontal and vertical) and large size, bright light, transverse texture and cool color properties were found to be strongly related with the perception of spaciousness. In order to support this idea, the behavior of participants all intentions were investigated. It was hypothesed that the behavioral intentions (approach-avoidance behaviors) are different in the four settings in terms of specific properties (size/ light/ texture/ color). This hypothesis was also supported with the behavioral intentions results. Figure 46 shows summary of the findings of the study, supported/not supported hypothesis and related references.

	Findings of the study	Related References
Perception of Spaciousness in Terms of Specific Properties		
H1	Spaciousness difference between 4 setting Boundary type & Specific property	Hayward & Franklin, 1974; Stamps, 2010a; Bokharaei & Nasar, 2016; Banaei et all., 2017b
Interaction of the Boundary Type and Specific Property		
H2	Interaction = Boundary type & Specific property = Impact on spaciousness	
Spaciousness and Aesthetic Judgement		
H3a	Boundary type	Alp, 1993; Madani Nejad, 2007, Dazkır, S. & Read, M., 2012; Vartanian et al., 2013; Shemesh et all., 2016
H3b	Specific Property	
Spaciousness and Emotional Responses		
H4a	Boundary type	Alp, 1993; Madani Nejad, 2007, Dazkır, S. & Read, M., 2012; Vartanian et al., 2013; Shemesh et all., 2016
H4b	Specific Property	
Related to Behavioral Intention		
H5	AA behaviours	Russell & Mehrabian 1974,1977

Figure 46. Summary of the Findings of the Study

6.2. Conclusion

This study intended to investigate the relationship between the perception of spaciousness and curved boundaries with different specific properties of the environment such as size, light, texture and color. Also, the aim of the study was to identify the relationship with the aesthetic judgements and emotional responses of the participants in a virtual environment. According to the results, perception of spaciousness is positively related with the curved boundaries and large size, bright light, transverse texture and cool color of the spaces.

It was also found that the aesthetic judgements and emotional responses support the perception of spaciousness with relevant adjectives. Curved boundaries evoked safer, exciting, arousing and pleasant aesthetic judgements and more pleasing, satisfying, relaxed and happier emotional responses in perception of spaciousness of individuals.

The findings of this study suggested that designers and architects can manipulate curvilinearity of the boundaries with many specific properties (size, light, texture and color) to provide a high level of perception of spaciousness in the built environment.

6.3. Implications on Interior Architecture

The design implications for interior designers were developed in detail with the relevant specific properties and boundary type. Large size, bright light, transverse texture, cool color of the specific properties and the curved horizontal boundaries effect the perception of spaciousness in a high rating.

This work may be a guide for designers to provide spacious environments for all users. Spaces sharp forms can change in the living environment in order to create more spacious atmosphere. Also, smooth transition between wall to wall increase the people aesthetic judgement as pleasant, exciting and safe and emotional responses as pleased, satisfied, relaxed and happy. Interior architects and architects can use such knowledge in order to achieve desired effects. The findings of the study could apply to indoor environment, which have a space that should appear spacious.

6.4. Limitations of the Study

There are main limitations of the study. It is not possible to measure all the components of aesthetic judgements and emotional responses objectively and completely. Aesthetic judgements and emotional responses are short term, subjective, complex and multidimensional concepts.

Also, the imitation of this study was the absence of a context while evaluating the setting. Many of the participants asked the function of the empty space and try to understand the purpose of the space.

6.5. Implications of Further Research

Additional studies can be conducted related this topic in various way. There are some suggestions for further research about perception of spaciousness and curved boundaries. This study can be repeated in order to analyzing equal gender, education level and major area.

Besides, the study utilized curved boundary type and size, light, texture and color properties without any other forms. The relationship between curved boundary type and other geometric form of space boundaries can be tested in those fields as well. How those other specific properties and boundary types influence the aesthetic judgement and emotional responses can also be investigated.

This study can be repeated by adapting context to VR stimuli. Various interior settings can be tested including residential settings, restaurants, cafes, office environments, classrooms, hospitals, hotels, dormitories, and etc. Thus, spaciousness level and emotional responses - aesthetic judgements can be investigated in different environments.

The experiment can be conducted with mobile brain/body imaging (MoMI) machine besides the Gear VR. In this way aesthetic judgement and emotional responses adjectives results can be compared with the brain function results.

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APPENDICES

APPENDIX A

JUDGEMENTS ON CURVES OF VARYING RADII

Table A. Adult Judgement of the Eight Line Segments From Which the Four Stimuli Were Chosen

Radius (Inches)	Inverse of Radius	Median Adult Judgement[a]
3*	.33	0.00
4	.25	1.75
4 ½	.22	2.25
6	.16	3.00
7½	.13	3.00
9*	.11	4.75
12	.08	5.25
Straight line*	.00	7.50

*Four three-dimensional orange wooden line segments.

[a] Adult judgements were gathered in a psychophysical scaling technique in which the judge assigned a number to indicate “how curved” the line segments appeared.

APPENDIX B

2D RECORDED 360 DEGREE IMAGES IN 3DS MAX

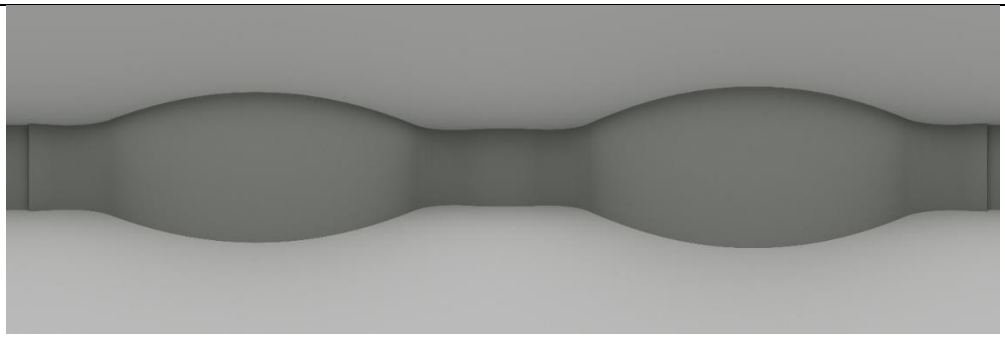
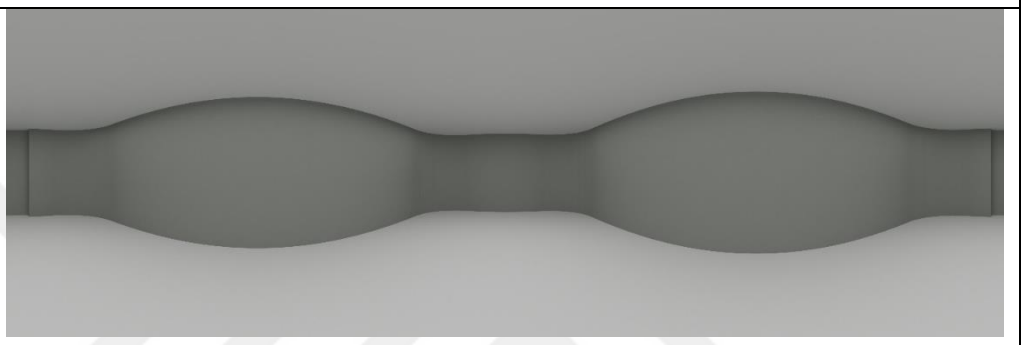
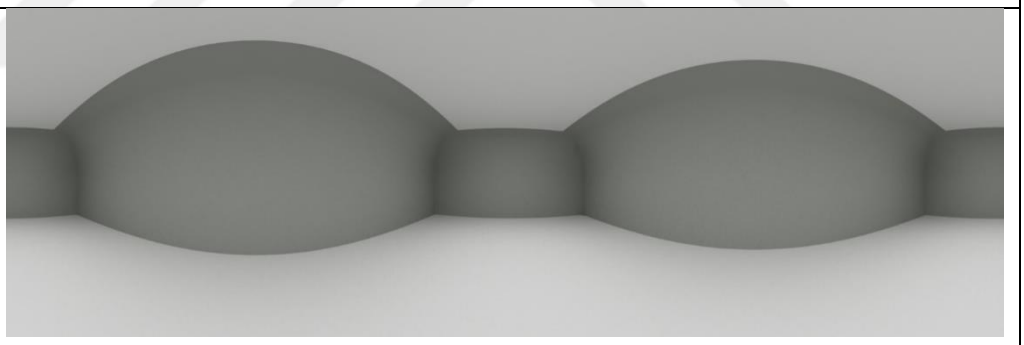
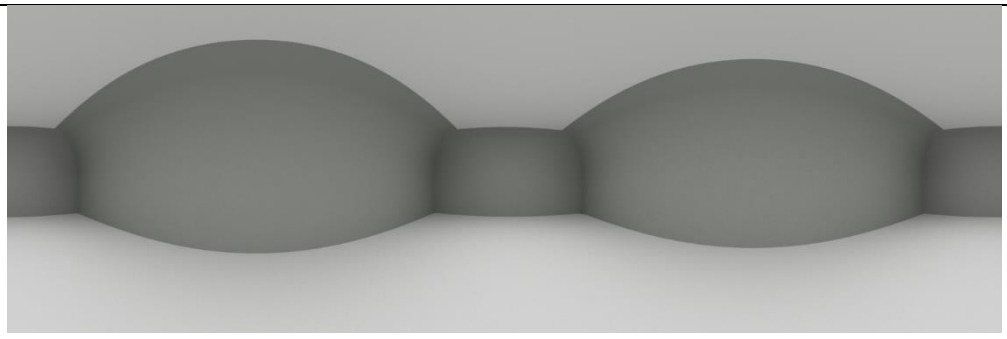
	Horizontal Boundary
SIZE small	
SIZE large	
	Vertical Boundary
SIZE small	
SIZE large	

