EFFECTS OF COLORED LIGHTING ON THE PERCEPTION OF INTERIOR SPACES

A THESIS
SUBMITTED TO THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN AND THE INSTITUTE OF ECONOMICS AND SOCIAL SCIENCES
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FOR THE DEGREE OF
MASTER OF FINE ARTS

By
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June, 2009

I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts.

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ABSTRACT

EFFECTS OF COLORED LIGHTING ON THE PERCEPTION OF INTERIOR SPACES

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The aim of this study is to understand the effects of colored lighting on the perception of interior spaces and to compare different colored lightings in order to understand their effects on interior space perception. The experiment was conducted with the same sample group for three different lightings which are red, green and white. The participants were ninety-seven students from different departments of Bilkent University, most of them from the Department of Interior Architecture and Environmental Design. The study was conducted in three phases. Firstly, participants were tested for color vision deficiencies and the ones who passed this test entered the first part of the experiment. They evaluated the experiment room under red lighting in the first phase. Secondly, they evaluated the experiment room under green lighting. Lastly, they evaluated the experiment room under white lighting. It was found that colored lighting (red and green) affects the perception of an interior space and the space perception differs according to the color of the lighting for some of the evaluative factors.

KEYWORDS: space perception, interior spaces, colored lighting.

ÖZET

RENKLİ AYDINLATMANIN İÇ MEKANLARIN ALGILANMASINDAKİ ETKİLERİ

Seden Odabaşıoğlu
İç Mimarlık ve Çevre Tasarımı Yüksek Lisans Programı
Danışman : Y. Doç. Dr. Nilgün Olguntürk
Haziran, 2009

Bu çalışmanın amacı, renkli aydınlatmanın iç mekan algısı üzerindeki etkilerini anlamak ve farklı renklerdeki aydınlatmaları, iç mekan algısındaki farklı etkilerini anlamak için, karşılaştırmaktır. Deney, kırmızı, yeşil ve beyaz aydınlatma olarak üç farklı aydınlatma için aynı katılımcı grubuyla gerçekleştirilmiştir. Katılımcılar, çoğunluğu İç Mimarlık ve Çevre Tasarımı Bölümü'nden olmak üzere, Bilkent Üniversitesi'nin farklı bölümlerinden 97 öğrenciden oluşmaktadır. Deney üç aşamada yürütülmüştür. İlk olarak katılımcılar, renk görme yeterliliklerini ölçmek üzere test edilmişlerdir ve bu testi geçenler deneyin ilk bölümüne girmişlerdir. Katılımcılar ilk aşamada deney odasını kırmızı ışık altında değerlendirmişlerdir. İkinci olarak, katılımcılar deney odasını yeşil ışık altında değerlendirmişlerdir. Son olarak da, katılımcılar deney odasını beyaz ışık altında değerlendirmişlerdir. Renkli aydınlatmanın iç mekan algısını etkilediği ve mekan algısının aydınlatmanın rengine göre bazı değerlendirme faktörleri için farklılık gösterdiği bulunmuştur.

Anahtar kelimeler: mekan algısı, iç mekanlar, renkli aydınlatma.

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1. INTRODUCTION

The need of people to understand their environment is the basis of many researches. Interior space perception is one of the topics in this research area. Factors affecting perception of a space can be analyzed under two topics: Physical and psychological factors. Light and color are two of the important physical factors influencing the perception of a space. There have been studies done on the effects of light (Durak, Olguntürk, Yener, Güvenç & Gürçınar, 2007; Manav, 2007; Manav & Yener, 1999; Fotios & Levermore, 1999; Flynn, Hendrick, Spencer & Martyniuk, 1979; Flynn, Spencer, Martyniuk & Hendrick, 1973) and on the effects of color (Kwallek, 1996) on space perception.

As a result of the improving technology, color is started to be obtained from many different light sources and there is an increase use of colored lights both in exterior and interior spaces. Colored lights are used by interior architects and lighting designers in many spaces including parks, building facades, interiors of bars, restaurants, hotels, houses, cinemas, and shops. Therefore, it is important to understand the effects of colored lighting on space perception. However, there are not any studies on colored lights and their effect on space perception.

1.1. Aim of the Study

The main purpose of this study is to understand the effects of colored lighting on perception of interior spaces. It is important to understand and know the effects of colored lighting on interior space perception because this knowledge would contribute to lighting design of interior space. The study also aims to compare different colored lightings in order to understand their different effects on interior space perception.

This study also examines space associations with different colored lights. The findings of the study can be helpful not only for interior architects but also lighting designers who have the control of light in a space.

1.2. Structure of the Thesis

The thesis consists of six chapters. The first chapter is introduction, in which the factors that are affecting space perception and importance of light, color and colored light on this perception are briefly stated. In addition, the aim of the study and the structure of the thesis are also explained in the introduction part.

The second chapter explores space perception and the factors that are affecting the perception of a space. Firstly, the physical factors that have an influence on space perception and how they change this perception are explained. Secondly, psychological factors influencing space perception are stated and studies on this subject are briefly explained. The psychological scales that are used in space perception are investigated under six headings which are pleasantness, aesthetics, use, comfort, spaciousness, and light considering the content of this study. In pleasantness, how light and color in a space can change the pleasantness and the value of liking of a space is explored. In aesthetics part, how a space is perceived as being aesthetic is explored. In use part, how light in a space can change the perception of a space in terms of use and how space may be perceived as being public or private is explored. In comfort part, it is explored how light in a space can change the perceived comfort of that space is explored. In spaciousness part, how light and color in a space can change its perceived spaciousness is explored. Lastly, in light part, how light in a space can change its perceived brightness and clarity is explored.

In the third chapter, basic terms of light and color used in this study are explained. In addition, light sources for obtaining color such as colored incandescent lamps, colored halogen lamps, colored fluorescent lamps, neon lamps, colored metal halide lamps, light emitting diodes, lasers, fiber optics, and filters are explored. Lastly, the use of colored light in interior spaces is investigated.

In the fourth chapter, the experiment is described with the aim, research questions and hypothesis of the study. The methodology of the experiment is explained with the identification of the sample group, description of the experiment room and the explanation of the procedure of the experiment. The statistical analysis and evaluation of the data obtained from the experiment is explained. In the fifth chapter, the findings are discussed.

The sixth chapter is the conclusion in which major results of the study are stated and suggestions for further researches are composed.

2. PERCEPTION OF INTERIOR SPACES

People spend most of their lives in man-made environments and inevitably have an interaction with the spaces they live in. A space is perceived, evaluated and emotionally reacted by its users. Perception of a space is not only gathered information through all senses; it is also a cognitive event (Gifford, 2002). People, related to their perceptions, may have different impressions about the same space. Therefore, a space can be evaluated differently by its users.

Gifford (2002) divided the evaluation of an environment into two which are environmental appraisal and environmental assessment. Environmental appraisal is an individual's personal impressions of a setting whereas environmental assessment is the combination of ratings by several observers (users of the setting) for a broader judgment of an environment.

For both environmental appraisal and assessments an observer and a place are required, but in research on appraisals, the emphasis is on understanding the person rather than understanding the place whereas, in research on assessments, the emphasis is on investigating the environment (quality or lack of quality of the setting) rather than understanding the person who makes the judgment. In other words, it can be said that appraisals are person centered and focus on what individuals think and feel about a place. On the other hand, assessments are place centered and focus on the quality of a place measuring physical properties and environmental quality by using perceptual skills of individuals.

In order to measure the quality of a space by using perceptual skills of individuals, the space should be perceived with the four senses of seeing, hearing, touching and smelling. Seeing is the first step for a person to perceive an environment and the other senses contribute to seeing. Additionally the psychological factors that are affecting the perceptual skills of a person are also important. Therefore, physical properties of an interior space regarding design and environmental properties of an environment and the psychological aspects of individuals are two main factors that influence the perception of interior spaces.

2.1. Physical Factors

The physical factors of an interior space that are affecting the perception of that space can be divided into two main parts which are design and environment. The design part consists of form and composition, texture and material, size and proportion of the space. Environment part, considering environmental design of a space, consists of heat, sound, color and lighting in the space.

2.1.1. Design

Design of an interior space influences the perception of that space considering form and composition, size and proportion and the materials and textures used in the space. Yıldız (1995) stated that size and proportion of a space, the textural and formal properties of the surfaces in the space, and the dimensions and density of furniture play an important role in the perception of an architectural space.

In design, form is the term used for defining the formal structure of a work including a sense of three-dimensional mass or volume (Ching, 1996). In addition, composition is defined in the Oxford English Dictionary (2002) as the formation of a harmonious whole by combining various elements or parts. The form and composition of an interior space affects visual perception, therefore it affects the evaluation of that space. The pleasantness of a space is influenced by the form of the space and the balance of the space with the elements inside it. Balance is the psychological sense of equilibrium which is usually achieved when visual weight is placed equally (Lauer, 2000). After the perception of size, proportion, and form of a space, eyes require a balanced composition in the space. If there is not a balance between these properties of a space, time required to perceive the space extends and the space is perceived to be unpleasant.

Another factor that influences the perception of an interior space is the size and proportion of the elements of the space with its size. Size is the physical dimensions of length, width and depth of a space and the relation between these dimensions determines the proportion of that space (Ching, 1996). For instance, the perception of height of a space can change according to the proportion of the wall and the windows in the space.

Texture is the visual and tactile quality of a material (Ching, 1996). The materials used in the design of a space and the texture of these materials affect the perception of a space. Smooth materials without any texture affect the perception of a space different than rough materials with textures.

Ritterfield & Cupchik (1996) examined how people perceive and respond to living and dining rooms inhabited by others. The participants rated the photographs of different living and dining rooms on different scale with adjective pairs. The ratings of the participants were submitted to a factor analysis and three factors were obtained: decorative, stylish and familiar. The results of the study indicated that the decorative rooms are perceived as fancy, formal and stimulating and the stylish rooms are perceived as orderly, modern, and cool. This shows how the design of an interior space affects the perception and evaluation of it.

2.1.2. Environmental Factors

In addition to design, environmental properties of a space, which are light, color, heat and sound, are also effective in the perception of that space. Durak, et.al. (2007) stated that in the design of an interior space many interrelated elements are considered such as form, structure, lighting, texture; and color and lighting should receive considerable attention among these elements.

Lighting, as a planned application of light, can change the perception of a space in different ways. For instance, color properties of lamps, as a function of their spectral distribution, affect the perception of an interior space illuminated with that light (Fotios & Levermore, 1999). By changing the quality and quantity of light, attraction or attention to a space, impressions of spaciousness, impressions of cheerfulness and playfulness can be reinforced, and sensations of spatial intimacy or warmth can be stimulated. As an example, impression of relaxation of a space can be reinforced by nonuniform lighting, peripheral (wall) lighting and warm tones of white light (IES, 1987).

Color, as surface colors in a space, also affects the perception of that space and emotions of people. A space can be observed small or large, the objects in a space can be perceived near or far by using color. Besides, color used in a space can change the mood of its users which can also affect how a space is perceived. For instance, a green room may be perceived to be open, tranquil and lacking cheerfulness whereas a pink room may give a cheerful impression (Stahre, Harleman & Billger, 2004).

In addition to light and color, heat, as thermal comfort and sound, as noise in a space, also have influences on the perception of a space. For instance, if the required temperature is not obtained in a space at comfort level, the vital functions of people like respiration may become difficult. As a result of this, people perceive the space cramped. It is important to obtain a temperature level considering the function of the space. Furthermore, sound plays an important role in perceiving a space because sound can orient a person in a space. If sound is the dominant factor in a space, it can retard the perception of details of a space.

2.2. Psychological Factors

In addition to the physical factors affecting the perception of a space, there are also psychological factors. Psychological and physical factors are interrelated while evaluating a space. If people are expected to describe and distinguish, in other words evaluate an architectural space, in order to do so tools are needed (Kasmar, 1992). This tool can be a scale appropriate for the space with adjectives that are descriptive of that architectural space. However, as it is stated in most of the studies there is not an available specific source of such items and most researches use the scales they created. Franz, Heyde & Bülthoff (2002) informed that in architecture, evaluating the quality of an interior space is an unsolved difficulty because of the lack of generally accepted measuring methods.

In one of these studies, in order to obtain an adjective pool for describing a space, fifty-four undergraduate students were asked to describe two rooms they liked and two rooms they disliked and they listed the adjectives they believed to be descriptive of these four rooms (Kasmar, 1992). After completing this first questionnaire, eleven fourth- and fifth- year architecture students completed a second questionnaire, which was a list of thirteen categories that were suggested by architects and designers as important in describing an architectural space (size, volume, scale, odor, acoustical quality, and miscellaneous). The students listed descriptive adjectives appropriate to each of the thirteen categories and the bipolar complements of these adjectives. Then these adjective pairs were eliminated related to their appropriateness to describe architectural space in general. Then, they were eliminated related to the appropriateness to describe specific architectural environments. Lastly, the retained sixty-six adjective pairs were used for environmental description (see Appendix D, Table D.1.) The results of this research presented a workable and meaningful lexicon of architectural descriptors that were relevant and appropriate to describe architectural spaces. Another useful set of dimensions for describing interior spaces was proposed by Cass & Hersberger (as cited in Gifford, 2002). The set consisted of three dimensions evaluating many features of interior spaces (see Appendix D, Table D.2).

As it is mentioned above, light and color play an important role in the perceived quality of interior spaces. There have been studies done on the psychological effects of light and surface color on the evaluation of a space. The pioneer of these is Flynn. Flynn and his colleagues investigated the appearance of various luminous conditions in a conference room and obtained ratings on semantic scale configurations and reduced these scales to three factors as perceptual clarity, evaluative impressions, and spaciousness by using factor analysis (Flynn, Spencer, Martyniuk, Hendrick, 1973) (see Appendix D, Table D.3). The results of the study indicated that changing only light intensity had a negligible effect on 'evaluative impressions' but the overhead diffusing systems with higher intensity was found to be most clear, brightest and distinct among the other luminous conditions. Besides, higher brightness levels produced an impression of increased 'spaciousness' in the conference room. Downlighting arrangement produced more positive 'evaluative impressions' than overhead diffusing system with the same illuminance level and also there were significant differences in the impression of 'spaciousness' between the two. Arrangement of downlights with wall lights was evaluated more positively than downlighting only. This arrangement also improved 'perceptual clarity' and significantly affected the impression of 'spaciousness'.

Later study of Flynn and his colleagues aimed to develop a research methodology for studying psychological and related subjective effects of illumination and focused on scaling procedures for studying subjective impressions (Flynn, Hendrick, Spencer, Martyniuk, 1979) (see Appendix D, Table D.4). The intention of the study was to propose a standardized series of test procedures and contribute to a common base of knowledge on the impressions of lighting in a space.

Most of the studies done on the subjective evaluation of spaces under different lightings have the inspiration from the studies of Flynn. In one of these studies, the impressions of visual comfort were evaluated with semantic-differential rating techniques using bi-polar adjective pairs promoted by Flynn (Heerwagen & Heerwagen, 1986) (see Appendix D, Table D.5). Mania (2001) divided the impressions of a space into three categories as Flynn did in one of his studies. One of them was the perceptual category including visual clarity, spaciousness, spatial complexity, color tone, and glare. The other one was the behavior setting category including public vs. private space and impressions of relaxing vs. tense. The last one was the overall preference impressions including impressions of like vs. dislike and impressions of pleasantness. Mania also used bipolar adjectives related to the impressions of lighting in a simulated 3D room and a real room (see Appendix D, Table D.6). Another study inspired by the studies of Flynn considering the effects of different lighting arrangements, found that wall washing enhanced the impressions of clarity and order in a space whereas cove lighting was the lighting system that increased the impressions of spaciousness and order and uplighting was preferred for the impressions of pleasantness, privacy, and relaxation (Manav & Yener, 1999).

In addition to the semantic scales promoted by Flynn, in one of the studies of Veitch (1997) regarding the effects of lamp type on mood and performance, the mood measure of the Russell and Mehrabian Three-Factor-Mood Scale which is a set of eighteen bipolar adjective pairs for indicating the degree of feeling of the participants, was used. Three factors were arousal, pleasure, and dominance. Moreover, on the strength of the existing literature suggesting that luminance distributions and lighting patterns affect subjective impressions of architectural interior spaces Houser, Tiller, Bernecker & Mistrick (2002) investigated the subjective response to linear fluorescent direct/indirect lighting using adjective pairs and found that the room appeared more spacious when more light was supplied indirectly (see Appendix D, Table D.7).

In a study considering the color effects, architects and non-architects made semantic differential ratings of color samples and a simulated interior space (a model) (Hogg, Goodman, Porter, Mikellides & Preddy, 1979). Five factors occured in the analyses of the total ratings of color chips and the model. These were dynamism, spatial quality, emotional tone, evaluation, and complexity (see Appendix D, Table D.8). Hogg et.al., in this study, used the bipolar adjectives of Tucker (as cited in Osgood, 1978) who used fourty adjective scales, which were derived from the free associations of both artists and non-artists observing color slides of both representational and abstract paintings (see Appendix D, Table D.9).