Figure B.1. Size Simulations

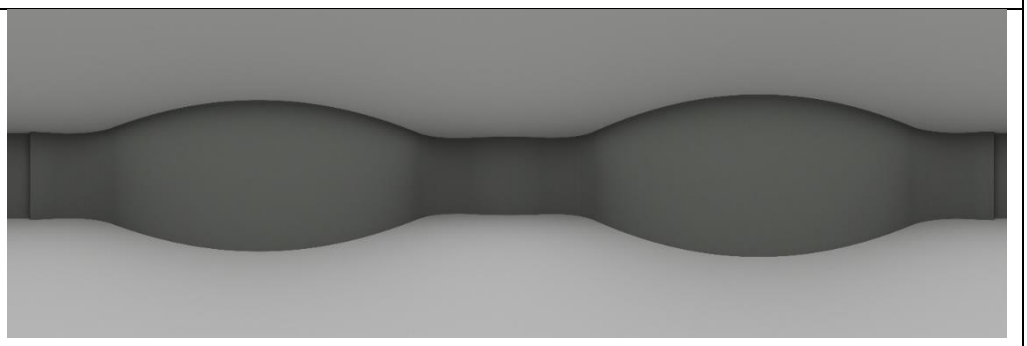
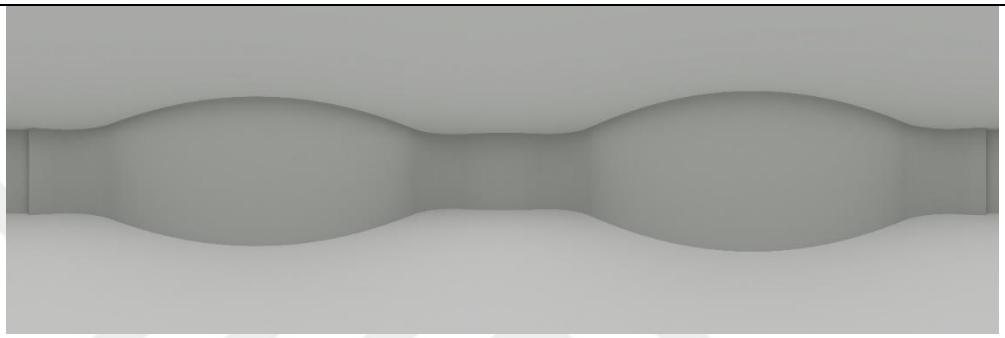
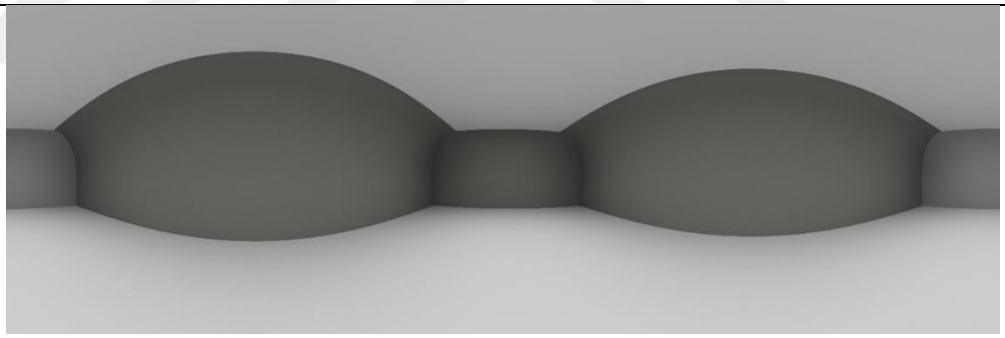
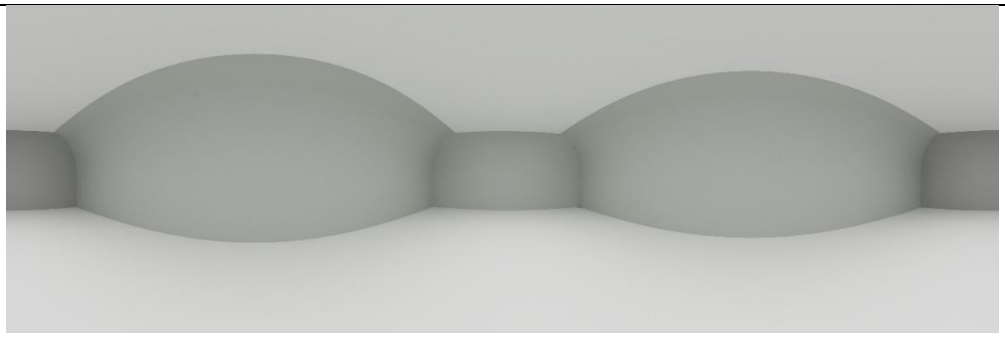
	Horizontal Boundary
LIGHT dim	
LIGHT bright	
	Vertical Boundary
LIGHT dim	
LIGHT bright	