Gao & Xin (2006) in their study on color emotions that uses semantic differentials, divided researches about the evaluation of emotional responses to color into two broad categories: the experimental aesthetics of color dealing with evaluative dimensions of colors, such as 'comfortable vs. uncomfortable', 'good vs. bad', etc.; and the descriptive dimensions dealing with 'warm vs. cool', 'light vs. dark', etc.

In another study, the perceptual quality of a café/restaurant with yellow and violet interiors were evaluated by using a total of eight bipolar semantic differentials (Yıldırım, Akalın-Başkaya & Hidayetoğlu, 2007) (see Appendix D, Table D.10). The results of the study indicated that warm colors made a space perceived to be smaller, lower and depressing, compared to cool colors.

2.2.1. Pleasantness

Impression of pleasantness is a subjective impression evaluating whether a space appealing or not (Yücetaş, 1997). An interior space can be perceived more or less appealing depending on the lighting conditions (Reisinger, Huedo & Vogels, 2008). It can be reinforced by nonuniform lighting and peripheral wall brightness (IES, 1987). Veitch (2001) also stated that a space appears interesting or pleasant with nonuniform luminance distributions. The higher the luminance ratio at the eye height of a seated viewer, the more interesting and pleasant the space appears. Additionally, Bornstein (1975) indicated that pleasantness ratings vary with the wavelength of the light.

Furthermore, Manav & Küçükdoğu (2006) stated that according to the studies related to the illuminance level and space perception there is a significant difference between a 960 lx and 1500 lx in terms of the perception of the space. The illuminances over 1500 lx make the impression of a space unpleasant and cramped. However, Fleischer, Krueger, & Schierz (2001) stated that higher illuminance levels make a room more pleasing.

Ou, Luo, Woodcock & Wright (2004) in their study considering the color-emotions conducted a psychophysical experiment related to color emotions for colors and used ten bipolar color-emotion scales as warm-cool, heavy-light, modern-classical, clean-dirty, active-passive, hard-soft, tense-relaxed, fresh-stale, masculine-feminine and like-dislike. Each observer associated the colors presented with one of the words in each adjective pair. It was indicated that Chinese observers like the colors that are clean, fresh or modern whereas British observers like cool colors which is a result obtained from the three-dimensional factor plots established from the extraction data.

Pleasantness and liking affects the preferences of people (Norman & Scott, 1952). Considering the affective values of colored lights in a space, Walton & Morrison (1931) found out that the saturated single colors of light are preferred following the preference order of blue, green, red, amber (yellow) and clear (white) lights. The results changes when the intensities of the lights are equated. In this condition, red light becomes the most preferred one which shows that lowering the intensity of red light makes it more pleasing. There is also a difference between the preferences of men and women. The preference order of the men is blue, red, green, amber and clear whereas the order of women is green, red, blue, amber and clear lights.

Additionally, Lewinski (1938) examined the reactions of people to different chromatic illuminations of a room. The results of the study indicated that blue and green lights are found to be the most pleasant whereas orange and yellow lights are found to be the most unpleasant in the room.

2.2.2. Aesthetics

Impression of aesthetics is a subjective impression evaluating whether a space is beautiful, distinctive, tasteful and stylish or not. Light and color in a space can change the aesthetic evaluation of a space. Veitch (2001) stated that aesthetic judgments are related to the interpretation and categorization of what people see.

Additionally, aesthetic judgments are also related to the appearance of space. There are not any studies found on the aesthetic perception of a space considering light and color in that space.

2.2.3. Use

Impression of use is a subjective impression evaluating whether a space is for public or private use, or whether a space is useful, functional, efficient or not. Impression of privacy as it is mentioned in IES Lighting Handbook is in the content of use of a space. Impression of privacy can be reinforced by low light levels, nonuniform lighting and peripheral wall brightness (IES, 1987).

Nakamura & Karasawa (1999) also stated that there was the tendency that high illuminance was preferred in a space for public use and low illuminance was preferred in a space for private use. A calm and restful atmosphere was needed for privacy and a warm and intimate place could be obtained by using a lighting at low color temperature and low illuminance.

2.2.4. Comfort

Impression of comfort is a subjective impression evaluating whether a space is comfortable. Evaluation of comfort considering the lighting in a space is based on the following factors influencing the subjective judgments of visual comfort such as room size and shape, room surface reflectances, illuminance level, lamp type, number and location of lamps, luminance, light distribution, and differences in individual glare sensitivity (IES, 1987).

Lighting is one of the factors that are affecting the comfort in a space. Fleischer, et.al. (2001) stated that according to the results of the study done with the workers of an office, warm light sources and at low illuminance levels make people feel comfortable and when the illuminance level increases the pleasantness increases and the space is found comfortable. Among the scenarios created with 4000°K color temperature, the scenario with 500 lx illuminance is preferred but the space is found to be uncomfortable (Manav & Küçükdoğu, 2006).

As it is seen, the change in color temperature and illumination level affects the visual appeal of a space. For the impressions of comfort, spaciousness, and brightness in a space, an illumination level of 2000 lx is preferred to 500lx (Manav, 2007). For impressions of comfort and spaciousness, a 4000K color temperature is preferred to 2700K (Manav, 2007).

2.2.5. Spaciousness

Impression of spaciousness is a subjective impression evaluating whether a space is spacious or not. It can be reinforced by higher luminance on the horizontal plane and uniform, peripheral (wall) lighting (IES, 1987). According to İmamoğlu (1975), spaciousness of a room is related to size, but a large room is not expected to be a spacious one, or vice versa and a room can be spacious if it is appealing, well planned and have space freedom. Solid surfaces around a space make the space look restricted and low brightness levels also make the space look restricted.

Kirschbaum & Tonello (1997) reported that the variance in judgments of spaciousness can be based on the amount of light in the space. As it is seen, there is a relationship between light level and spaciousness. Stamps (2007) stated that when the luminance level is increased in a space the perceived spaciousness also increases. Therefore, designers can make a room appear larger or smaller by changing the level of light in that space.

On the other hand, Aksugür (as cited in Manav & Küçükdoğu, 2006) stated that a space was found to be more spacious under 5000°K color temperature fluorescent lamps than it was under 2700°K color temperature halogen lamps. This indicates that the change in color temperature doesn't change the impression of spaciousness of a space.

Spaciousness, considering the use of color in a space, can be increased by using cool, desaturated and light colors (Franz, 2006). However, spaciousness of a space can be decreased by using dark, saturated and warm colors. Parallel with this, in applied color design it is recommended to use saturated dark colors only in large rooms (Franz, 2006).

2.2.6. Lighting Quality

Impression of light is a subjective impression evaluating whether the space is perceived light, bright and clear or not and whether the lighting in the space is good or not. Impression of perceptual clarity as a content of light is an important factor to be considered in the design of spaces and can be reinforced by higher luminance on the horizontal plane, peripheral wall emphasis, e.g. wall washing and cool, continuous spectrum light sources (IES, 1987). In order to obtain clarity in a space general lighting and wall washing are preferred to cove lighting (Durak, et.al., 2007).

Kanaya (as cited in Manav & Küçükdoğu, 2006) stated in the results of the study measuring the relation between space perception and color temperature, color rendering index and illuminance level indicated that perception of brightness in a space is reinforced with color rendering index but not with color temperature. Bornstein (1975) indicated that light from sources that are in equal wattage are perceived the brightest for wavelengths between 550 and 560nm which corresponds to yellow-green. The perception of the brightness decreases dramatically toward violet and red.

3. COLOR AND LIGHT

Light is an energy that makes people see objects and distinguish colors. People cannot see and the world cannot be perceived without light. Light makes people perceive the world and affects how they perceive their environments; therefore, it is an important factor in architecture. According to Lam (1992), light is one of the most powerful form givers in design which puts men in touch with their environments and great architects and designers have always understood the importance of it. For instance, Le Corbusier (1923/1987, p.29) stated that “Architecture is the masterly, correct and magnificent play of masses brought together in light”.

Either natural or artificial, light influence the perception of an environment. Light in a space, affects its users both physiologically and psychologically. Heerwagen & Heerwagen (1986) indicated that light affects physiological functioning, as well as it affects the mood, energy, and behavior of people. Knez (2001) stated that light influences nonvisual psychological processes. Light makes people not only see the physical qualities of a space but also add meaning and emotion to the space.

Perceptions of the luminous environment always include an evaluation or emotional response to the perceived state of affairs and evaluation of a space depends on the value of meeting the expectations (Lam, 1992). It can be said that judgment of whether a space is light or dark, does not depend on the actual luminance levels in that space. It depends on whether the luminosity in this space meets the expectations of a person and satisfies the needs of that person. The evaluation of the privacy of a space is also affected by the expectation, visual order and appropriateness of the hierarchy of focus in the luminous environment in that space. Private spaces are perceived as cozy but they don't need to be dark (Lam, 1992).

Different lighting compositions can be obtained in a space with various lights and lighting arrangements and each composition affects the users differently. Different lighting environments (illuminance levels, spectral distribution, temporal patterns, etc.) in interior spaces affect people in various ways. For example, Belcher & Kluczny (as cited in Küller, Ballal, Laike, Mikellides & Tonello, 2006) found out that the mood of women shifts negatively in bright environments whereas men respond in the opposite direction. The users perceive a space differently related to the changes in lighting conditions in a space, although they know that they are in the same space. Therefore, it is possible to change the perception of the users of a space by changing the lighting conditions including the quality and quantity of light.

Considering the quality and quantity of light, Manav and Küçükdoğu (2006) found out that both the changes in illuminance level and color temperature affect space evaluation. The change in illuminance level also affects the psychological comfort. Biner and Butler (1989) supposed that lighting levels affect arousal which is a measure of how an environment stimulates perception of people. Color temperature affects the emotional responses of people, as well as it affects space evaluation. Knez (1995) stated that females react more positively to the warm white lighting than males related to their emotional responses to color of light. This indicates that the color of light has different emotional effects in gender.

Moreover, the brightness of light influences the size of a space (Birren, 1988). For the brightness of a room the amount of light in the room is evaluated. The most obvious lighting variable determining the perception of room brightness is the illuminance on the working plane. Luminance, light distribution, and light spectrum also influence the perception of room brightness to a significant extent (IESNA, 2000). According to Tiller & Veitch (1995), the apparent brightness of a room depends not only on the amount of light falling on the horizontal surfaces in the space but also depends on light source color and lamp color rendering.

As it is stated above, illuminance level, color temperature, and brightness of a light source influence the emotional responses to a space and evaluation of that space. By changing these properties of light, a space can be shaped for different uses. All spaces are designed and lighted for satisfying specific needs and for different uses. A good luminous environment is expected to be comfortable, pleasant and appropriate for the purposed uses of that environment. For Lam (1992), the most comfortable and pleasant spaces are those in which the designers and users can have a control over the layout and fine tuning of the lighting and a comfortable, pleasant luminous environment satisfies the visual needs of the users automatically.

Color, is another important factor that identifies the atmosphere of a space and affects the psychology of users. In addition to light, color, also influences perception and behavior. According to Smith (2008), color is integral to how we understand a space and cannot be isolated from other environmental aspects such as texture, pattern, and form. The relationship between color and behavior, especially emotional responses to color, is very rich and complex. Nakshian (1964) mentioned that red and the other warm colors such as orange and yellow have arousing or exciting effects on behavior whereas blue and green have a restful effect.

3.1. Basic Terms

It is necessary to understand the basic terminology of color and light for discussing them. Illuminance, luminance, color chromaticity are the three main terms that requires explanation in this study. Additionally, brightness, color rendering and color temperature terms are also explained.

Illuminance, as it is defined in IESNA Lighting Handbook (2000), is the density of the luminous flux, the perceived power of light, incident at a point on a surface. In other words, it is the measure of the intensity of the light incident on a surface. Illuminance is measured both in lux (lx) or footcandle (fc). In order to measure illuminance, an instrument called illuminance meter is used. On the other hand, **luminance** describes the amount of light that is emitted from a particular area. Luminance is measured with an instrument called luminance meter and the unit for luminance is candela per square meter (cd/m^2).

Chromaticity of a color is the dominant or complementary wavelength and purity aspects of the color taken together, or it is the aspects specified by the chromaticity coordinates of the color taken together (IESNA, 2000). The chromaticity coordinates of a color x, y, z are the ratios of each of the tristimulus values of a color to the sum of them. The tristimulus values of a color are the values used to match a color against the three primary colors red, green and blue which are represented as x, y, z. In order to show the chromaticity coordinates of a color chromaticity diagram is used which is a plane diagram formed by plotting one of the chromaticity coordinates against other (IESNA, 2000). CIE standard chromaticity diagram is a diagram in which the x and y chromaticity coordinates are plotted in rectangular coordinates (see Figure 3.1).

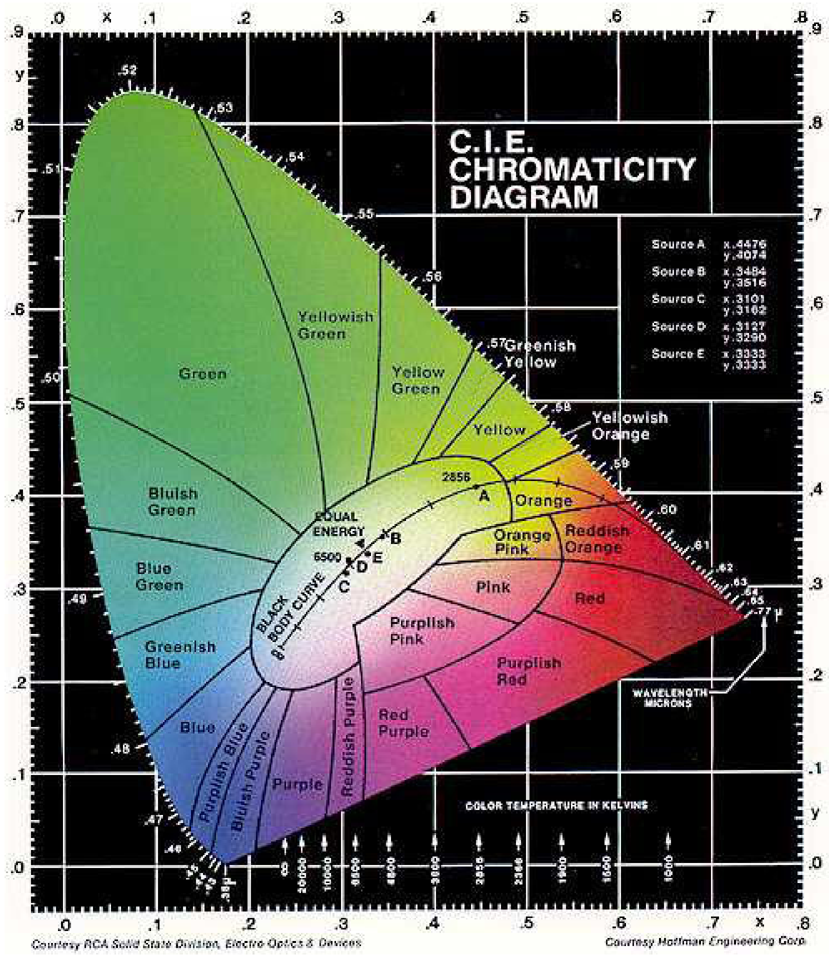

Figure 3.1. CIE standard chromaticity diagram

From www.rfcafe.com/references /general/color-chart.htm

Brightness is the subjective visual sensation to the intensity of light and brightness of a perceived light source is the property that is related with illuminance. In other words, brightness is in accordance with the level of luminous flux that is emitted from the light source.

Color rendering is the general expression for the effect of a light source on the color appearance of objects (IESNA, 2000). The **color rendering index** (CRI) is the "measure of how well light sources render color" (Egan & Olgyay, 2002, p.79). A CRI of 100 is considered as best (Flynn, Segil & Steffy, 1988).

Finally, **color temperature** of a light source is the temperature of a blackbody radiator that has a chromaticity equal to the chromaticity of the light source. The color produced by lamps when they are energized, is classified as 'white' ranging from a very cool white to a very warm white (Flynn, et.al. 1988). This color of light is called as color temperature which is measured in degrees Kelvin.

3.2. Light Sources for Color

Color of light depends on its wavelength. It is possible to obtain different colors with light sources. Luckiesh & Taylor (1924) at beginning of the 20th century, indicated three general methods for producing colored light which are colored glass bulbs, colored accessories, glass, gelatine, etc., and superficial colorings. There were a limited range of colors available for colored-glass bulbs and they were very expensive. Therefore, they were not preferable. There were also colored glasses available for incandescent lamps to produce colored light (Luckiesh & Taylor, 1924). In addition, there were colored-glass caps in various sizes and color which have spring clips holding them on the lamp bulbs and there were colored glass globes with a number of types of holders adapting them for use with reflectors. Moreover, there were colored gelatins, in other words gelatine color filters, of various tints and pure colors which were satisfactory for temporary installations.