Figure B.2. Light Simulations

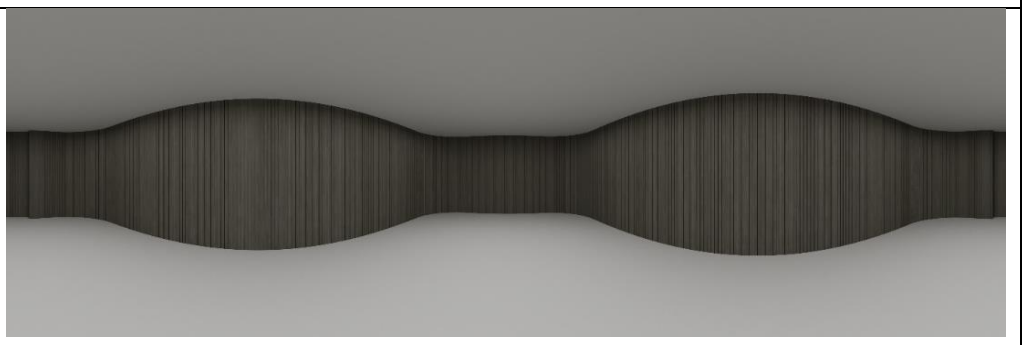
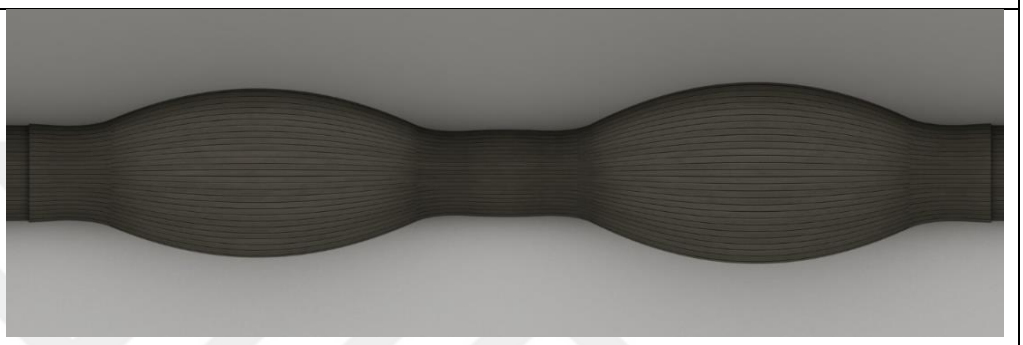
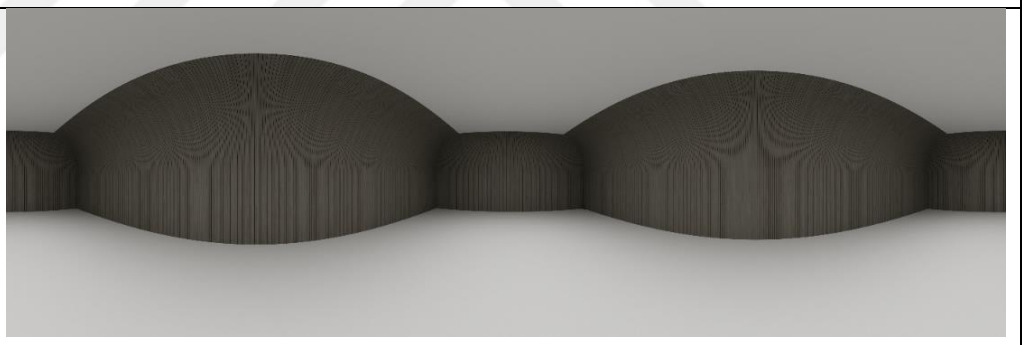
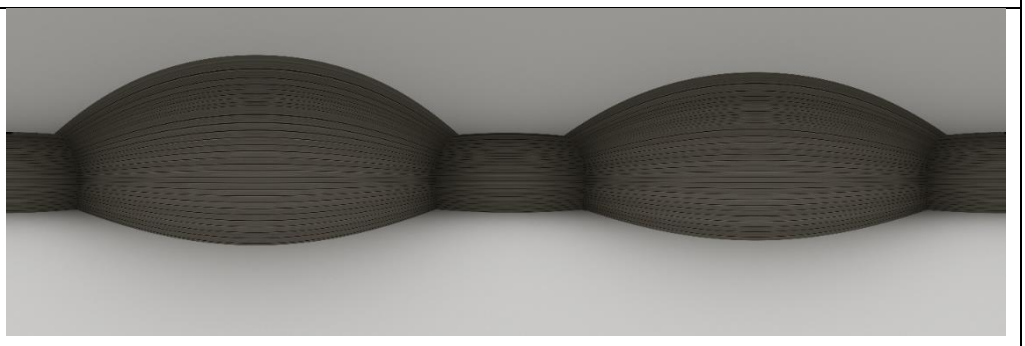
	Horizontal Boundary
TEXTURE longit.	
TEXTURE transv.	
	Vertical Boundary
TEXTURE longit.	
TEXTURE transv.	

Figure B.3. Texture Simulations

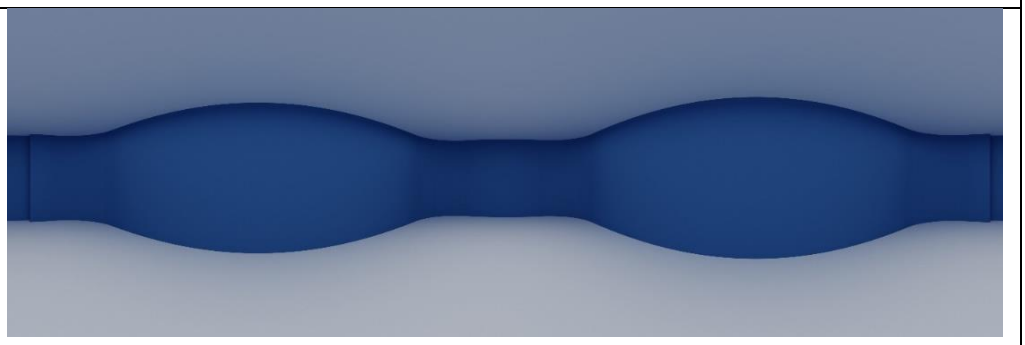
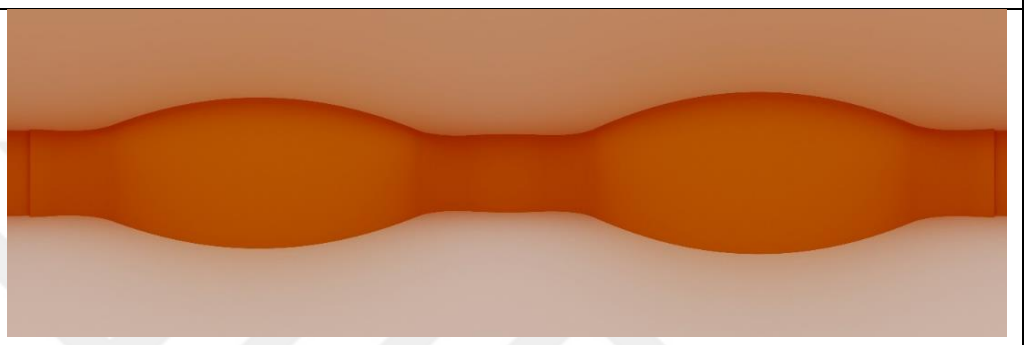
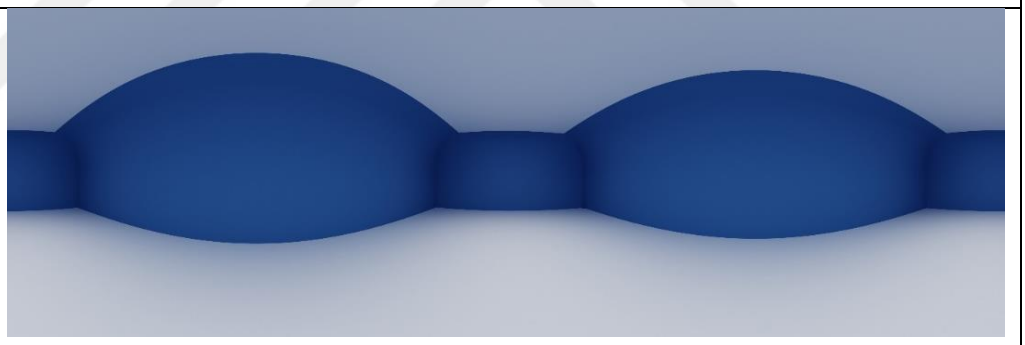
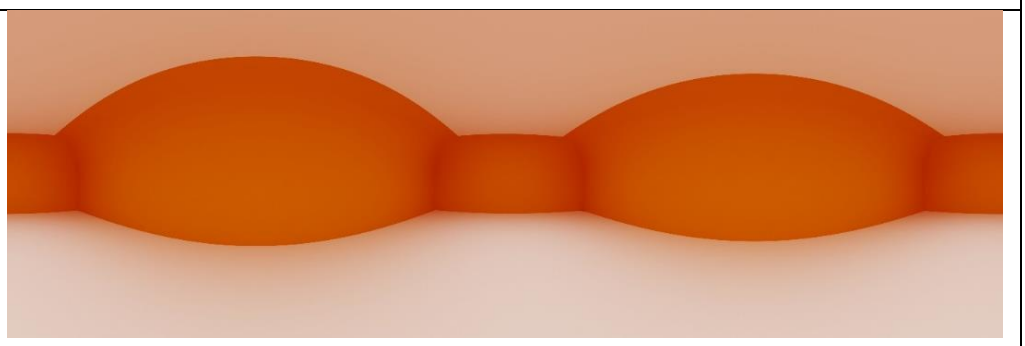
	Horizontal Boundary
COLOR cool	
COLOR warm	
	Vertical Boundary
COLOR cool	
COLOR warm	

Figure B.4. Color Simulations

APPENDIX C

360 DEGREE IMAGES WEB SITES

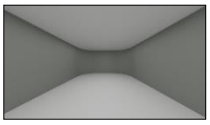
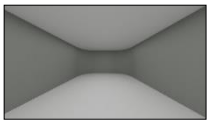
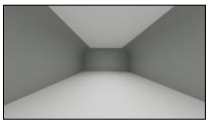
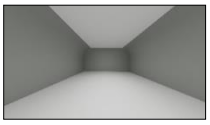
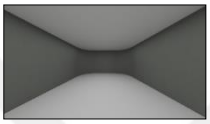
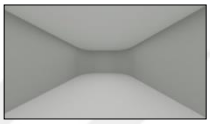
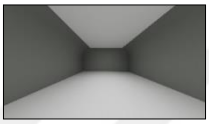
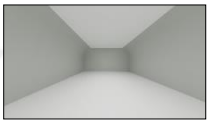
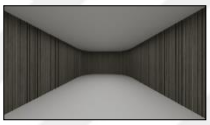
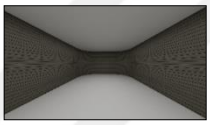
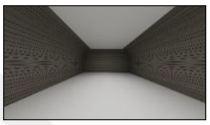
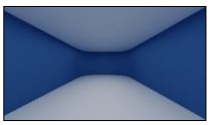
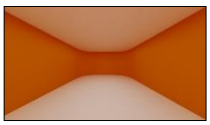
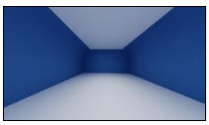
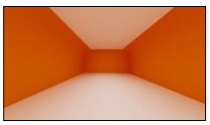
	Horizontal Boundary		Vertical Boundary	
1.Size	 1.1.Small	 1.2.Large	 1.3.Small	 1.4.Large
2.Light	 2.1.Dim	 2.2.Bright	 2.3.Dim	 2.4.Bright
3.Texture	 3.1.Longitudinal	 3.2.Transverse	 3.3.Longitudinal	 3.4.Transverse
4.Color	 4.1.Cool	 4.2.Warm	 4.3.Cool	 4.4.Warm

Figure C. Visual Study Variables and Web Site Codding

Table C. Study Variables Web Sites

1.SIZE	1.1.https://360.vizor.io/v/pb7aa 1.2.https://360.vizor.io/v/dardj 1.3.https://360.vizor.io/v/bndm4 1.4.https://360.vizor.io/v/awpwb
2.LIGHT	2.1.https://360.vizor.io/v/6pkdv 2.2.https://360.vizor.io/v/vwkvy 2.3.https://360.vizor.io/v/oxbnm 2.4.https://360.vizor.io/v/wkjeq
3.TEXTURE	3.1.https://360.vizor.io/v/njbnd 3.2.https://360.vizor.io/v/l8o4y 3.3.https://360.vizor.io/v/3eyp7 3.4.https://360.vizor.io/v/lwvkq
4.COLOR	4.1.https://360.vizor.io/v/j7ax2 4.2.https://360.vizor.io/v/mojpa 4.3.https://360.vizor.io/v/owxbn 4.4.https://360.vizor.io/v/kavpw

APPENDIX D

CONSENT FORM

Consent to Participate in a Research Study

(Wearing Samsung SM-R325 Gear VR)

Title: Perception of Spatial Enclosure as a Function of Different Space Boundaries.

Purpose: The purpose of this research is to examine the relationship between the perception of spaciousness and curvilinear boundaries with different physical properties of the environment such as size, light, texture and color. This research relates to the master thesis of Tuğçe Elver who is a graduate student of the Department of Interior Architecture and Environmental Design at Bilkent University. In this study, approximately 128 undergraduate and graduate students at Bilkent University who are over 18 years old, experience spatial 360-degree spaces with Gear Virtual Reality (VR) equipment. This study begins on January 2018 and ends on March 2018.

Procedure: Each participant is responsible for only one set of survey that consists of four spaces with different curvilinear boundaries associated with only one of the environmental properties. Boundaries are related to the way of how the surface are connected with each other in the space. The spaciousness of four 360-degree spaces is determined using a Gear VR. This equipment creates realistic virtual environment simulations. After the analysis of spaces, a survey consisting of aesthetic judgements and emotional responses of the participants is completed; the participants will be asked to assess how much they perceived the environment and how they felt in the spaces after experiencing the environment.

Benefits and Risks: This research aims to guide architects and interior architects to design better quality and spacious living environments. The result of the research may enhance the aesthetic judgements of the users of space and increase the emotional well-beings of the individuals. Moreover, I understand that the current research does not entail any physical or emotional risks other than those encountered in everyday life. There is no personal benefit to me.

Compensation: I will not be compensated for my participation in this research.

Confidentiality/ Privacy: Any information obtained in this research will only be reported and published for scientific purposes. As a participant, any information about my identity remain confidential and placed in investigator's locked secure storage for three years after the completion of the research study.

Participation: I am one of approximately 128 participants who will participate in this research study. My participation is voluntary. If I feel uncomfortable as a participant, I can decide to withdraw from participation in this research study by informing the researcher at any time or I can be excluded from the research study if it is deemed necessary by the researcher. I understand that my final decision will not positively or negatively influence my academic evaluation, or the service provided to me. In addition, if I have question regarding this research study, I can contact the investigator, advisor of the investigator or Bilkent University Local Ethics Committee. Research study has been reviewed and approved by Local Ethics Committee of Bilkent University.

I have read and understood the information provided to me. I voluntarily participate in this study. I have been given a copy of this consent form.

Participant No: _____ Date: _____

Name of the Participant: _____ _____

(First) (Last) (Signature of the Participant)

E mail:_____

_____ _____

Signature of the Investigator Date

Tuğçe Elver (Investigator)

Department of Interior Architecture and Environmental Design
Bilkent University

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Prof. Dr. Halime Demirkan (Advisor)