Today, there are many more methods and various light sources for obtaining colored light. Colored incandescent lamps, colored halogen lamps, colored fluorescent lamps, neon lamps, colored metal halide lamps, light emitting diodes (LEDs) and lasers are the light sources for obtaining color. In addition to these light sources, fiber optics and filters can also be used for producing colored light. The following sections explain what these sources are and how they work.

3.2.1. Colored Incandescent Lamps and Colored Halogen Lamps

Incandescent filament and tungsten-halogen lamps are similar in terms of their construction and principle of operation but a tungsten-halogen lamp has longer life, higher color temperature, higher efficacy than incandescent lamp because of the halogen regenerative cycle (IESNA, 2000) (see Figure 3.2).

Colored incandescent lamps are available with inside and outside-spray-coated, outside-ceramic, transparent-plastic-coated, and natural-colored bulbs (IESNA, 2000). Outside-spray-coated lamps are used indoors generally and not exposed to weather because their surfaces collect dirt and are not cleaned easily. On the other hand, inside-coated bulbs have smooth surfaces that are easily cleaned. The colored pigments fused on the glass of ceramic-coated-bulbs provide a stable finish.

Ceramic-coated bulbs and most transparent-plastic-coated bulbs are suitable for indoor and outdoor use. Natural-colored bulbs are made of colored glass.

Colored Halogen Lamps

Colored Incandescent Lamps

Figure 3.2. Colored halogen and colored incandescent lamps

From http://catalog.myosram.com/ and http://www.lightbulbsdirect.com/page/001/CTGY/HalColor

Tungsten-halogen lamps are incandescent lamps which have a halogen gas inside the bulb. These lamps require special glass enclosures, usually quartz, because they operate at very high temperatures (Egan & Olgyay, 2002). Various colors can be obtained by using colored halogen lamps such as red, blue, green, yellow, amber and pink.

3.2.2. Colored Fluorescent Lamps

The fluorescent lamp is a low-pressure gas discharge source, in which light is produced by fluorescent powders activated by UV energy that is produced by mercury arc (IESNA, 2000). The lamp contains mercury vapor at low pressure with a small amount of inert gas for starting and the inner walls of the bulb are coated with fluorescent powders commonly called phosphors. An arc is produced by current flowing between the electrodes through the mercury vapor after the application of proper voltage. This discharge produces some visible radiation at 254, 313, 365, 405, 436, 546, and 578nm (IESNA, 2000). Fluorescent lamps need ballast for limiting the current to the value appropriate for each lamp, providing the required starting and operating lamp voltages and dimming controls.

Figure 3.3. Fluorescent tube

From http://catalog.myosram.com/

Fluorescent lamps are usually in the form of a long tubular bulb with an electrode sealed into each end (see Figure 3.3). The blend of phosphors, which is used to coat the wall of the tube, determines the color of the light generated by a fluorescent lamp. Many different white and colored fluorescent lamps are available. For an example of colored fluorescent lighting see Figure 3.4.

Figure 3.4. Colored fluorescent lighting in the installation of Dan Flavin

From http://famousinstallations.wordpress.com/2008/09/23/

3.2.3. Neon Lamps

Neon lamps are cold cathode lamps which do not have a phosphor coating different than fluorescent lamps (IESNA, 2000). The color of the neon lamps is determined primarily by the fill gas. When it is filled with neon gas the lamp emits red and with argon mixed with mercury vapor the lamp emits blue. These and other fill gases create additional colors when combined with colored glass. For an example of neon lighting see Figure 3.5.

Figure 3.5. Neon lighting

From http://www.starceiling123.com/index.php?/LED-Flexible-Neon/View-all-products.html

3.2.4. Colored Metal Halide Lamps

Metal halide lamps belong to high-intensity discharge lamps and all high-intensity discharge lamps produce light by an electrical arc discharge in an arc tube inside the bulb (IESNA, 2000) (see Figure 3.6). Metal halide lamps produce light related to the type of metal that is contained in the arc. Desired spectrum is obtained by using blends of metal halides. Scandium and sodium iodides, and dysprosium, holmium, and thulium rare-earth iodides are the two typical combinations of halides (IESNA, 2000). The scandium-sodium system can produce color temperatures from 2500 to 5000K by varying the blend ratio. Selected colors also can be produced by using single elements in the arc tube: sodium for orange, thallium for green, and indium for blue.

Figure 3.6. Colored metal halide lamp (available in blue, green, and red)

From http://catalog.myosram.com/

3.2.5. Light Emitting Diodes (LEDs)

A Light Emitting Diode (LED) is a semiconductor device which converts electricity to light. The wavelength of the light depends on the semiconductor material. Shur & Zukauskas (2005) stated that due to the characteristics of radiative recombination in semiconductors and holes in the active layers of structures of semiconductors, LEDs emit light within narrow-band spectra, therefore, "LEDs are inherently colored sources of light" (p.1693).

There are two types of LEDs described in IESNA Lighting Handbook (2000) which are AllnGaP (aluminum indium gallium phosphide) and InGaN (indium gallium nitride) LEDs. AllnGaP LEDs produce the colors red (626 to 630nm), red-orange (615 to 621nm), orange (605nm), and amber (590 to 592nm). InGaN LEDs produce the colors green (525nm), blue green (498 to 505nm), and blue (470nm). White light can also be obtained with LEDs by both mixing red, green, and blue LEDs in the right proportions or by combining blue LEDs with yellow phosphorus (Schubert, 2003). By using LEDs red, green, blue, and white and variations of these colors can be obtained. In addition to their applications in traffic signals, signage/contour lighting, large area displays and automotive, LEDs are also used for general lighting.

Figure 3.7. LED lighting systems

From http://www.prismaecat.lighting.philips.com

There are four types of LED lighting system which are LED string system, LED strip system, LED module system and LED spots (see Figure 3.7). They are attractive for general lighting because of their high efficacy, long life, low voltage, and small size and because they are also easy to dim and control. For an example of LED lighting see Figure 3.8.

Figure 3.8. LED lighting in Rockefeller, New York

From http://www.mediaarchitecture.org/2006/

3.2.6. Lasers

A laser, a device concentrating light waves on an intense, low-divergence beam, is a complete lighting system consisting of three main parts which are the laser tube (a gas-filled tube that emits the light), the projector that controls the beam, and the computer hard-ware and software that stores and controls the performance (IESNA, 2000). The laser tube filled with argon lasers emit light in the blue-green range whereas krypton lasers emit red light. The concentrated energy in the low-divergence beam of lasers can cause retinal damage if projected directly into the eye. For an example of laser lighting see Figure 3.9.

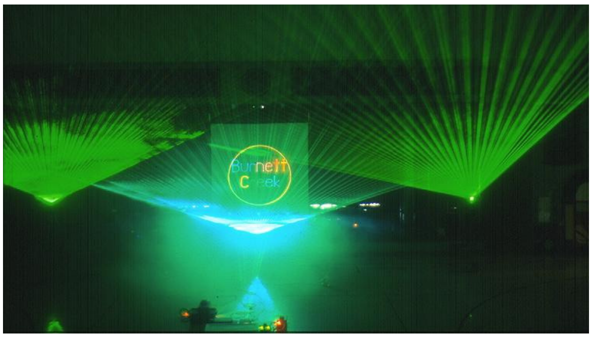

Figure 3.9. Blue and green laser beams

From http://www.jklasers.com/

3.2.7. Fiber Optics

Fiber optic is a transparent material along which light can be transmitted. A simple fiber optic system consists of a light source and an optic fiber (Crisp & Elliott, 2005) (see Figure 3.10). Optionally, lighting fixtures can also be used. In this system, the light source is placed away from the illuminated point. Therefore, it doesn't carry heat and it is cool. The light is carried by the fiber optics cables. There are two types of cables which makes two types of lighting. In the side glow fiber optic cables the light comes out along the cable. In end glow fiber optic cables, the light comes out only from the end points of the cables.

Figure 3.10. Light source, fiber optic cables, fixtures

From http://news.cnet.com/2300-1008_3-6111109-1.html

Among halogen-based, LED based and metal-halide fiber optic illuminator, LED-based fiber optic illuminators are the most popular in use. When red, green and blue diodes are combined in the same array millions of different output colors can be obtained. For an example of fiber optics lighting see Figure 3.11.

Figure 3.11. Fiber optics in a cabinet

From http://www.trinorthlighting.com/Residential%20Interior%20Lighting.htm

3.2.8. Filters

Spectral elements of white light emitted from a light source are selectively transmitted or blocked (absorbed) by color filters (Rosco, n.d.). For instance, red light is obtained by using a red filter. Red light frequencies pass through the red filter and blue and green light frequencies are absorbed. The largest part of the blocked radiant energy is absorbed as heat by the filter and heat can cause degradation in the filter. Therefore, heat stability is an important consideration when filters are used. Gelatin filters and plastic filters, as conventional filters, functions this way. However, a dichroic color filter works differently than the conventional filters. Dichroic filters reflect the unwanted portions of the spectrum and the appropriate colored light pass through the filter and have more benefits than plastic filters (Rosco, n.d.). They can resist high temperature lighting units without fading or degrading and the color of light obtained by using these filters is very pure and saturated. For dichroic filters see Figure 3.12.

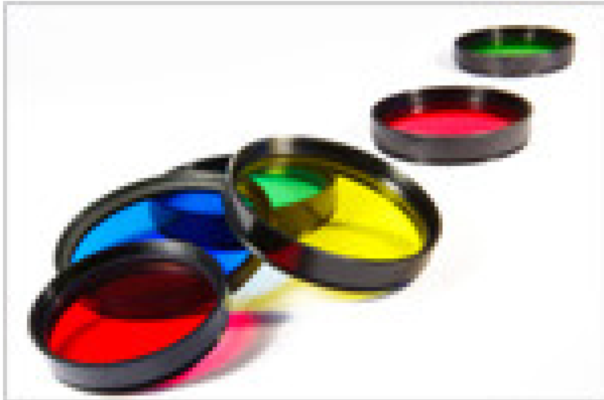

Figure 3.12. Dichroic filters

From http://www.visimaxtechnologies.com/dichroic-bandpass-filters.htm

3.3. Use of Colored Light in Interior Spaces

The life styles and related to this the design of spaces are changing with the developing technology. People started to spend most of their times in spaces illuminated with artificial lighting. The most distinctive improvement in lighting is the freedom that artificial light brings to architecture. Architects and designers can control interior and exterior spaces effectively and can make spaces perceived differently by changing the effects of light. New technologies in lighting offer various sources for different colors in lighting and the use of colored lighting increases. Colored lighting is started to be used everywhere including both interior and exterior spaces. The facades of buildings, landscape elements are all started to be illuminated with colored lights (see Figure 3.13).

Figure 3.13. Colored lighting of the facade of Lumiere, Paris

From www.lightingdesigninternational.com

Generally colored lights are expected to be used in bars among interior spaces. The following is an example of colored lights used in a bar in Belgium (see Figure 3.14).

Figure 3.14. Colored lighting in Bar Rubens, Belgium

From www.leddesigninnovation.com

Colored lights are also used in spas. The following example is the spa area of Seaham Hall Hotel (see Figure 3.15).

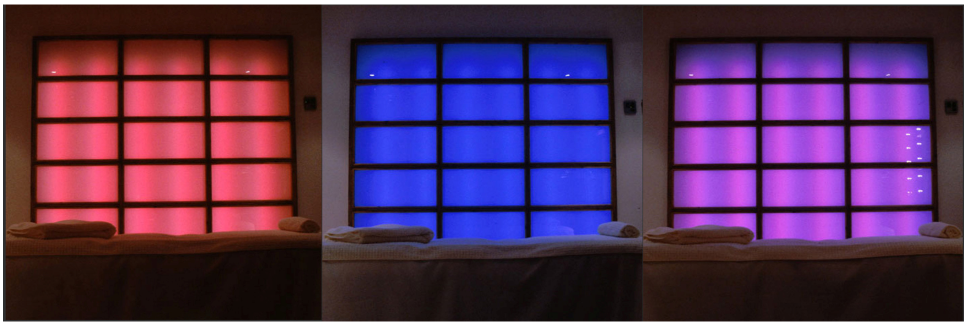

Figure 3.15. Colored lighting in Serenity Spa in Seaham Hall Hotel, England

From www.lightingdesigninternational.com

Restaurants are also started to be illuminated with colored lights. The following example is the restaurant of Hotel Sofitel Rio de Janeiro in Brazil in which different colored lights are used (see Figure 3.16).

Figure 3.16. Colored lighting in Hotel Sofitel Rio de Janeiro Restaurant- Brazil

From www.leddesigninnovation.com

Colored lights are used in various parts of hotels. The followings are examples of colored lights used in the rooms and in the corridors of Hotel Mercure Etoile in France (see Figures 3.17, 3.18 and 3.19).

Figure 3.17. Colored lighting in Hotel Mercure Etoile, France

From www.leddesigninnovation.com

Figure 3.18. Colored lighting in Hotel Mercure Etoile, France

From www.leddesigninnovation.com

Figure 3.19. Colored lighting in Hotel Mercure Etoile, France

From www.leddesigninnovation.com

Additionally, colored lights also entered private houses and offices. People start to use colored lights in their living rooms or in their offices. The followings are examples of colored light used in a living room of a private house in Belgium and a head office in London (see Figures 3.20 and 3.21).

Figure 3.20. Colored lighting in private living room, Belgium

From www.leddesigninnovation.com

Figure 3.21. Colored lighting in Morgan Sindall Head Office, London

From www.lightingdesigninternational.com

To sum up, as a result of the developing technology there are variety of lamp sources for obtaining colored lights and colored lightings are started to be used in both exterior and interior spaces. This increase in use of colored lights and the diversity of the places, in which the colored lights are used, should be considered while designing both interior and exterior spaces.

4. THE EXPERIMENT

4.1. Aim of the Study

The aim of this study is to understand the effects of colored lighting on the perception of interior spaces. It is important to understand the effects of colored lighting on interior space perception as designing interiors with colored light is in demand. The study also aims to investigate the effect of gender on space perception with colored lights.

4.1.1. Research Questions

The research questions of the study are as follows:

1. Are there any differences between different colored lightings in the perception of interior space?
2. Are there any differences between white and colored lightings in the perception of interior space?
3. Are there any gender differences in the perception of interior spaces under different colored and white lightings?
4. Are there any differences between colored lightings in terms of the places they are associated to be used?

4.1.2. Hypotheses

The hypotheses of the study are as follows:

1. There are differences between different colored lightings in the perception of interior space.

2. There are differences between white and colored lightings in the perception of interior space.

3. There are gender differences in the perception of interior space under different colored and white lighting.

4. There are differences between colored lightings in terms of the places they are associated to be used.

4.2. Method of the study

The method of the study is explained under the following sections: sample group, experiment room and procedure. Detailed information is given about the experiment considering the participants, the experiment room and how the experiment is conducted.

4.2.1. Sample Group

The sample group was ninety-seven students from Bilkent University in Ankara, Turkey. The majority of the participants were from the Department of Interior Architecture and Environmental Design (94%) (see Appendix A1, Table A1.1). The experiment did not concentrate on the effects of age. The mean of ages of the participants was 21.36 and they were mostly in their second year (see Appendix A1, Table A1.2 and Table A1.3). As it was important to eliminate the effect of psychological and inter-personal differences, the experiment was conducted with the same sample group, which consisted of fifty-nine females and thirty-eight males, for three different lightings (see Table 4.1).

Table 4.1. Gender and number of the participants

	GENDER		
	Female	**Male**	**Total**
Red light	59	38	97
Green light	59	38	97
White light	59	38	97

4.2.2. Experiment Room

The experiment was conducted in the building science laboratory of the Department of Interior Architecture and Environmental Design, at Bilkent University. The room has no windows and no heating units. The measures of the room are 4.10 X 4.18m, which makes 17.138m^2 and ceiling height is 3.84m. All the walls and the ceiling are painted in matte white and the floor is covered with 30X30cm terrazzo tiles.

The room has three lighting types previously installed which are wall washing, cove lighting and spotlights. Cove lighting and wall washing are installed on the two walls facing each other that are 4.10m apart, 60 cm below the ceiling, with dimmable electronic ballasts required for dimming fluorescent lamps (see Figure 4.1).

The main reason for choosing this room for the experiment is that there are no windows in the room and no daylight can penetrate inside. So the changes in the atmosphere related with the used artificial lighting could be evaluated easily and reliably.