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Bilkent University

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APPENDIX E

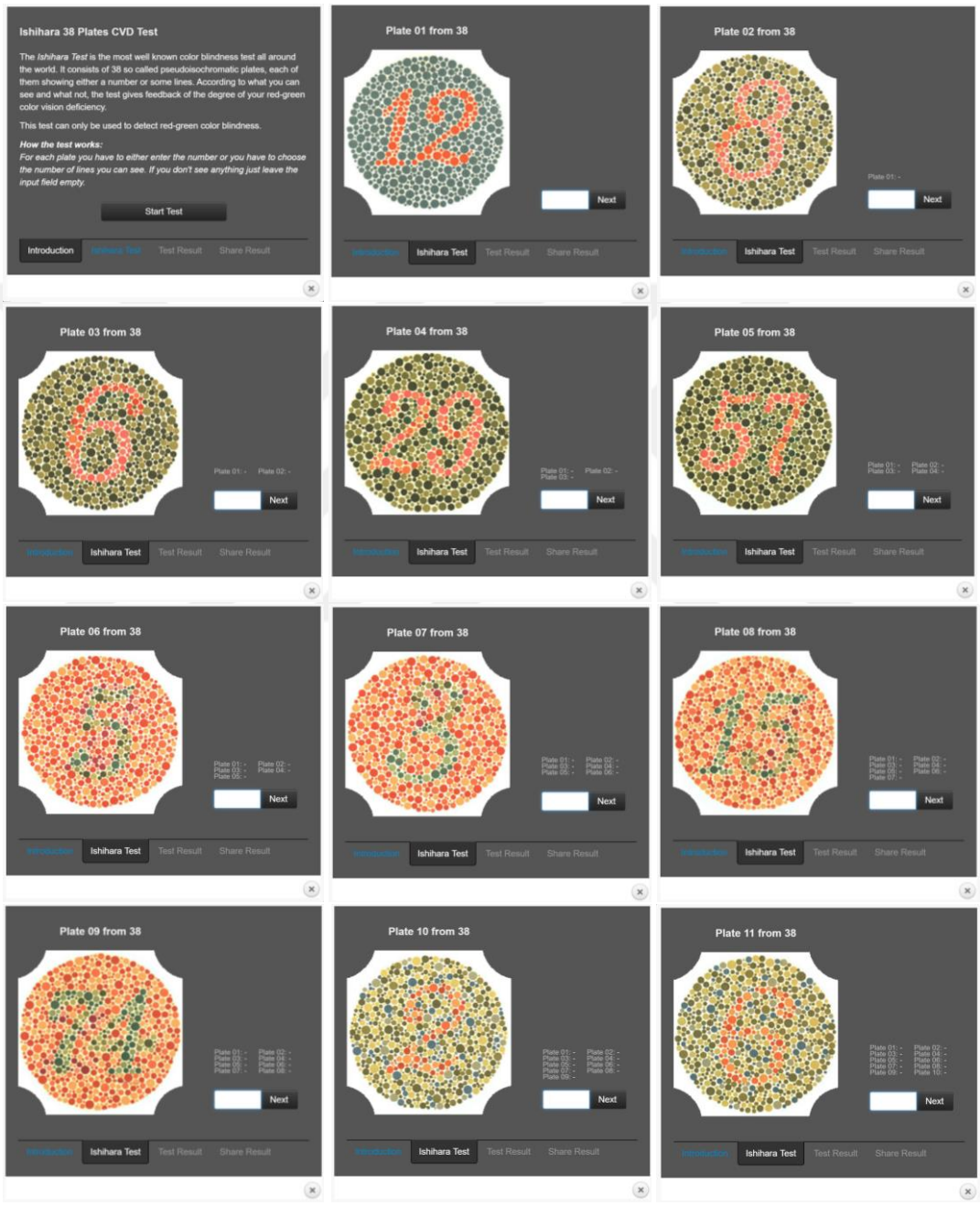
SAMSUNG SM-R325 GEAR VR

Figure E. Samsung SM-R325 Gear VR

APPENDIX F

ISHIHARA ELECTRONIC COLOR BLINDNESS TEST

http://www.color-blindness.com/ishihara-38-plates-cvd-test/#prettyPhoto/0/



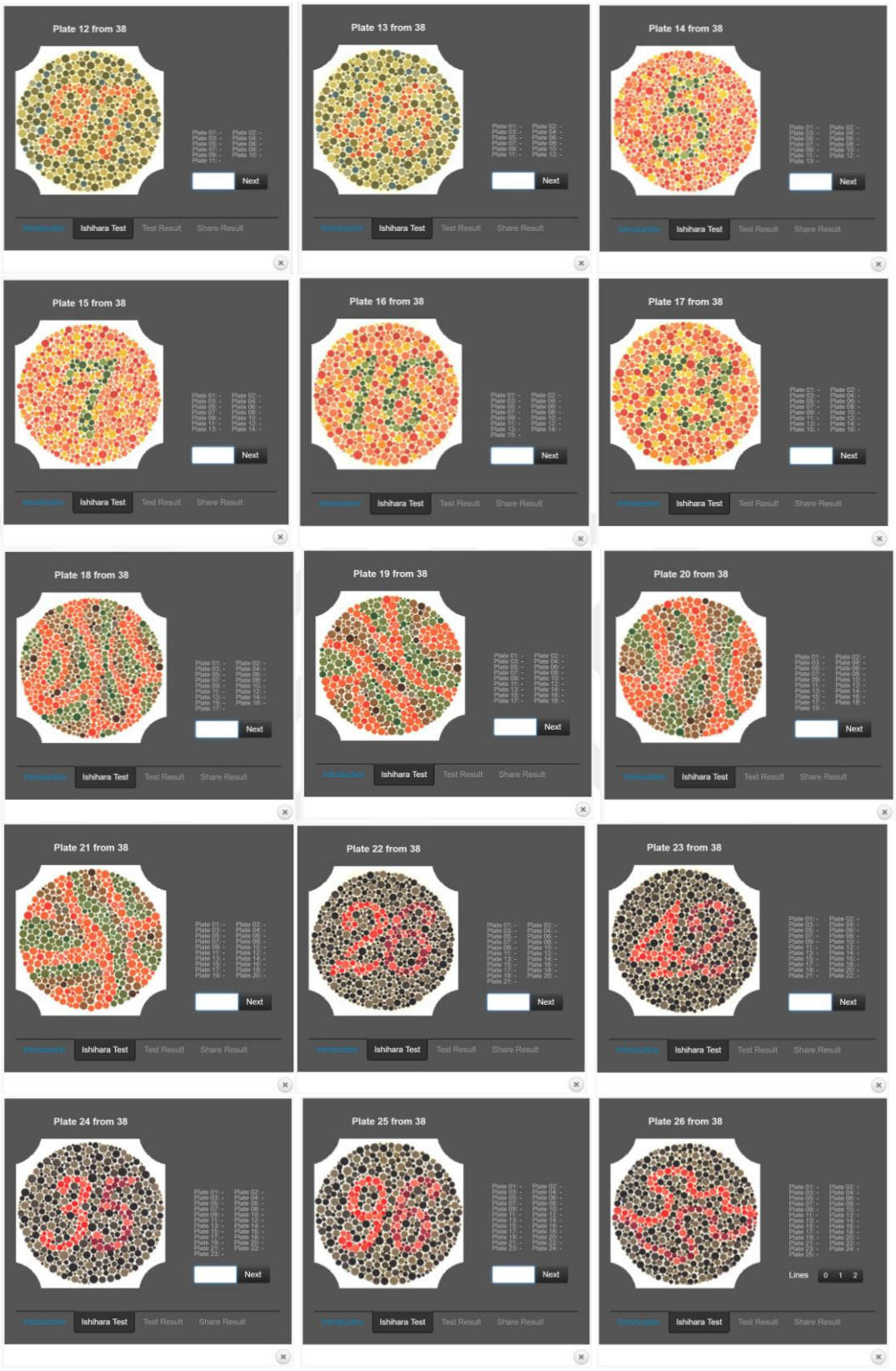


Plate 12 from 38
Plate 13 from 38
Plate 14 from 38
Plate 15 from 38
Plate 16 from 38
Plate 17 from 38
Plate 18 from 38
Plate 19 from 38
Plate 20 from 38
Plate 21 from 38
Plate 22 from 38
Plate 23 from 38
Plate 24 from 38
Plate 25 from 38
Plate 26 from 38
Next
Introduction
Ishihara Test
Test Result
Share Result
Lines 0 1 2