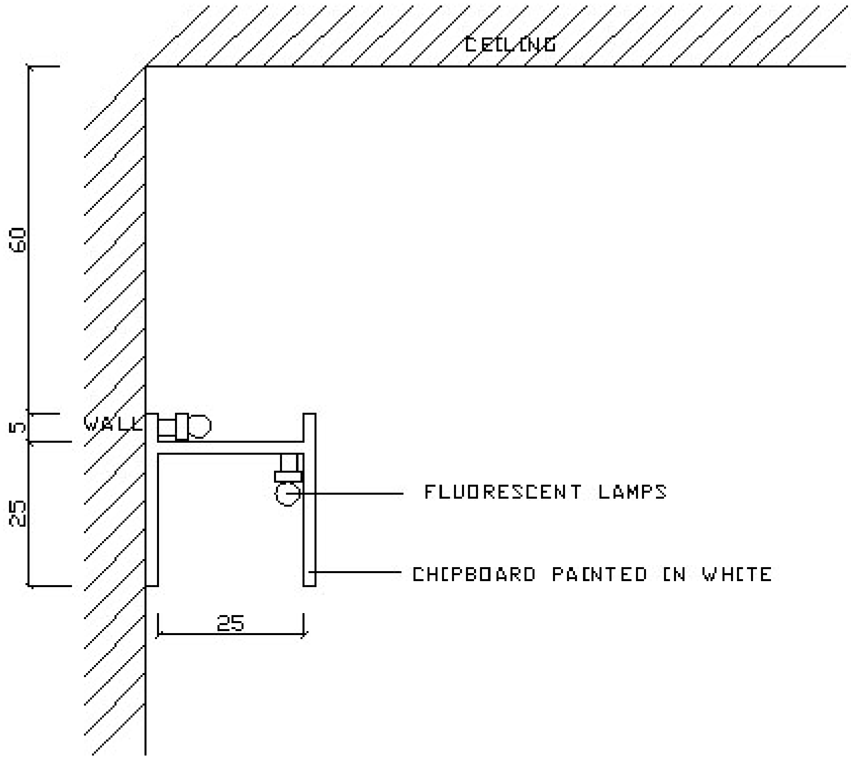

Figure 4.1. Wall washing installation dimensions

The arrangement of the room was changed for the purposes of the study. The room was used empty and only one chair and one lamp for task lighting were used in the room for the experiment (see Figure 4.2). Two storage units which are used to keep important equipment could not be moved out from the experiment room. So they were placed behind the chair where the participants sat and evaluated the room.

Fluorescent lamps were used for the experiment and the walls were washed with red, green and white lights. For white lighting, six PHILIPS, TLD36/54 fluorescent lamps were used that have a color temperature value of 6200K, and their color rendering index was 72. For colored lighting, six OSRAM, L36W/60 (red) and six OSRAM, L36W/66 (green) colored fluorescents were used. In addition to these, OSRAM, DSTAR TW 24W/865 compact fluorescent lamp, which has a color temperature value of 6500K, was installed to the existing torchere in the room in order to be used for task lighting.

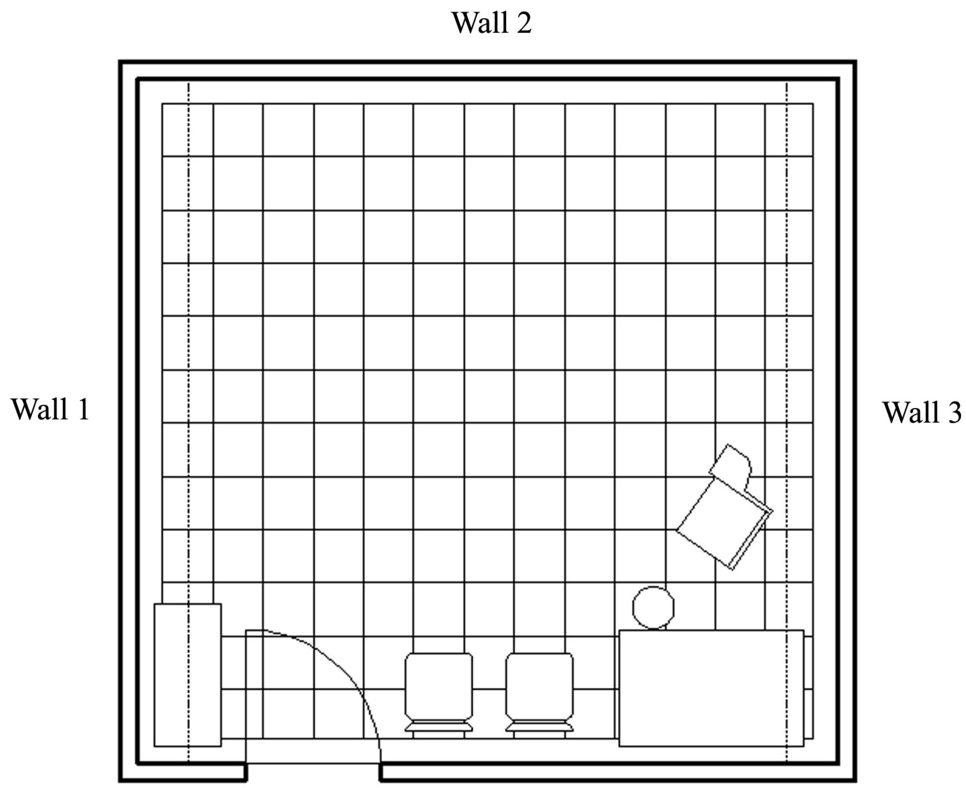

Figure 4.2. Plan of the experiment room

The chromas of the fluorescent lamps used for wall washing were measured with Minolta Chroma Meter CS-100 and the chromaticity coordinates of the lamps were obtained. The black dots in the diagrams show the chromaticity coordinates of the lamps (see Figures 4.3, 4.4, 4.5). The illuminance on the surface of the armband of the chair where the participants filled the questionnaire was fixed to 323 lux for all lightings, which is acceptable for reading tasks (IESNA, 2000) (see Appendix A2, Figure A2.1, A2.2). The illuminance levels on the floor and at eye level were equal or proximate. In order to provide these equal or proximate illuminance levels on the surface of the armband, on the floor and at eye level, the lamps were dimmed by using OSRAM, HF 1x36/230-240 DIM, dimmable electronic ballasts.

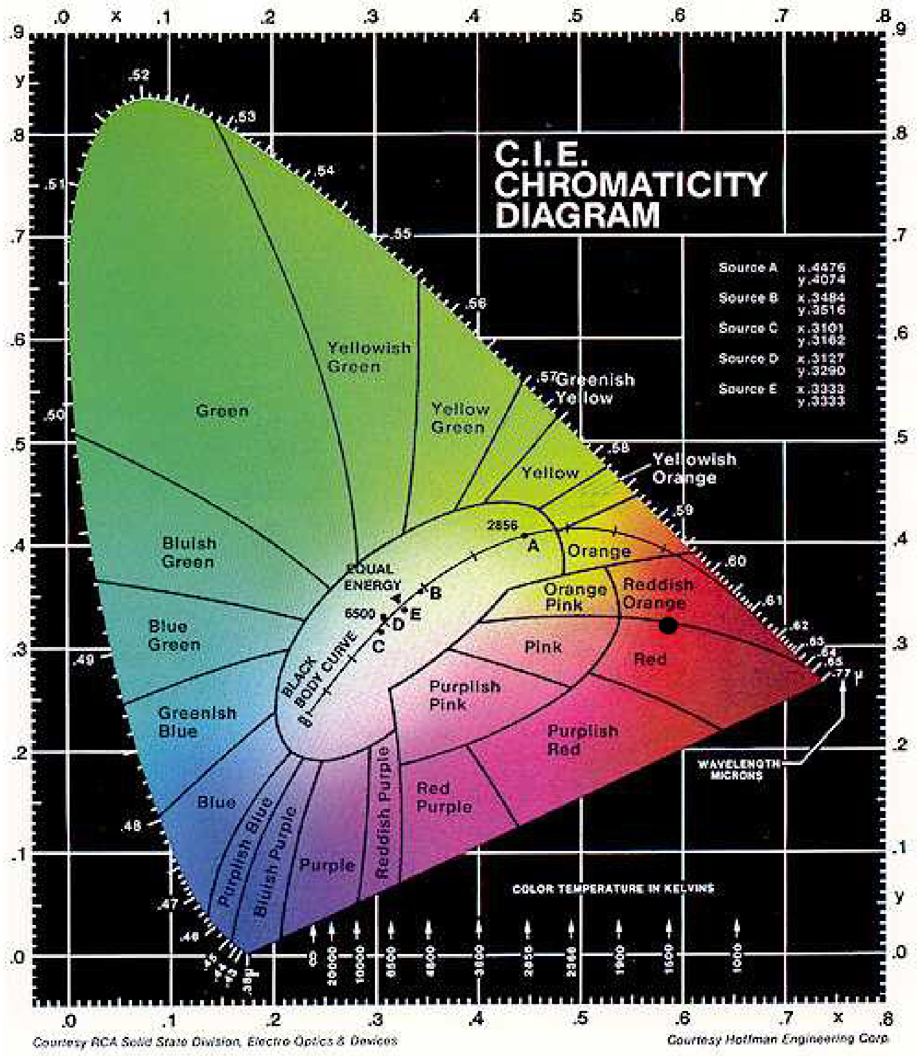

Figure 4.3. Chromaticity coordinate of red light (x → .595, y → .335)

From www.rfcafe.com/references /general/color-chart.htm

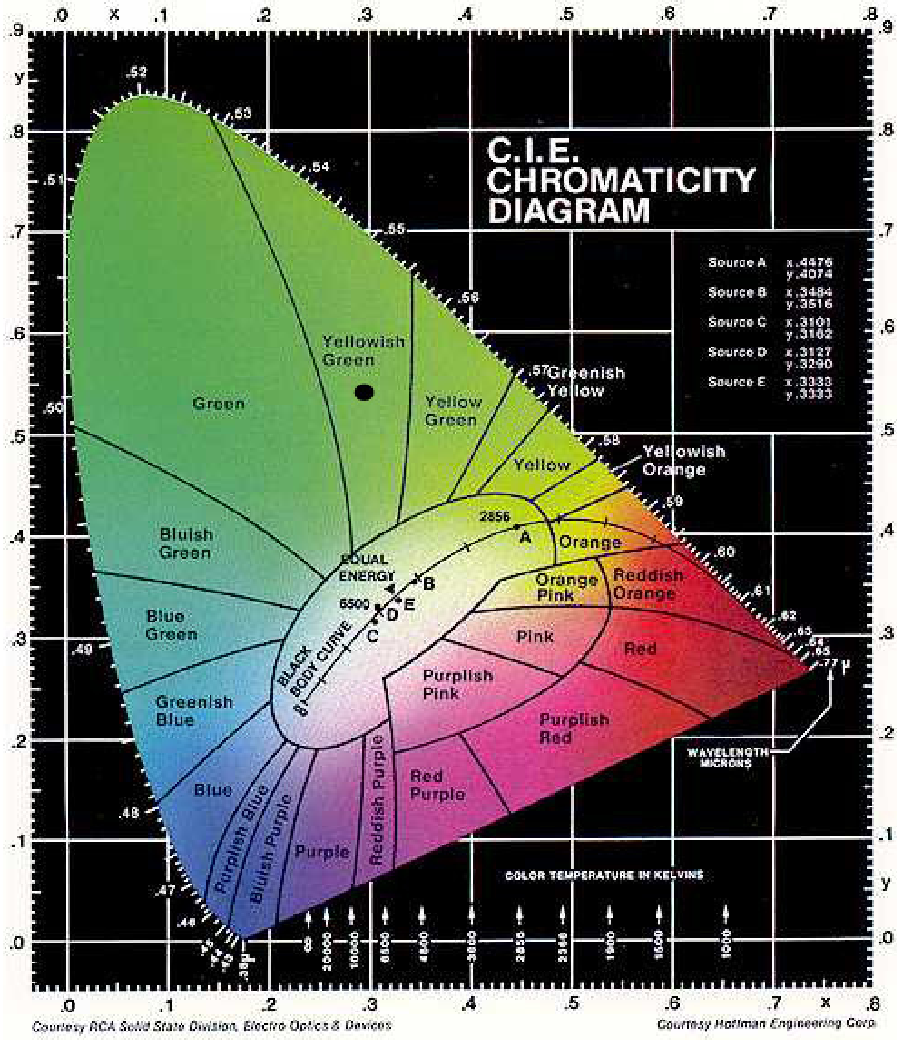

Figure 4.4. Chromaticity coordinate of green light (x → .313, y → .547)

From www.rfcafe.com/references /general/color-chart.htm

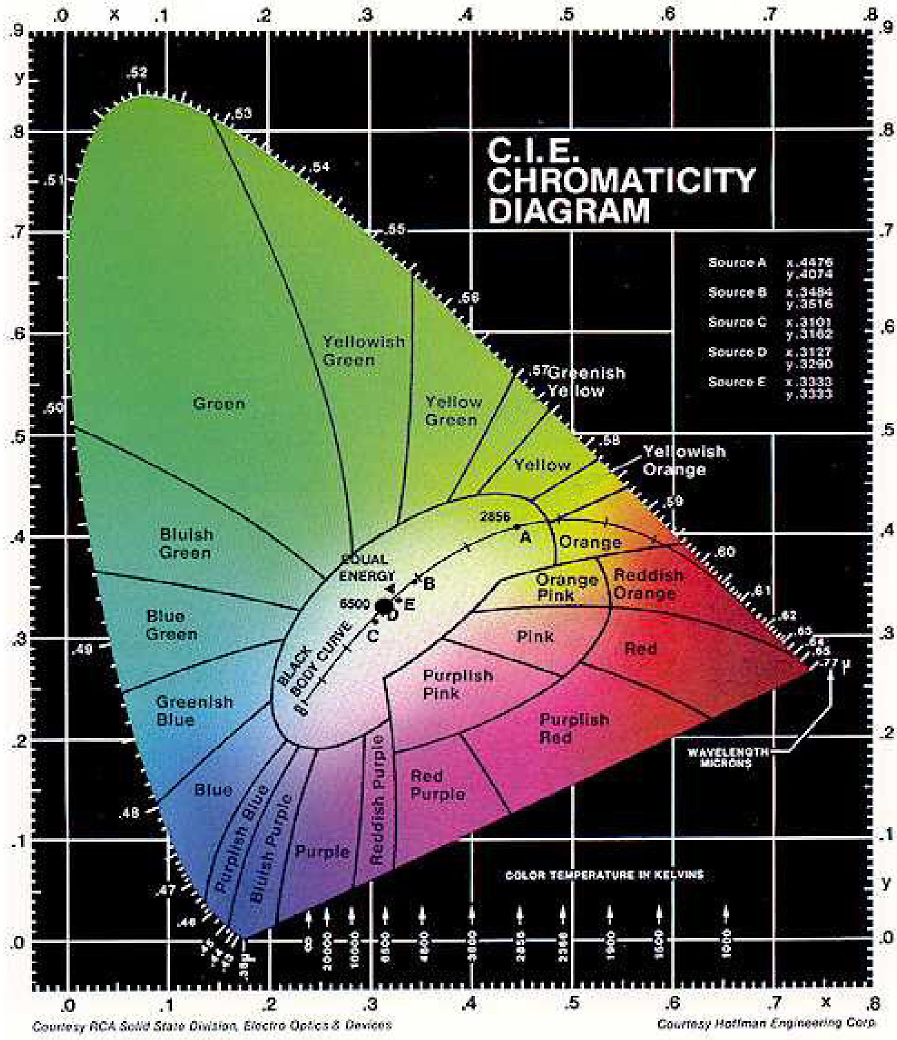

Figure 4.5. Chromaticity coordinate of white light (x → .328, y → .348)

From www.rfcafe.com/references /general/color-chart.htm

Different types of sources are available for colored lighting in the market. The reason for choosing colored fluorescent lamps is that they are cheap and easy to install and dim with the existing system in the room. The reason for using white fluorescent lamps is that they are used broadly and have a color temperature value which is close to daylight. Therefore, white fluorescent lamps were used in order to understand the role of colored lighting in the perception.

For the views of the experiment room illuminated with three lightings see Figures 4.6, 4.7, 4.8, and see Appendix B, Figures B.1, B.2, B.3, B.4, B.5, B.6, B.7, B.8, B.9, B.10, B.11, B.12).

Figure 4.6. View of the experiment room under red lighting

Figure 4.7. View of the experiment room under green lighting

Figure 4.8. View of the experiment room under white lighting

4.2.3. Procedure

The procedure followed in the study is explained in the following sections as: adjustment of the lights, preparation of the questionnaire, planning of the experiment, and phases of the experiment.