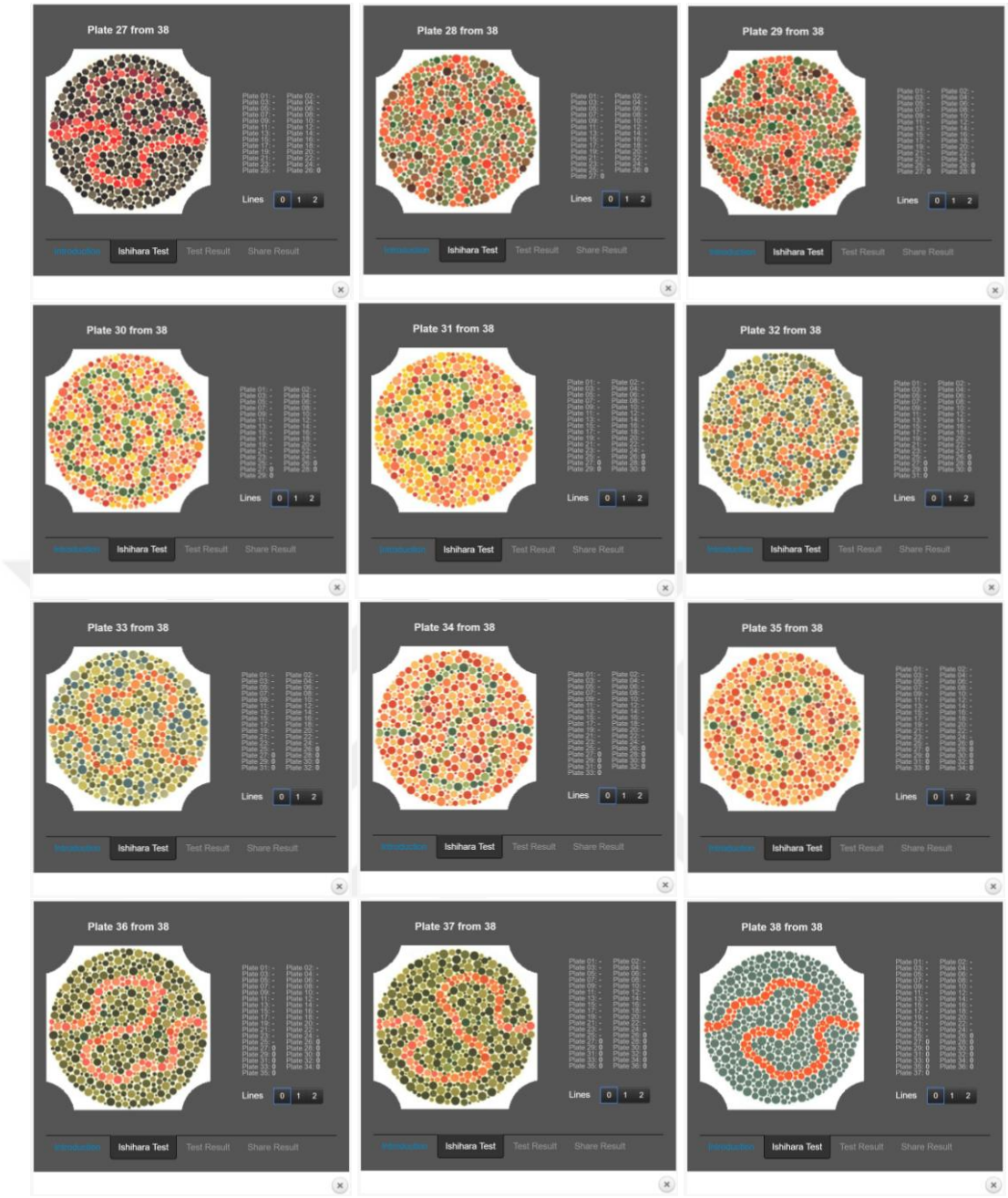


Figure F. 38 Plate of Ishihara Electronic Color Blindness Test

APPENDIX G

SURVEY SET

PERCEPTION OF SPACIOUSNESS

WITH AESTHETIC JUDGEMENTS AND EMOTIONAL RESPONSES

SET NO : Size / Light / Texture / Color _____ HB / VB - 1…. 2…. HB / VB - 3… 4…

Participant Information

Participant No: _____ **Age:** _____ **Sex:** ☐ Female ☐ Male

Education Level: ☐ Undergraduate ☐ Graduate **Major:** ☐ Social Science ☐ Design

Space 1

1.Perception of Spaciousness

Please rate the followed Virtual Reality environment on the criterion of how not spacious (1) or spacious (5) they appear.

Extremely Negative	Negative	Neutral	Positive	Extremely Positive
1	2	3	4	5

2.Aesthetic Judgements

Please mark your aesthetic judgement elicited by related space on each scale.

	-2	-1	0	1	2	
Affective Variables:						
Sleepy						Arousing
Unpleasant						Pleasant
Gloomy						Exciting
Distressing						Relaxing
Formal Variables:						
Simple						Complex
Incoherent						Coherent
Symbolic Variables:						
Unsafe						Safe
Not mysterious						Mysterious
Masculine						Feminine

3.Emotional Responses

Please mark your emotional responses elicited by related space setting on each scale. You should respond quickly (quick responses are important).

	-2	-1	0	1	2	
Pleasure:						
Annoyed						Pleased
Unhappy						Happy
Bored						Relaxed
Unsatisfied						Satisfied
Melancholic						Contended
Despairing						Hopeful
Arousal:						
Unaroused						Aroused
Calm						Excited
Sluggish						Frenzied
Dull						Jittery
Sleepy						Wide-awake
Relaxed						Stimulated

Are there any other feelings/ emotions that you'd like to describe about related space setting?

What have you liked/ disliked about this room? Please explain

Q1: How much time would you like to spend in this room?

☐ Never ☐ Almost never ☐ A few minutes ☐ An hour ☐ A few hours

Q2: Once in this room, how much would you enjoy exploring around?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

Q3: To what extent does this place make you feel friendly and talkative to a stranger who happens to be near you?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

Space 2

1.Perception of Spaciousness

Please rate the followed Virtual Reality environment on the criterion of how not spacious (1) or spacious (5) they appear.

Extremely Negative	Negative	Neutral	Positive	Extremely Positive
1	2	3	4	5

2.Aesthetic Judgements

Please mark your aesthetic judgement elicited by related space on each scale.

	-2	-1	0	1	2	
Affective Variables:						
Sleepy						Arousing
Unpleasant						Pleasant
Gloomy						Exciting
Distressing						Relaxing
Formal Variables:						
Simple						Complex
Incoherent						Coherent
Symbolic Variables:						
Unsafe						Safe
Not mysterious						Mysterious
Masculine						Feminine

3.Emotional Responses

Please mark your emotional responses elicited by related space setting on each scale. You should respond quickly (quick responses are important).

	-2	-1	0	1	2	
Pleasure:						
Annoyed						Pleased
Unhappy						Happy
Bored						Relaxed
Unsatisfied						Satisfied
Melancholic						Contended
Despairing						Hopeful
Arousal:						
Unaroused						Aroused
Calm						Excited
Sluggish						Frenzied
Dull						Jittery
Sleepy						Wide-awake
Relaxed						Stimulated

Are there any other feelings/ emotions that you'd like to describe about related space setting?

_____

What have you liked/ disliked about this room? Please explain_____

Q1: How much time would you like to spend in this room?

☐ Never ☐ Almost never ☐ A few minutes ☐ An hour ☐ A few hours

Q2: Once in this room, how much would you enjoy exploring around?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

Q3: To what extent does this place make you feel friendly and talkative to a stranger who happens to be near you?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

Space 3

1.Perception of Spaciousness

Please rate the followed Virtual Reality environment on the criterion of how not spacious (1) or spacious (5) they appear.

Extremely Negative	Negative	Neutral	Positive	Extremely Positive
1	2	3	4	5

2.Aesthetic Judgements

Please mark your aesthetic judgement elicited by related space on each scale.

	-2	-1	0	1	2	
Affective Variables:						
Sleepy						Arousing
Unpleasant						Pleasant
Gloomy						Exciting
Distressing						Relaxing
Formal Variables:						
Simple						Complex
Incoherent						Coherent
Symbolic Variables:						
Unsafe						Safe
Not mysterious						Mysterious
Masculine						Feminine

3.Emotional Responses

Please mark your emotional responses elicited by related space setting on each scale. You should respond quickly (quick responses are important).

	-2	-1	0	1	2	
Pleasure:						
Annoyed						Pleased
Unhappy						Happy
Bored						Relaxed
Unsatisfied						Satisfied
Melancholic						Contended
Despairing						Hopeful
Arousal:						
Unaroused						Aroused
Calm						Excited
Sluggish						Frenzied
Dull						Jittery
Sleepy						Wide-awake
Relaxed						Stimulated

Are there any other feelings/ emotions that you'd like to describe about related space setting?

_____

What have you liked/ disliked about this room? Please explain_____

Q1: How much time would you like to spend in this room?