4.2.3.1. Adjustment of the Lights

When the colored lamps were attached, first the illuminance levels on the floor were measured by using Minolta Illuminance meter. The illuminance level was higher under green lighting than it was under red lighting. In order to eliminate the effects of illuminance differences on the perception, the lamps were dimmed until proximate illuminance levels were measured. After dimming, the measurements were taken both on the floor and at eye level from the center points of the grid prepared (see Figure 4.9, Figure 4.10, Figure 4.11 and Appendix C, Figures C.1, C.2, C.3). The wall surface luminances of the experiment room were measured with Minolta LS-100 luminance meter from the center point and 20 cm away from the corners of the walls. Mean values of the measurement were obtained for each wall and they were at proximate levels (see Table 4.2).

Both illuminance and luminance measurements were taken from the area that the participants could see from the chair they sit on.

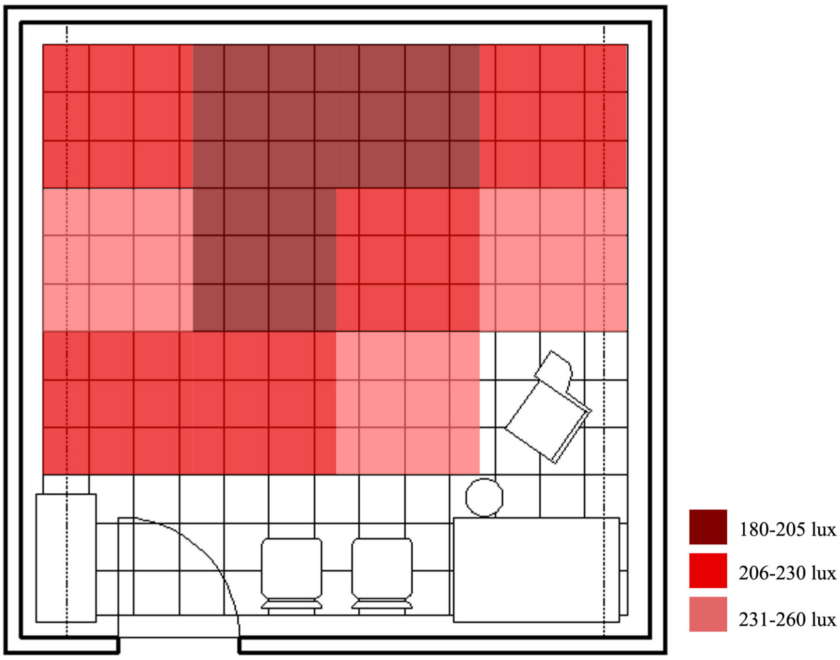

Figure 4.9. Illuminance map of the experiment room at eye level under red lighting

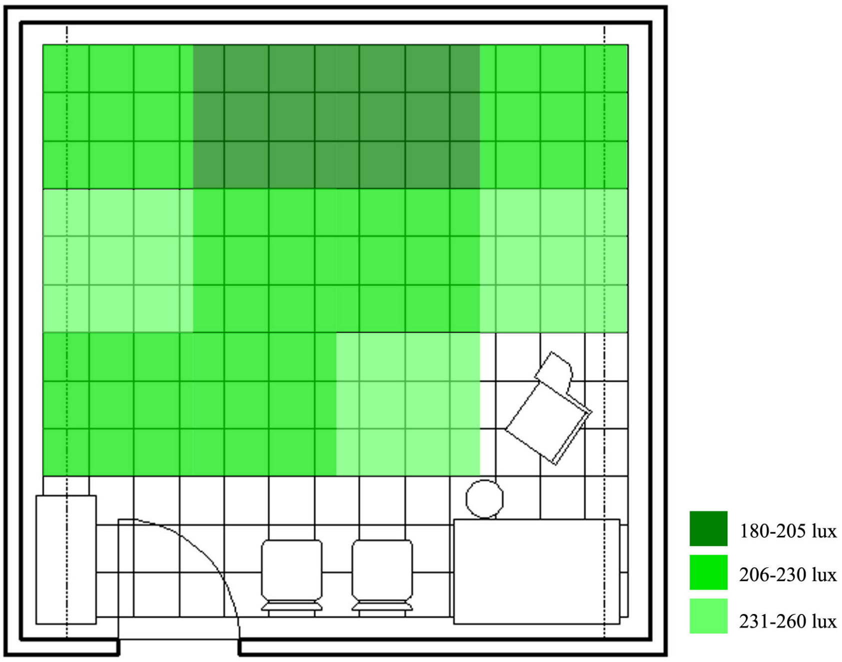

Figure 4.10. Illuminance map of the experiment room at eye level under green lighting

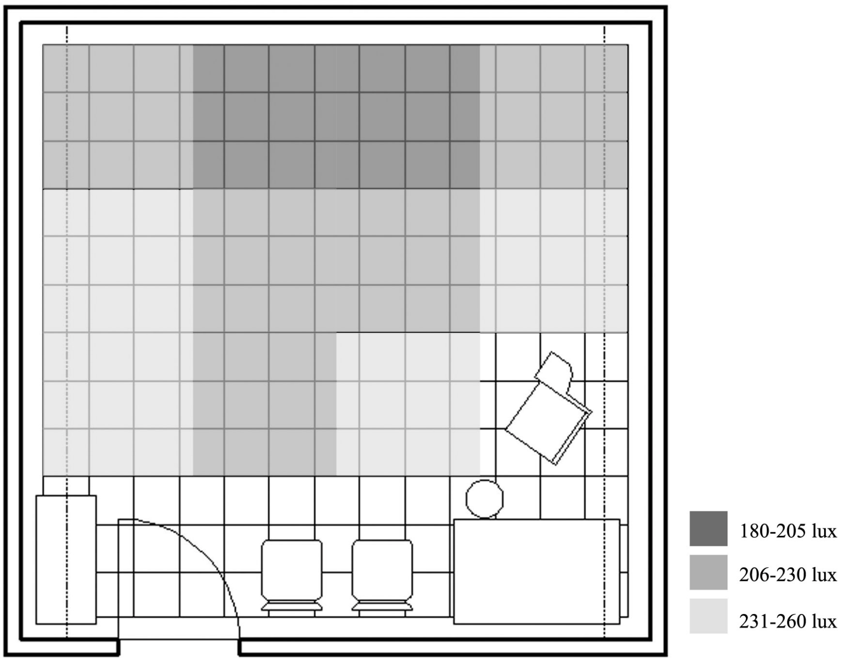

Figure 4.11. Illuminance map of the experiment room at eye level under white lighting

Table 4.2. Wall surface luminances of the experiment room

	Wall 1	Wall 2	Wall 3
RED	60,7	73,2	62,1
GREEN	62,3	73,5	64,0
WHITE	62,8	74,2	64,3

Walls are indicated in Figure 4.2. and all measurements are in cd/m^2.

4.2.3.2. Preparation of the Questionnaire

As Houser & Tiller stated, one of the common psychophysical methods used in lighting research is semantic differential (SD) scaling (Houser & Tiller, 2003). The use of semantic differential method in descriptive dimensions is an important development (Gao & Xin, 2006) and this method was developed by Osgood (1978) SD scales consist of sets of bipolar adjectives.

In order to prepare the questionnaire, firstly, bipolar adjectives from previous studies about lighting and color were gathered (see Appendix D1, Tables D1.1, D1.2, D1.3, D1.4, D1.5, D1.6, D1.7, D1.8, D1.9, D1.10). From these adjective pairs, the ones that were not suitable for evaluating an empty room were eliminated (see Appendix D2, Table D2.1). Secondly, the adjective pairs were translated into Turkish with the help of dictionaries (Oxford Turkish Dictionary, 1992; Redhouse Sözlüğü İngilizce-Türkçe, 2006; TDK eşanlamlılar sözlüğü, Türkçe'de yakın ve karşıt anlamlılar sözlüğü, 1998; Türkçe'de anlamdaş ve karşıt kelimeler sözlüğü, 1982) and the ones that were same or similar meanings in translation and the ones that became meaningless when translated into Turkish were eliminated (see Appendix D2, Table D2.2). Some of the adjective pairs were eliminated considering their meanings for the experiment and new ones were added. Adjective pairs, which were left from these eliminations additions, were divided into groups according to the factors they were used to evaluate. These adjectives were used in the questionnaire for evaluating perception of space under different lightings.

In addition to the first question for evaluating the impressions of the room, there was a second question which was asked for understanding which actual spaces users would associate these colored lightings and white lighting with. For the questionnaire see Appendix E1.1 and Appendix E2.1.

4.2.3.3. Planning of the Experiment

Before conducting the experiment, it was decided to have a minimum of five days in between evaluations with different lightings. The working program occurred according to this decision. When the subjects participated in the first experiment, they were asked when it would be possible for them to enter the second experiment after five days or more. Thus the schedule of the second experiment was prepared. The schedule of the third experiment was prepared when the subjects participated in the second experiment. One day before the scheduled experiment day and time, the participants were warned by sending e-mails that they had an appointment the day after. If the participants forgot their appointments, another appointment day and time were assigned on telephone.

4.2.3.4. Phases of the Experiment

The experiment was conducted in three phases (see Table 4.3). In the first phase, the participants were tested for color vision with Ishihara's Tests for color blindness (Ishihara, 1975). There was one student, who was color blind and he was not permitted to participate in the experiment. In addition, the participants who had eye defects were asked to wear their correction equipments such as glasses or contact lenses. 46.4% of the participants stated that they had minor eye defects and they evaluated the lightings with their glasses or contact lenses.

Students, who passed the Ishiara Tests, participated in the first experiment. They entered the experiment room from a corridor, which was illuminated with PHILIPS, TLD36/54 fluorescent lamps. All the participants were taken to the experiment room one by one. After one minute adaptation to the lighting in the experiment room, they evaluated the space under red lighting in the first phase by filling in the questionnaire.

In the second phase, the students evaluated the room under green lighting. As it is said above, each participant evaluated the room under one lighting and minimum five days later they evaluated it under another and in all three experiments the same procedure was applied. In the third phase, the room was evaluated under white lighting.

Table 4.3. Phases of the experiment

Phase 1	- Ishihara's test for color blindness - 1min adaptation to red lighting in the experiment room - Filling in the questionnaire
Phase 2	- 1min adaptation to green lighting - Filling in the questionnaire
Phase 3	- 1min adaptation to blue lighting - Filling in the questionnaire

4.3. Findings

Statistical Package for the Social Sciences (SPSS) 15.0 was used to analyze the data collected with the questionnaires. For analyzing the data, independent samples t-test and paired samples t-test were used.

Firstly, the internal consistency reliability of the questions was tested. Internal consistency reliability is applied to groups of items measuring different aspects of the same concept (Litwin, 1995). The data obtained by using several different items to gain information about a particular behavior or topic is richer and more reliable than single items. Internal consistency reliability among a group of items combined to form a single scale are measured by calculating a statistic known as Cronbach's coefficient alpha which is a reflection of how complemental the different items are in measuring different aspects of the same variable or quality (Litwin, 1995). The scale is more reliable when the score of the alpha coefficient is high. Nunnaly (as cited in Reynaldo & Santos, 1999) indicated that score of 0.70 is an acceptable reliability coefficient. Therefore, the internal consistency reliability of the questions were tested by using Cronbach's coefficient alpha and the adjective groups that had an Alpha value of over 0.70 (acceptable) were taken into consideration while evaluating the answers. Six adjective groups that had an Alpha value over 0.70 were as follows:

- Pleasantness (alpha value 0.9208)
- Aesthetics (alpha value 0.7335)
- Use (alpha value 0.7999)
- Comfort (alpha value 0.7573)
- Spaciousness (alpha value 0.8675)
- Light (alpha value 0.7572)

The adjective groups arousal (alpha value 0.332) and color (alpha value 0.5337) were thus eliminated from the results as the adjective pairs of these groups were not reliable because of their low alpha value.

Findings from the statistical analysis are given with respect to the research hypotheses (see section 4.3.1, 4.3.2, 4.3.3)

4.3.1. Effects of Colored Lighting on the Perception of Interior Spaces

The effects of colored lighting on the perception of interior spaces were evaluated and analyzed under six groups that are stated above. For all the analysis paired samples t-test were used and the mean value of the adjectives under one adjective group was compared for red-green, red-white, and green white lightings. The paired-samples t-tests were used because the same sample group participated in the experiments. The mean values of the adjectives were obtained in order to have one value for each adjective group and with these values a continuous data was obtained.

4.3.1.1. Pleasantness

T-test indicated that there is not a significant difference between red lighting and green lighting in the perception of the room in terms of pleasantness (df= 96, p= .746). There is not a significant difference between red lighting and white lighting in the perception in terms of pleasantness (df= 96, p= .130). Also, there is not a significant difference between green lighting and white lighting in the perception in terms of pleasantness (df=96, p= .167). Eventually, the results of the t-test showed that there is not a significant difference between any lighting in the perception of interior space in terms of pleasantness (see Appendix F, Table F.1). When the mean values of all lightings were compared the results showed that all the lightings were found approximately pleasant (see Figure 4.12 and Appendix F2, Table F2.1).

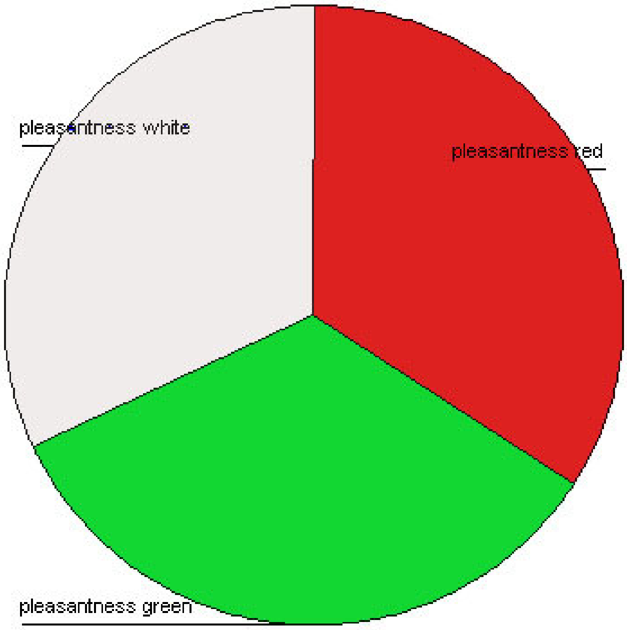

Figure 4.12. Pie chart of pleasantness

4.3.1.2. Aesthetics

T-test results showed that there is a significant difference between red lighting and white lighting in the perception of interior space in terms of aesthetics (df=96, p= .000). There is also a significant difference between green lighting and white lighting in the perception in terms of aesthetics (df=96, p= .000). On the other hand, there is not a significant difference found between red lighting and green lighting in the perception in terms of aesthetics (df=96, p= .895). Eventually, the results showed that there is a significant difference in the perception between colored lightings and white lighting in terms of aesthetics (see Appendix F, Table F.2). When the mean values of all lightings were compared the results showed that under colored lightings the space was found more aesthetics than under white lighting (see Figure 4.13 and Appendix F2, Table F2.1).

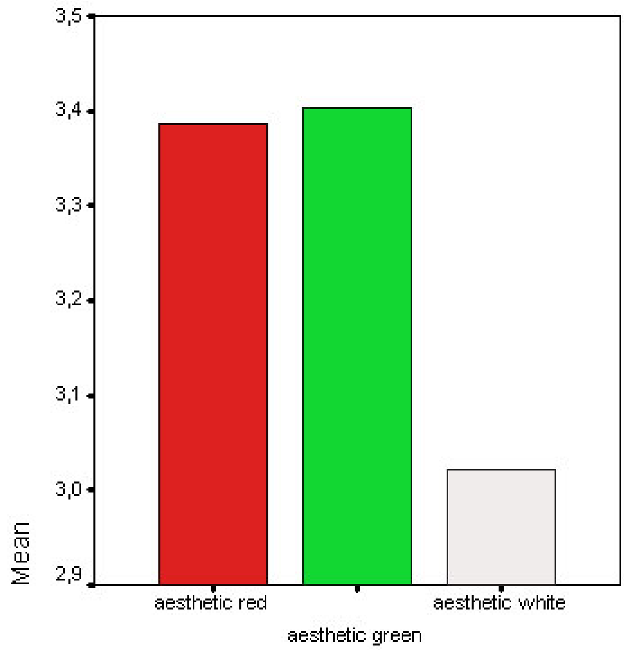

Figure 4.13. Bar chart of aesthetics

4.3.1.3. Use

The results of t-test showed that there is a significant difference between red lighting and green lighting in the perception of interior space in terms of use (df=96, p= .047). There is a significant difference found between red lighting and white lighting in the perception in terms of use (df=96, p= .000). There is also a significant difference between green lighting and white lighting in the perception in terms of use (df=96, p= .000). Eventually, the results showed that there is a significant difference in the perception between all the lightings in terms of use (see Appendix F, Table F.3). When the mean values of all lightings were compared the results showed that under white lighting the space was found more useful than under colored lightings (see Figure 4.14 and Appendix F2, Table F2.1).