☐ Never ☐ Almost never ☐ A few minutes ☐ An hour ☐ A few hours

Q2: Once in this room, how much would you enjoy exploring around?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

Q3: To what extent does this place make you feel friendly and talkative to a stranger who happens to be near you?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

Space 4

1.Perception of Spaciousness

Please rate the followed Virtual Reality environment on the criterion of how not spacious (1) or spacious (5) they appear.

Extremely Negative	Negative	Neutral	Positive	Extremely Positive
1	2	3	4	5

2.Aesthetic Judgements

Please mark your aesthetic judgement elicited by related space on each scale.

	-2	-1	0	1	2	
Affective Variables:						
Sleepy						Arousing
Unpleasant						Pleasant
Gloomy						Exciting
Distressing						Relaxing
Formal Variables:						
Simple						Complex
Incoherent						Coherent
Symbolic Variables:						
Unsafe						Safe
Not mysterious						Mysterious
Masculine						Feminine

3.Emotional Responses

Please mark your emotional responses elicited by related space setting on each scale. You should respond quickly (quick responses are important).

	-2	-1	0	1	2	
Pleasure:						
Annoyed						Pleased
Unhappy						Happy
Bored						Relaxed
Unsatisfied						Satisfied
Melancholic						Contended
Despairing						Hopeful
Arousal:						
Unaroused						Aroused
Calm						Excited
Sluggish						Frenzied
Dull						Jittery
Sleepy						Wide-awake
Relaxed						Stimulated

Are there any other feelings/ emotions that you'd like to describe about related space setting?

_____

What have you liked/ disliked about this room? Please explain_____

Q1: How much time would you like to spend in this room?

☐ Never ☐ Almost never ☐ A few minutes ☐ An hour ☐ A few hours

Q2: Once in this room, how much would you enjoy exploring around?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

Q3: To what extent does this place make you feel friendly and talkative to a stranger who happens to be near you?

☐ Not at all ☐ Slightly ☐ Moderate ☐ Much ☐ Very much

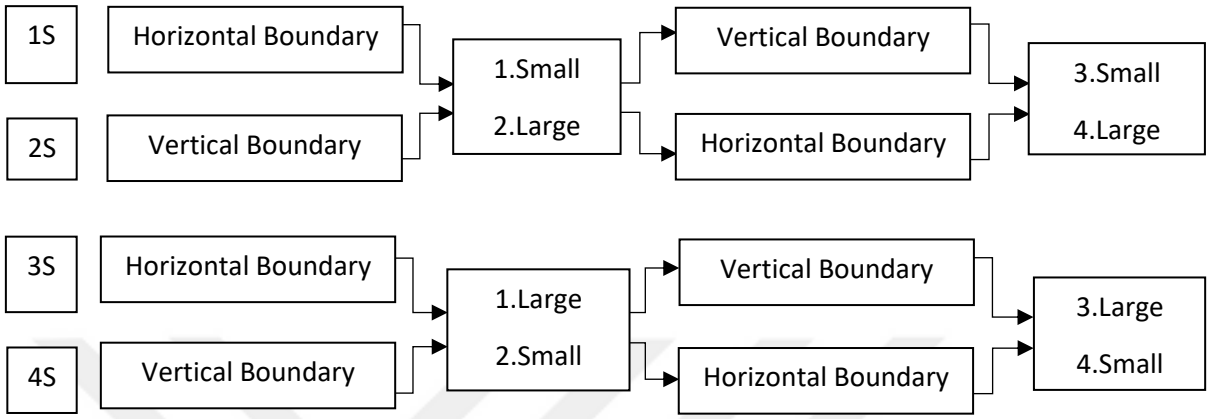
2.Aesthetic Judgements Questions Adapted from "Curvilinear in architecture: emotional effect of curvilinear forms in interior design" by Madani Nejad, K. 2009, *Doctoral Dissertation*, pp.243.

3.Emotional Responses; Questions Adapted from "Emotional effect of curvilinear vs. rectilinear forms of furniture in interior setting" by Dazkır, S. 2009, *Master Thesis*, pp.91-92.

APPENDIX H

PROCEDURE OF THE DATA

Size – Data Gathering Order



1
4 Male participants……..HB - 1.s 2.l VB - 3.s 4.l
4 Female participants…….....HB - 1.s 2.l VB - 3.s 4.l

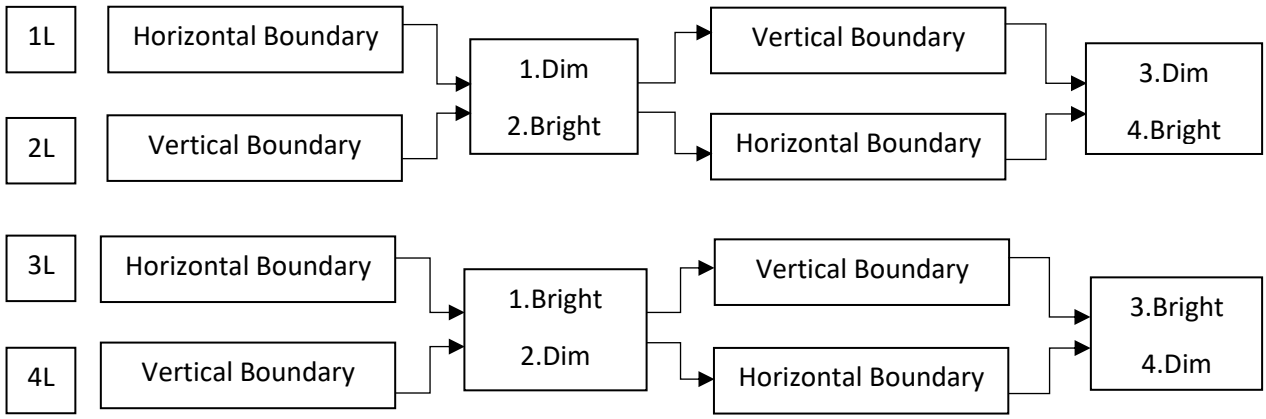
2
4 Male participants…….....VB - 1.s 2.l HB - 3.s 4.l
4 Female participants…….....VB - 1.s 2.l HB - 3.s 4.l

3
4 Male participants…….....HB - 1.l 2.s VB - 3.l 4.s
4 Female participants…….....HB - 1.l 2.s VB - 3.l 4.s

4
4 Male participants……..VB - 1.l 2.s HB - 3.l 4.s
4 Female participants……VB - 1.l 2.s HB - 3.l 4.s

Figure H.1. Size Data Gathering Order

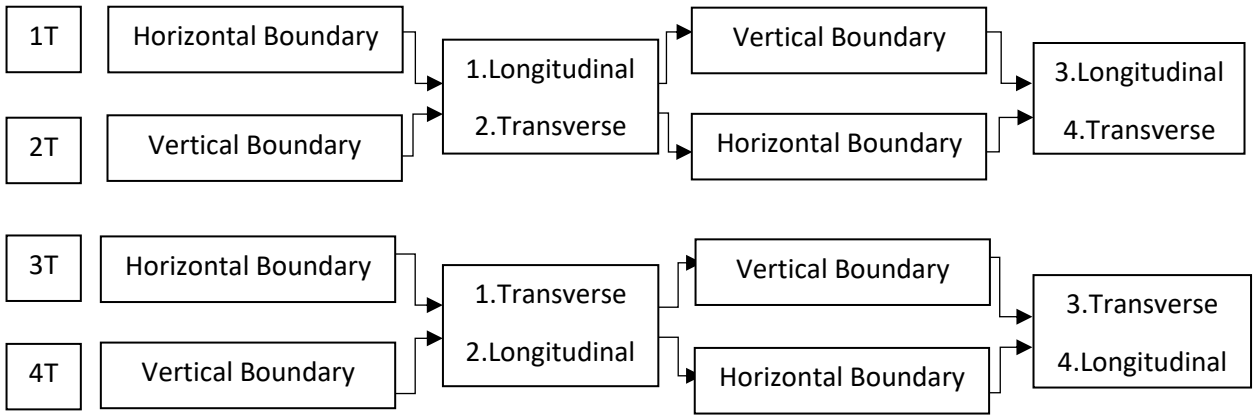
Light – Data Gathering Order



1	4 Male participants……...HB - 1.d 2.b VB - 3.d 4.b 4 Female participants…….....HB - 1.d 2.b VB - 3.d 4.b
2	4 Male participants……..…….....VB - 1.d 2.b HB - 3.d 4.b 4 Female participants…….....VB - 1.d 2.b HB - 3.d 4.b
3	4 Male participants…….....HB - 1.b 2.d VB - 3.b 4.d 4 Female participants…….....HB - 1.b 2.d VB - 3.b 4.d
4	4 Male participants……..……..VB - 1.b 2.d HB - 3.b 4.d 4 Female participants……VB - 1.b 2.d HB - 3.b 4.d

Figure H.2. Light Data Gathering Order

Texture – Data Gathering Order



1

4 Male participants……..……..HB - 1.l 2.t VB - 3.l 4.t

4 Female participants…….....HB - 1.l 2.t VB - 3.l 4.t

2

4 Male participants…….....VB - 1.l 2.t HB - 3.l 4.t

4 Female participants…….....VB - 1.l 2.t HB - 3.l 4.t

3

4 Male participants…….....HB - 1.t 2.l VB - 3.t 4.l

4 Female participants……..HB - 1.t 2.l VB - 3.t 4.l

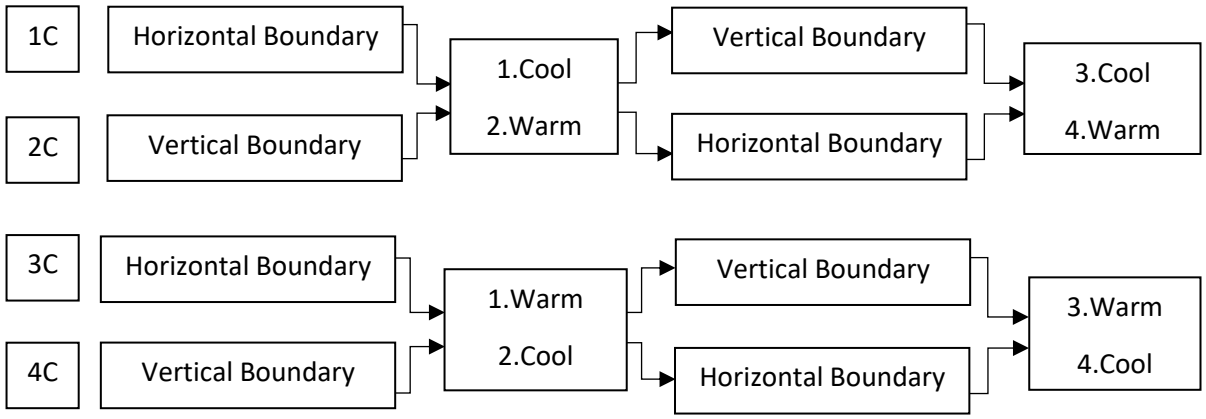
4

4 Male participants……VB - 1.t 2.l HB - 3.t 4.l

4 Female participants……...VB - 1.t 2.l HB - 3.t 4.l

Figure H.3. Texture Data Gathering Order

Color – Data Gathering Order



1

4 Male participants……..HB - 1.c 2.w VB - 3.c 4.w

4 Female participants…….....HB - 1.c 2.w VB - 3.c 4.w

2

4 Male participants……....VB - 1.c 2.w HB - 3.c 4.w

4 Female participants…….....VB - 1.c 2.w HB - 3.c 4.w

3

4 Male participants…….....HB - 1.w 2.c VB - 3.w 4.c

4 Female participants……....HB - 1.w 2.c VB - 3.w 4.c

4

4 Male participants……..VB - 1.w 2.c HB - 3.w 4.c

4 Female participants……VB - 1.w 2.c HB - 3.w 4.c

Figure H.4. Color Data Gathering Order

APPENDIX I

BOUNDARY TYPE AND SPECIFIC PROPERTY CODING

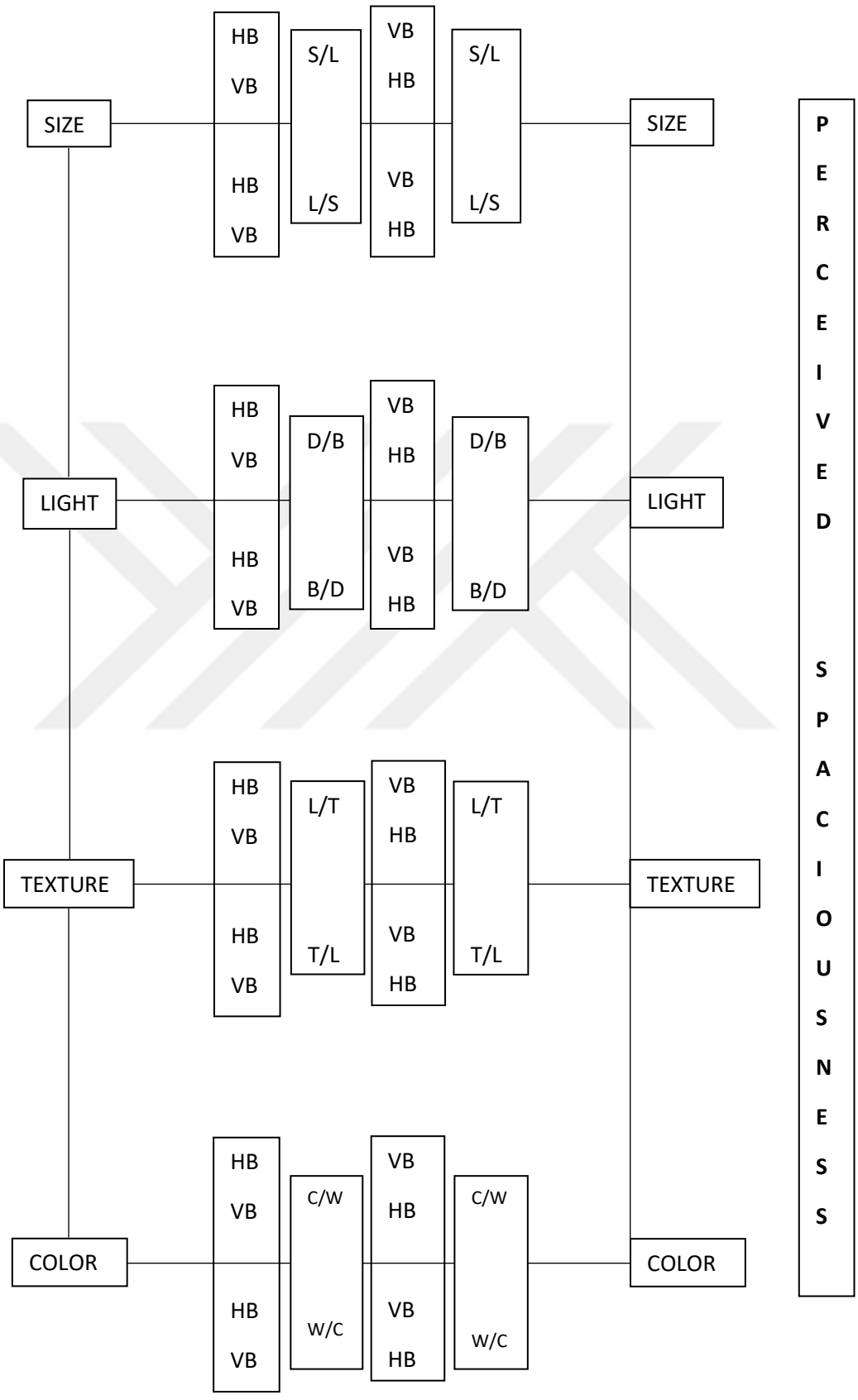


Figure I. Color Data Gathering Order