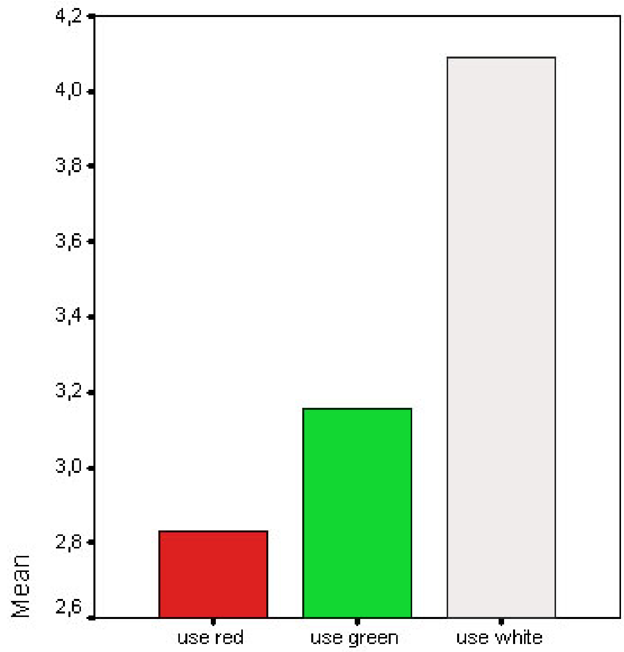

Figure 4.14. Bar chart of use

4.3.1.4. Comfort

T-test results showed that there is a significant difference between red lighting and green lighting in the perception of interior space in terms of comfort (df=96, p= .004). There is also a significant difference between red lighting and white lighting in the perception in terms of comfort (df=96, p= .000). However, there is not a significant difference between green lighting and white lighting in the perception in terms of comfort (df=96, p= .098). Eventually, the results indicated that there is a significant difference between red lighting and other lightings in perception in terms of comfort (see Appendix F, Table F.4). When the mean values of all lightings were compared the results showed that under red lighting the space was found the least comfortable than green and white lightings (see Figure 4.15 and Appendix F2, Table F2.1).

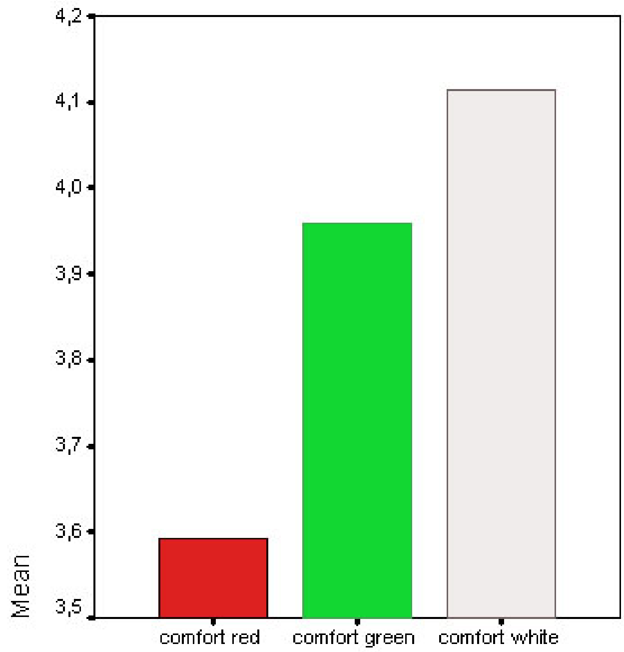

Figure 4.15. Bar chart of comfort

4.3.1.5. Spaciousness

T-test results showed that there is a significant difference between red lighting and green lighting in the perception of interior space in terms of spaciousness (df=96, p= .000). There is a significant difference between red lighting and white lighting in perception in terms of spaciousness (df=96, p= .000). There is also a significant difference between green lighting and white lighting in perception in terms of spaciousness. (df=96, p= .004). Eventually, the results indicated that there are significant differences between all lightings in the perception of the room in terms spaciousness (see Appendix F, Table F.5). When the mean values of all lightings were compared the results showed that under white lighting the space was found more spacious than colored lightings (see Figure 4.16 and Appendix F2, Table F2.1).

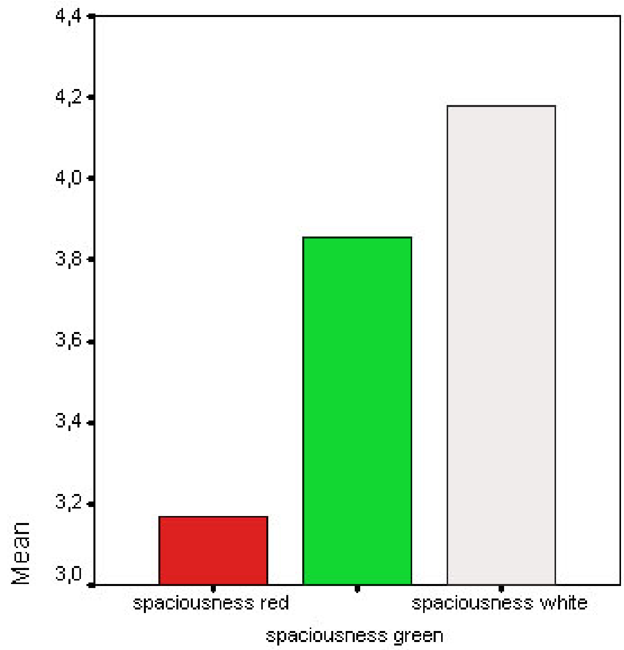

Figure 4.16. Bar chart of spaciousness

4.3.1.6. Lighting Quality

The adjectives grouped under the topic lighting quality were bright vs. dim, clear vs. hazy, light vs. dark and good lighting vs. poor lighting. T-test results showed that there is a significant difference between red lighting and green lighting in the perception considering the light in the room (df=96, p= .000). There is a significant difference between red lighting and white lighting in the perception considering the light (df=96, p= .000). There is also a significant difference between green lighting and white lighting in the perception considering the light (df=96, p= .000). Eventually, there are significant differences between all the lightings in the perception considering the light in the room (see Appendix F, Table F.6). When the mean values of all lightings were compared the results showed that under white lighting in the space was perceived clearer and more luminous and the light was perceived brighter than colored lights (see Figure 4.17 and Appendix F2, Table F2.1).

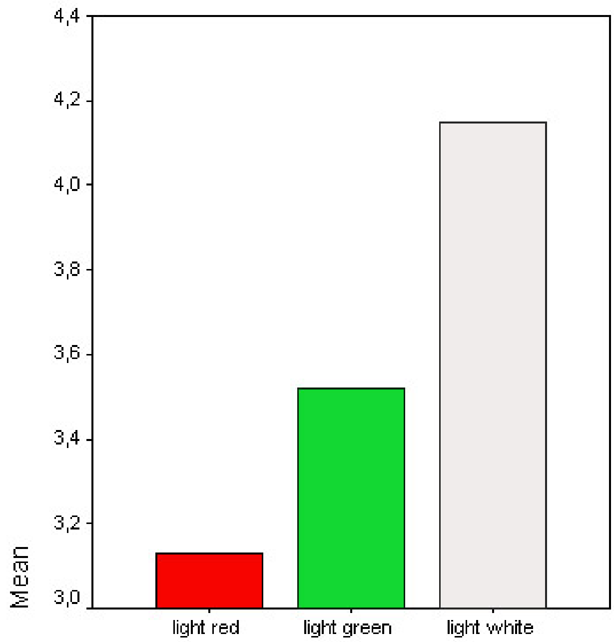

Figure 4.17. Bar chart of lighting quality

4.3.2. Effect of Gender on the Perception of Interior Spaces

Independent samples t-test was used for evaluating the gender differences. The effect of gender on perception was evaluated separately for all of the lightings. The results showed that there is not a significant difference between males and females in perception under colored lightings but there is a significant difference found between males and females in the perception under white lighting considering the lighting quality in the room (see Table 4.4). Eventually, there is not a significant difference in the perception considering gender in colored lightings and white lighting in terms of pleasantness, aesthetics, use, comfort, and spaciousness (see Appendix F, Tables F.7, F.8, F.9). On the other hand, there is a significant difference between males and females in the perception under white lighting considering the light in the room. When the mean values of all lightings were compared the results showed that females perceived the space clearer and more luminous under white lighting and they perceived the light brighter than males (see Figure 4.18 and Appendix F2, Table F2.2).

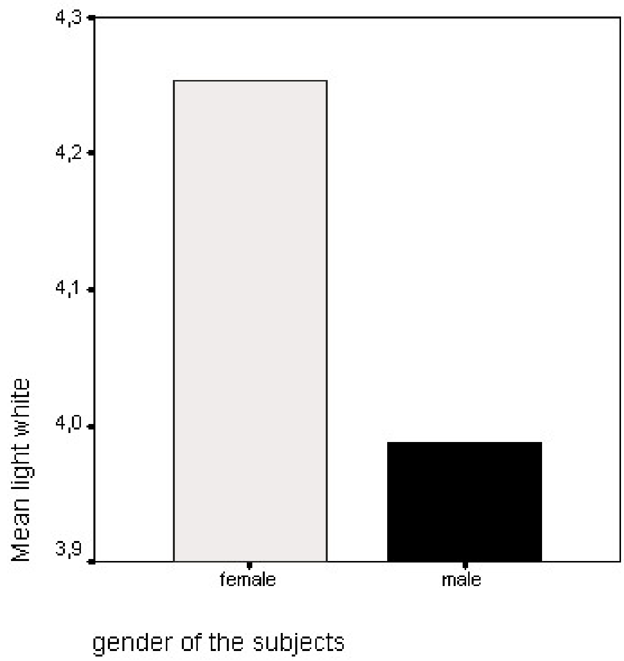

Figure 4.18. Bar chart of gender difference in lighting quality of white

Table 4.4. Gender difference in perception under different lightings

	RED	GREEN	WHITE
Pleasantness	df=95, p= ,315	df=95, p= ,284	df=95, p= ,865
Aesthetics	df=95, p= ,954	df=95, p= ,679	df=95, p= ,307
Use	df=95, p= ,734	df=95, p= ,443	df=95, p= ,401
Comfort	df=95, p= ,742	df=95, p= ,538	df=95, p= ,558
Spaciousness	df=95, p= ,708	df=95, p= ,200	df=95, p= ,602
Lighting quality	df=95, p= ,644	df=95, p= ,933	df=95, p= ,044

4.3.3. Effect of Colored Lighting on Place Association

The percentages of the answers of the second question showed that colored lightings were associated to be used mostly in bars (51.5% for red, 25.8% for green) and white lighting was associated to be used mostly in offices (33%). Colored lighting was also associated with cafes (9.3% for red, 14.4% for green), shops (8.2% for red, 13.4% for green) and cinemas (9.3% for red) whereas white lighting was also associated with schools (19.6%) and houses (20.6%). For all the percentages see Table 4.5.

Table 4.5. Percentages of question two

	RED	**GREEN**	**WHITE**
Houses	2.1	4.1	20.6
Hotels	3.1	6.2	4.1
Offices	0	1	33
Schools	0	2.1	19.6
Shops	8.2	13.4	2.1
Cafes	9.3	14.4	0
Restaurants	7.2	6.2	1
Bars	51.5	25.8	0
Cinemas	9.3	6.2	0
Sports Centers	3.1	7.2	10.3
Other	6.2	13.4	9.3

6.2% of the participants specified places that were not on the list for red lighting such as places for psychological treatments, greengroceries, and sex hops. 13.4% of the participants specified places that were not on the list for green lighting such as places of worship, landscape, gardens, florist, playgrounds, museums, exterior spaces, hospitals, and zoos. 9.3% of the participants specified places that were not on the list for white lighting such as hospitals and studios.

5. DISCUSSION

In this dissertation, the effects of different colored lightings and white lighting on the perception of an interior space was studied. It was hypothesized that there are differences between different colored lightings and also between colored lightings and white lighting in the perception of an interior space. The differences in the perception were analyzed under three lightings: red lighting, green lighting and white lighting, considering pleasantness, aesthetics, use, comfort, spaciousness and lighting quality.

The results showed some similarities and differences with the literature. For example, in this study it was found that the room was rated as equally pleasant under all lightings. This result differed from the literature when it was compared with the study examining the effects of wall colors on assessment at offices painted with red, green and white paints. Kwallek (1996) found that white painted offices were rated as more pleasant than red and green painted offices. The result of pleasantness also differed from the results of the study examining the reactions of people to different chromatic illuminations of a room. Lewinski (1938) indicated that blue and green lights were found to be the most pleasant whereas orange and yellow lights were found to be the most unpleasant in the room.

The results of comfort and spaciousness were expected results which were similar with the literature. In this study it was found that under red lighting the space was perceived the least comfortable and under white and green lightings the space was perceived comfortable. It was also found that under white lighting the space was perceived the most spacious and under red lighting the space was perceived the least spacious. Manav (2007) found that a space illuminated with the lamps that had 4000K color temperature was found more comfortable and more spacious than it is illuminated with lamps that were 2700K which meaned that under higher color temperatures, when the color of the lamp became whiter or bluish white, the space was found more comfortable and more spacious. In the literature, considering the effect of color on perception, it was also stated that cool colors affected the perception of a space such that it became more spacious whereas warm colors affected the perception of a space to be smaller and lower (Franz, 2006; Yıldırım, Akalın-Başkaya, & Hidayetoğlu, 2007). In the study of Kwallek (1996) done with red, green and white paintings, it was stated that the offices painted with white are found more spacious than the red and green offices.

The percentages of the answers to the second question in the questionnaire showed that colored lightings were associated to be used mostly in bars. Shops, cafes, restaurants and cinemas were the following places colored lightings were associated to be used. On the other hand, white lighting was associated to be used in offices mostly: houses and schools were other associated places. These results show that the participants answered the second question considering the places they were familiar with seeing these lightings and they did not think of novel usage of colored lightings.

6. CONCLUSION

The effects of colored lighting on the perception of interior spaces and the differences between colored lights and white light in space perception were explored in an experiment room of the Interior Architecture and Environmental Design Department at Bilkent University in Ankara. The results of the statistical analysis of this study showed significant effects of colored lighting on the perception of an interior space. The differences and similarities between different colored lights and white light in the perception of interior spaces in terms of pleasantness, aesthetics, use, comfort, spaciousness and lighting quality were also analyzed.

As indicated in the literature review, different properties of light such as color temperature, illuminance and arrangement of lighting influence the perception of a space and space perception is also affected by color (Durak, et.al., 2007; Flynn, et.al., 1979; Flynn, et.al., 1973; Fotios & Levermore, 1999; Kwallek, 1996; Manav, 2007; Manav & Yener, 1999). There are not any studies combining colored light and space perception. In other words, there are not any studies done on the effects of colored lights in space perception. The results of this research are important to fill the gap in the literature about the effects of colored lighting.

The results of this study can be useful for interior architects, designers and lighting designers who use light in order to create different atmospheres in a space. It is important to know the effects of light in a space for designers because it is good to use light in a space by knowing how it affects the space. The results also may concern the researchers who study color, and its effects on human psychology and perception.

There are some limitations of the study. This study concentrated on an empty space although spaces are generally thought of with their functions. The reason for conducting the experiment in an empty room is, not to cause the participants prejudge the space considering its function when they see an unexpected colored light in that space. Another limitation of the study is that only red and green colored lightings were used in the experiment but other colored lights were not used. Yellow and blue lights could also be used in the experiment, but in the pre-tests the illuminance level obtained from a blue fluorescent lamp was too low to be matched with red, green and white lights. Thus, in future research different colored lights could be used as long as their illuminance levels could be fixed. The order of the lights was the same for all the participants in this study, but the order could also be randomly changed for each participant.

In future studies, an experiment can be conducted in a space that has a function or with virtual spaces that have functions. Additionally, the effects of colored lights different than the ones used in this study can be investigated such as blue and yellow. It can also be explored whether there is an age effect on perception under different colored lights. The sample group of this study consisted mostly of the students from the department of Interior Architecture and Environmental Design but in future researches it can be examined whether there is a difference between architects, designers, artists and non-architects, non-designers, non-artists in the perception of a space under different colored lightings.

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APPENDIX A

Appendix A1. Demographics of the Participants

Table A1.1. Distribution of number of participants according to their departments

Department	Number of Participants
Interior Architecture and Environmental Design	91
International Relations	2
Graphic Design	1
Computer Engineering	1
Electric and Electronics Engineering	1
Teaching Education	1
Total	**97**

Table A1.2. Grade of the participants

Grade	Number of the participants
First year	1
Second year	57
Third year	27
Fourth year	8
Master degree	4
Total	**97**

Table A1.3. Age of the participants

Age	Number of the participants
18	3
19	16
20	19
21	18
22	18
23	9
24	6
25	5
26	1
27	1
31	1
Total	**97**

Appendix A2. Required Illuminances for Reading Tasks

Determination of Illuminance Categories*

Orientation and simple visual tasks. Visual performance is largely unimportant. These tasks are found in public spaces where reading and visual inspection are only occasionally performed. Higher levels are recommended for tasks where visual performance is occasionally important.		
A	Public spaces	30 lx (3 fc)
B	Simple orientation for short visits	50 lx (5 fc)
C	Working spaces where simple visual tasks are performed	100 lx (10 fc)
Common visual tasks. Visual performance is important. These tasks are found in commercial, industrial and residential applications. Recommended illuminance levels differ because of the characteristics of the visual task being illuminated. Higher levels are recommended for visual tasks with critical elements of low contrast or small size.		
D	Performance of visual tasks of high contrast and large size	300 lx (30 fc)
E	Performance of visual tasks of high contrast and small size, or visual tasks of low contrast and large size	500 lx (50 fc)
F	Performance of visual tasks of low contrast and small size	1000 lx (100 fc)
Special visual tasks. Visual performance is of critical importance. These tasks are very specialized, including those with very small or very low contrast critical elements. Recommended illuminance levels should be achieved with supplementary task lighting. Higher recommended levels are often achieved by moving the light source closer to the task.		
G	Performance of visual tasks near threshold	3000 to 10,000 lx (300 to 1000 fc)

* Expected accuracy in illuminance calculations are given in Chapter 9, Lighting Calculations. To account for both uncertainty in photometric measurements and uncertainty in space reflections, measured illuminances should be with ± 10% of the recommended value. It should be noted, however, that the final illuminance may deviate from these recommended values due to other lighting design criteria.

Figure A2.1. Illuminance Categories

From *IESNA lighting handbook: reference and application*, by IESNA, 2000, New York: Illuminating Engineering Society of North America.

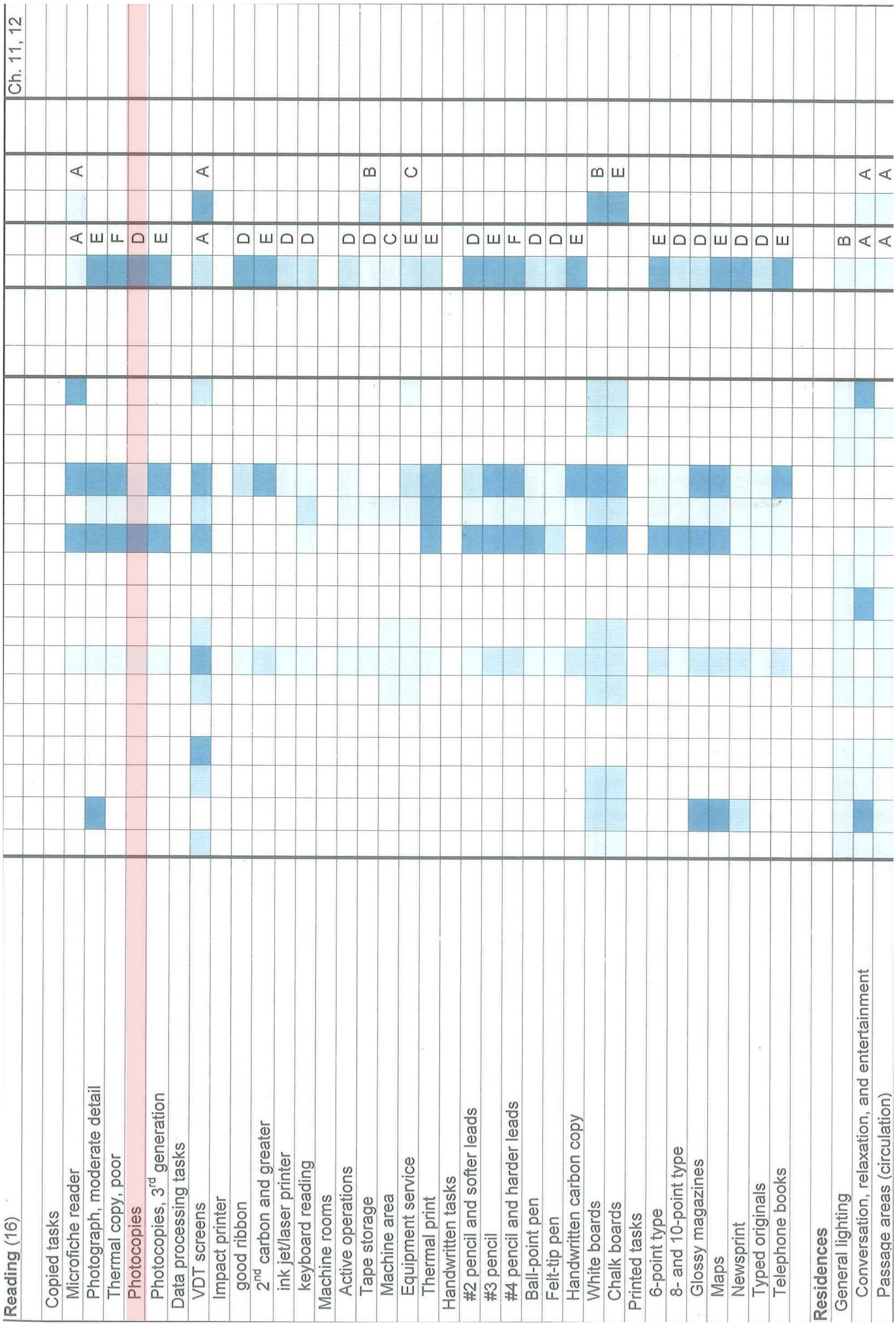

Figure A2.2. Required illuminances for reading tasks

From *IESNA lighting handbook: reference and application*, by IESNA, 2000, New York: Illuminating Engineering Society of North America.

APPENDIX B

Appendix B. Photographs of the Experiment Room under Red, Green and White Lightings

Figure B.1. View of the experiment room under red lighting 1

Figure B.2. View of the experiment room under red lighting 2

Figure B.3. View of the experiment room under red lighting 3

Figure B.4. View of the experiment room under red lighting 4

Figure B.5. View of the experiment room under red lighting 5

Figure B.6. View of the experiment room under green lighting 1

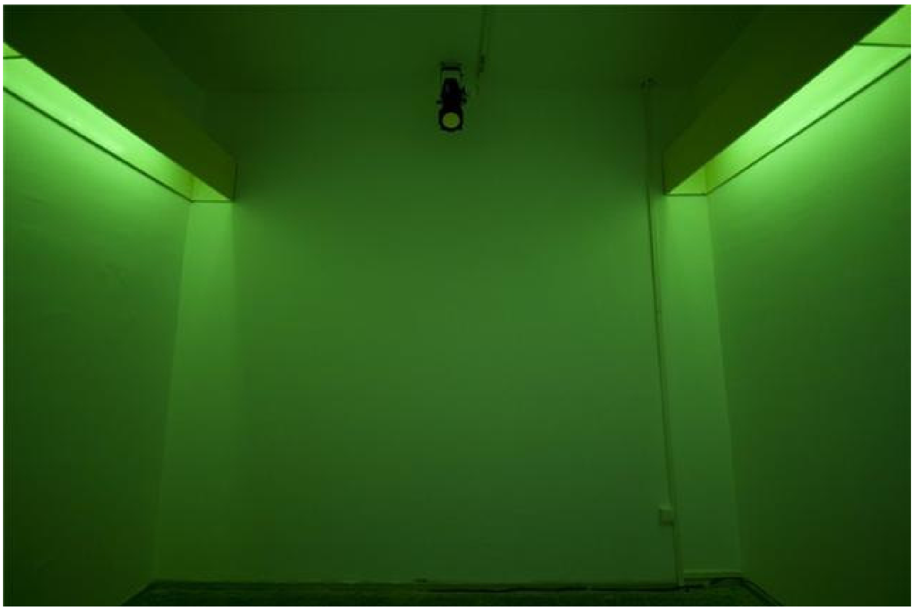

Figure B.7. View of the experiment room under green lighting 2

Figure B.8. View of the experiment room under green lighting 3

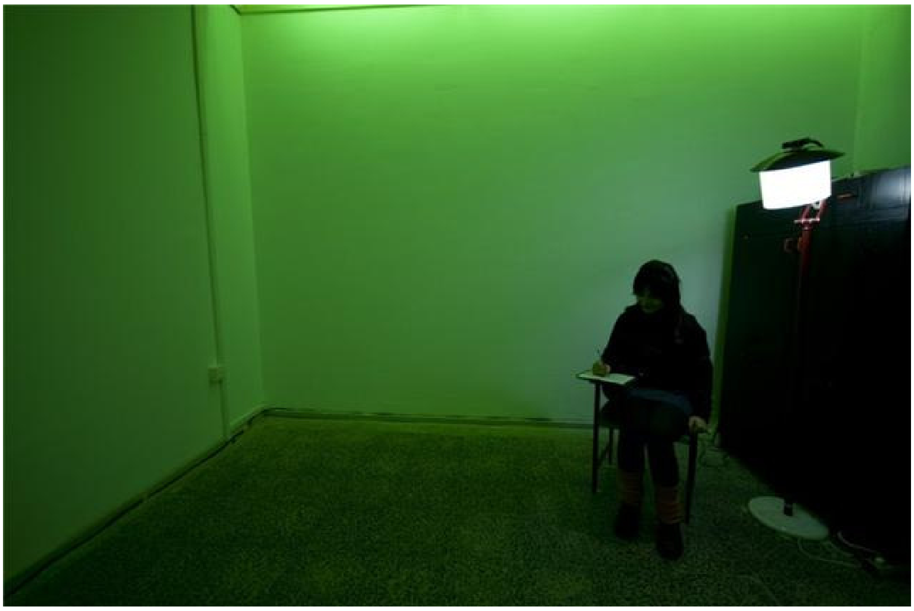

Figure B.9. View of the experiment room under green lighting 4

Figure B.10. View of the experiment room under white lighting 1

Figure B.11. View of the experiment room under white lighting 2

Figure B.12. View of the experiment room under white lighting 3

APPENDIX C

Appendix C. Illuminance Maps of the Experiment Room

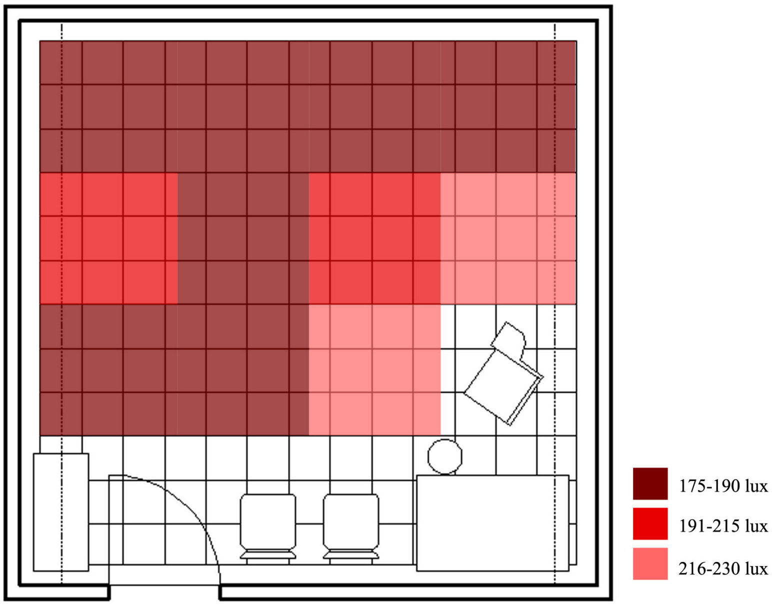

Figure C.1. Illuminance map of the experiment room on the floor under red lighting

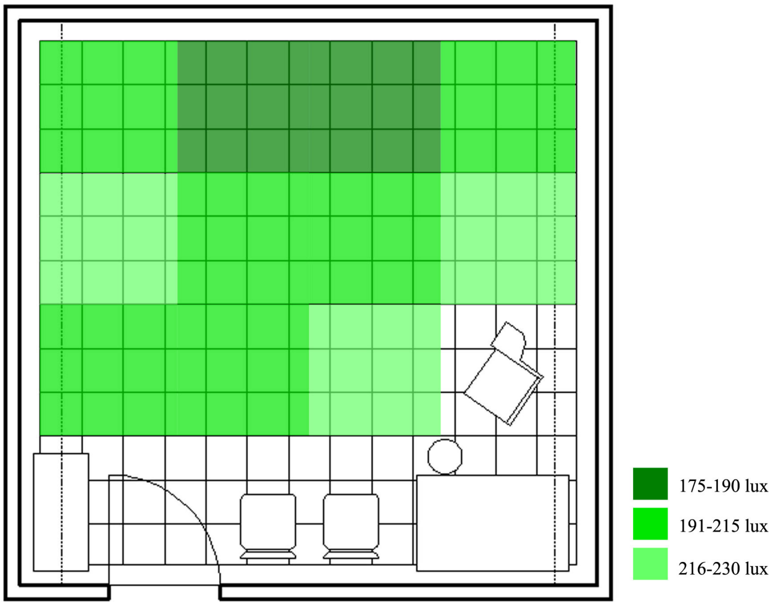

Figure C.2. Illuminance map of the experiment room on the floor under green lighting

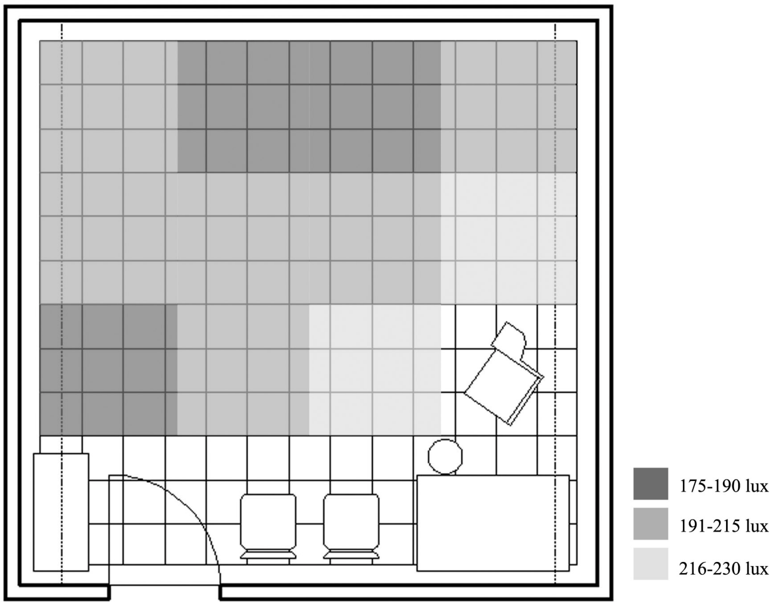

Figure C.3. Illuminance map of the experiment room on the floor under white lighting

APPENDIX D

Appendix D1. Adjective Pairs from the Previous Studies

Table D1.1. Adjective pairs of Kasmar (1992)

Descriptors retained:	
adequate size X inadequate size	huge X tiny
appealing X unappealing	impressive X unimpressive
attractive X unattractive	inviting X repelling
beautiful X ugly	large X small
bright X dull	light X dark
bright colors X muted colors	modern X old-fashioned
cheerful X gloomy	multiple purpose X single purpose
clean X dirty	neat X messy
colorful X drab	new X old
comfortable X uncomfortable	orderly X chaotic
comfortable temperature X uncomfortable	organized X disorganized
complex X simple	ornate X plain
contemporary X traditional	pleasant X unpleasant
convenient X inconvenient	pleasant odor X unpleasant odor
diffuse lighting X direct lighting	private X public
distinctive X ordinary	quiet X noisy
drafty X stuffy	roomy X cramped
efficient X inefficient	soft lighting X harsh lighting
elegant X unadorned	sparkling X dingy
empty X full	stylish X unstylish
expensive X cheap	tasteful X tasteless
fashionable X unfashionable	tidy X untidy
flashy colors X subdued colors	uncluttered X cluttered
free space X restricted space	uncrowded X crowded
fresh odor X stale odor	unusual X usual
functional X nonfunctional	useful X useless
gay X dreary	warm X cool
good acoustics X poor acoustics	well-balanced X poorly-balanced
good colors X bad colors	well kept X run down
good lighting X poor lighting	well organized X poorly organized
good lines X bad lines	well planned X poorly planned
good temperature X bad temperature	well scaled X poorly scaled
good ventilation X poor ventilation	wide X narrow

Table D1.2. Semantic Scales to Measure the Meaning of Designed Environments by Cass & Hershberger (as cited in Gifford, 2002)

Factors or Concepts	Primary Scale	Alternate Scale
1. General Evaluative	good-bad	pleasing-annoying
2. Utility Evaluative	useful-useless	friendly-hostile
3. Aesthetic Evaluative	unique-common	interesting-boring
4. Activity	active-passive	complex-simple
5. Space	cozy-roomy	private-public
6. Potency	rugged-delicate	rough-smooth
7. Tidiness	clean-dirty	tidy-messy
8. Organization	ordered-chaotic	formal-casual
9. Temperature	warm-cool	hot-cold
10. Lighting	light-dark	bright-dull

Table D1.3. Adjective pairs of Flynn, Spencer, Martyniuk, Hendrick (1973)

Evaluative	**Perceptual clarity**	**Spaciousness**
friendly X hostile	clear X hazy	large X small
pleasant X unpleasant	bright X dim	long X short
like X dislike	faces clear X faces obscure	spacious X cramped
harmony X discord	distinct X vague	
satisfying X frustrating	focused X unfocused	
beautiful X ugly	radiant X dull	
sociable X unsociable		
relaxed X tense		
interesting X monotonous		

Table D1.4. Adjective pairs of Flynn, Hendrick, Spencer, Martyniuk (1979)

beautiful X ugly	simple X complex
hazy X clear	pleasant X unpleasant
large X small	glare X non-glare
visually warm X visually cool	public X private
dislike X like	confined X spacious
faces clear X faces obscure	relaxing X tense
bright X dim	stimulating X subduing
distinct X vague	satisfying X frustrating
colorful X colorless	functional X non-functional
lively X subdued	ordinary X special
cluttered X uncluttered	stable X unstable

Table D1.5. Adjective pairs of Heerwagen & Heerwagen (1986)

attractive X unattractive	tense X relaxed
small X large	hazy X clear
uniform X non-uniform	pleasant X unpleasant
uncomfortable X comfortable	unacceptable X acceptable
focused X blurred	glare X non-glare
appealing X unappealing	favorable X unfavorable
bright X dim	spacious X confined
balanced X unbalanced	dislike X like

Table D1.6. Adjective pairs of Mania (2001)

spacious X confined	interesting X uninteresting
relaxing X tense	radiant X gloomy
bright X dim	large X small
stimulating X subduing	like X dislike
dramatic X diffuse	simple X complex
uniform X non-uniform	uncluttered X cluttered
warm X cold	pleasant X unpleasant
comfortable X uncomfortable	

Table D1.7. Adjective pairs used in the study of Houser, Tiller, Bernecker & Mistrick (2002)

Subjective brightness of the room:
dim X bright
Perception of visual comfort:
great eye discomfort X no eye discomfort
glare X non-glare
low quality X high quality
Impressions of spaciousness:
small X large
cramped X spacious
Overall preference:
dislike X like
unpleasant X pleasant
unsatisfying X satisfying

Table D1.8. Five factors and adjective pairs of the study of Hogg, Goodman, Porter, Mikellides & Preddy (1979)

Dynamism	**Spatial quality**	**Emotional tone**	**Complexity**	**Evaluation**
exciting-calming	open-closed	cold-hot	unusual-usual	pleasant-unpleasant
dynamic-static	weak-strong	hard-soft	complex-simple	receptive-repellent
vibrant-still	cramped-spacious	austere-lush	modern-traditional	
fresh-stale	uncontrolled-controlled			
blatant-muted	free-constricted			
obvious-subtle	private-public			
active-passive	loose-tight			
introverted-extroverted				
dull-sharp				

Table D1.9. Adjective pairs of Tucker (as cited in Osgood, 1978)

hot X cold	unique X commonplace
pleasant X unpleasant	emotional X rational
lush X austere	ugly X beautiful
vibrant X still	dull X sharp
repetitive X varied	sincere X insincere
happy X sad	rich X thin
chaotic X ordered	bad X good
smooth X rough	intimate X remote
superficial X profound	masculine X feminine
passive X active	vague X precise
blatant X muted	ferocious X peaceful
meaningless x meaningful	soft X hard
simple X complex	usual X unusual
relaxed X tense	controlled X accidental
obvious X subtle	wet X dry
serious X humorous	strong X weak
violent X gentle	stale X fresh
sweet X bitter	formal X informal
static X dynamic	calming X exciting
clear X hazy	full X empty

Table D1.10. Adjective pairs of Yıldırım, Akalın-Başkaya & Hidayetoğlu (2007)

roomy X cramped	interesting X boring
high X low	imposing X poor-looking
pleasant X unpleasant	calm X restless
attractive X unattractive	warm X cold

Appendix D2. Selection of the Adjective Pairs

Table D2.1. Adjective pairs eliminated considering the empty room

Austere-lush	Uncrowded-crowded
Elegant-unadorned	Orderly-chaotic
Ornate-plain	Organized-disorganized
Cluttered-uncluttered	Complex-simple

Table D2.2. Adjective pairs eliminated considering the Turkish translations

Appealing-unappealing	Harmony-discord
Pleasing-annoying	Imposing-poor-looking
Receptive-repellent	Inviting-repelling
Active-passive	Obvious-subtle
Calm-restless	Neat-messy
Gay-dreary	User friendly-hostile
Stimulating-subduing	Ordinary-special
Vibrant-still	Free-constricted
Arousing-not arousing	Huge-tiny
Loose-tight	Open-closed
Roomy-cramped	Colorful-drab
Radiant-gloomy	Sparkling-dingy

APPENDIX E

APPENDIX E1.1. The Questionnaire (in English)

Name-Surname:
Age:
Gender: □ F □ M
Department:
Class:
Do you have any eye defects? If so, what kind?
____

1) Select the value which suits you best for each adjective pairs considering the impressions of the room.

Pleasantness

attractive						unattractive
satisfying						unsatisfying
like						dislike
pleasant						unpleasant
impressive						unimpressive

Arousal

static						dynamic
interesting						boring
cheerful						gloomy
calming						exciting
relaxing						tense

Aesthetics

beautiful						ugly
clean						dirty
distinctive						ordinary
tasteful						tasteless
usual						unusual
stylish						unstylish

Use

private						public
efficient						inefficient
convenient						inconvenient

useful						useless
functional						nonfunctional

Comfort

comfortable						uncomfortable
glaring						non-glaring
great eye discomfort						no eye discomfort

Spaciousness

high						low
large						small
spacious						cramped
wide						narrow

Light

bright						dim
clear						hazy
light						dark
good lighting						poor lighting

Color

soft						hard
light						dark
vibrant						dull
warm						cool
strong						weak

2) As a user, which is the most appropriate place to use this lighting?
☐ Houses
☐ Hotels
☐ Offices
☐ Schools
☐ Shops
☐ Cafes
☐ Restaurants
☐ Bars
☐ Cinemas
☐ Sports Centers
☐ Other (Specify a space :____)

APPENDIX E2.1. The Questionnaire (in Turkish)

Ad-Soyad:
Yaş:
Cinsiyet: □ K □ E
Bölüm:
Sınıf:
Göz bozukluğunuz var mı? Varsa ne olduğunu belirtiniz.

____

1) Aşağıdaki her bir sıfat çifti için odayı nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

Memnuniyet

çekici						itici
tatmin edici						tatmin edici değil
beğendim						beğenmedim
hoş						hoş değil
etkileyici						etkileyici değil

Uyarıcılık

statik						dinamik
ilginç						sıkıcı
neşelendirici						iç karartıcı
sakinleştirici						heyecan verici
gevşetici						gerginleştirici

Estetik

güzel						çirkin
temiz						kirli
farklı						sıradan
zevkli						zevksiz
alışılmış						alışılmışın dışında
şık						şık değil

Kullanım

hususi						umumi
verimli						verimsiz
kullanışlı						kullanışsız

işe yarar						işe yaramaz
fonksiyonel						fonksiyonel değil

Konfor

rahat						rahatsız
gözüm kamaştı						gözüm kamaşmadı
gözüm rahatsız oldu						gözüm rahatsız olmadı

Ferahlık

yüksek						alçak
büyük						küçük
ferah						sıkışık
geniş						dar

Işık

parlak						sönük
net						bulanık
aydınlık						karanlık
iyi aydınlatılmış						kötü aydınlatılmış

Renk

yumuşak						sert
açık						koyu
canlı						donuk
sıcak						soğuk
güçlü						zayıf

2) Kullanıcı olarak sizce bu ışığın kullanılabileceği en uygun yer neresi olabilir?
☐ Evler
☐ Oteller
☐ Ofisler
☐ Okullar
☐ Mağazalar
☐ Kafeler
☐ Restoranlar
☐ Barlar
☐ Sinemalar
☐ Spor Merkezleri
☐ Diğer (Mekan belirtiniz:____)

APPENDIX F

Appendix F1. Raw Data

Table F1.1. Raw data of pleasantness for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
attractive	17	32	24	16	8	**unattractive**
satisfying	8	37	23	20	9	**unsatisfying**
like	16	35	20	17	9	**dislike**
pleasant	18	35	18	17	9	**unpleasant**
impressive	11	36	23	15	12	**unimpressive**

Table F1.2. Raw data of pleasantness for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
attractive	15	34	19	24	5	**unattractive**
satisfying	14	28	23	26	6	**unsatisfying**
like	21	30	19	19	8	**dislike**
pleasant	23	26	16	25	7	**unpleasant**
impressive	12	22	29	23	11	**unimpressive**

Table F1.3. Raw data of pleasantness for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
attractive	10	19	44	19	5	**unattractive**
satisfying	17	28	25	21	6	**unsatisfying**
like	13	31	27	20	6	**dislike**
pleasant	15	30	22	24	6	**unpleasant**
impressive	4	9	30	25	29	**unimpressive**

Table F1.4. Raw data of arousal for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
dynamic	14	35	23	13	12	**static**
interesting	16	43	22	9	7	**boring**
cheerful	8	29	43	11	6	**gloomy**
exciting	12	30	31	10	14	**calming**
tense	19	19	25	27	7	**relaxing**

Table F1.5. Raw data of arousal for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
dynamic	6	25	25	28	13	**static**
interesting	14	37	25	17	4	**boring**
cheerful	12	34	34	15	2	**gloomy**
exciting	0	15	34	28	20	**calming**
tense	4	18	25	32	18	**relaxing**

Table F1.6. Raw data of arousal for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
dynamic	5	12	19	29	32	**static**
interesting	1	6	34	36	20	**boring**
cheerful	4	24	48	17	4	**gloomy**
exciting	3	5	46	29	14	**calming**
tense	8	17	39	17	16	**relaxing**

Table F1.7. Raw data of aesthetics for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
beautiful	16	36	22	11	12	**ugly**
clean	16	27	36	16	2	**dirty**
distinctive	25	44	14	10	4	**ordinary**
tasteful	12	39	22	14	10	**tasteless**
unusual	31	39	17	6	4	**usual**
stylish	9	28	34	13	13	**unstylish**

Table F1.8. Raw data of aesthetics for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
beautiful	18	30	26	19	4	**ugly**
clean	37	36	16	7	1	**dirty**
distinctive	18	42	20	9	8	**ordinary**
tasteful	13	28	30	23	3	**tasteless**
unusual	17	45	19	13	3	**usual**
stylish	8	25	22	28	14	**unstylish**

Table F1.9. Raw data of aesthetics for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
beautiful	14	31	32	15	5	**ugly**
clean	52	35	8	1	1	**dirty**
distinctive	1	1	21	20	54	**ordinary**
tasteful	3	16	40	21	17	**tasteless**
unusual	4	7	10	12	64	**usual**
stylish	11	20	33	20	13	**unstylish**

Table F1.10. Raw data of use for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
private	35	22	20	11	9	**public**
efficient	5	12	40	28	12	**inefficient**
convenient	8	13	33	30	13	**inconvenient**
useful	7	27	34	22	7	**useless**
functional	13	15	35	26	8	**nonfunctional**

Table F1.11. Raw data of use for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
private	15	27	33	18	4	**public**
efficient	10	30	31	21	5	**inefficient**
convenient	9	22	36	21	9	**inconvenient**
useful	11	35	33	12	6	**useless**
functional	11	30	31	18	7	**nonfunctional**

Table F1.12. Raw data of use for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
private	10	10	25	20	32	**public**
efficient	42	36	10	7	2	**inefficient**
convenient	37	43	10	5	2	**inconvenient**
useful	39	40	13	4	1	**useless**
functional	32	39	20	5	1	**nonfunctional**

Table F1.13. Raw data of comfort for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
comfortable	13	31	20	24	9	**uncomfortable**
non-glaring	40	18	19	9	11	**glaring**
no eye discomfort	33	19	19	15	11	**great eye discomfort**

Table F1.14. Raw data of comfort for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
comfortable	30	24	20	17	6	**uncomfortable**
non-glaring	45	21	20	8	3	**glaring**
no eye discomfort	45	19	18	10	5	**great eye discomfort**

Table F1.15. Raw data of comfort for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
comfortable	37	36	12	6	6	**uncomfortable**
non-glaring	49	21	17	6	4	**glaring**
no eye discomfort	53	21	12	6	5	**great eye discomfort**

Table F1.16. Raw data of spaciousness for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
high	11	33	20	23	10	**low**
large	8	30	29	22	8	**small**
spacious	13	27	36	16	5	**cramped**
wide	10	26	37	21	3	**narrow**

Table F1.17. Raw data of spaciousness for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
high	29	40	14	9	5	**low**
large	21	45	18	11	2	**small**
spacious	28	47	16	5	1	**cramped**
wide	24	43	25	4	1	**narrow**

Table F1.18. Raw data of spaciousness for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
high	40	35	17	3	2	**low**
large	40	36	14	6	1	**small**
spacious	44	39	12	2	0	**cramped**
wide	44	36	10	7	0	**narrow**

Table F1.19. Raw data of lighting quality for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
bright	8	27	29	24	9	**dim**
clear	12	26	24	24	11	**hazy**
light	11	26	41	19	0	**dark**
good lighting	10	24	43	13	7	**poor lighting**

Table F1.20. Raw data of lighting quality for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
bright	6	33	37	16	5	**dim**
clear	18	38	19	18	4	**hazy**
light	21	44	23	8	1	**dark**
good lighting	19	32	35	10	1	**poor lighting**

Table F1.21. Raw data of lighting quality for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
bright	21	41	23	12	0	**dim**
clear	45	37	12	3	0	**hazy**
light	56	35	6	0	0	**dark**
good lighting	36	44	10	6	1	**poor lighting**

Table F1.22. Raw data of color for red lighting

Red lighting						
	5	**4**	**3**	**2**	**1**	
soft	28	38	17	12	2	**hard**
light	20	45	22	9	1	**dark**
vibrant	15	39	27	12	4	**dull**
warm	31	39	22	4	1	**cool**
strong	17	20	40	17	3	**weak**

Table F1.23. Raw data of color for green lighting

Green lighting						
	5	**4**	**3**	**2**	**1**	
soft	34	37	17	6	3	**hard**
light	35	51	10	1	0	**dark**
vibrant	22	31	19	17	8	**dull**
warm	12	14	41	16	14	**cool**
strong	4	27	33	22	11	**weak**

Table F1.24. Raw data of color for white lighting

White lighting						
	5	**4**	**3**	**2**	**1**	
soft	17	37	26	10	7	**hard**
light	61	31	5	0	0	**dark**
vibrant	13	30	28	18	8	**dull**
warm	5	6	36	30	20	**cool**
strong	20	30	38	7	2	**weak**

Appendix F2. Statistical Results of the Experiment

Table F2.1. Paired T-test for differences between red, green and white lightings in terms of pleasantness

Paired Samples Test

		Paired Differences					t	df	g. (2 taile
					5% Confidence Interval of the Difference				
		Mean	d. Deviatio	td. Erro Mean	Lower	Upper			
Pair 1	pleasantness pleasantness	,0474	1,44042	14625	-,2429	,3377	,324	96	,746
Pair 2	pleasantness pleasantness	,2392	1,54398	15677	-,0720	,5504	1,526	96	,130
Pair 3	pleasantness pleasantness	,1918	1,35675	13776	-,0817	,4652	1,392	96	,167

Table F2.2. Paired T-test for differences between red, green and white lightings in terms of aesthetics

Paired Samples Test

		Paired Differences					t	df	g. (2 taile
		Mean	d. Deviatio	td. Erro Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	aesthetic re aesthetic g	,0113	,84297	08559	-,1586	,1812	,132	96	,895
Pair 2	aesthetic re aesthetic w	,6588	1,05077	10669	,4470	,8705	6,175	96	,000
Pair 3	aesthetic g aesthetic w	,6474	,98638	10015	,4486	,8462	6,464	96	,000

Table F2.3. Paired T-test for differences between red, green and white lightings in terms of use

Paired Samples Test

	Paired Differences					t	df	. (2-taile
	Mean	. Deviat	:d. Err Mean	% Confiden nterval of the Difference Lower	Upper			
Pair use red - u	2021	,98805	0032	4012	0029	2,014	96	,047
Pair use red - u	7526	,08926	1060	9721	5330	3,805	96	,000
Pair use green	5505	,08706	1037	7696	3314	4,988	96	,000

Table F2.4. Paired T-test for differences between red, green and white lightings in terms of comfort

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	d Deviatic	td. Erro Mean	Lower	Upper	t	df	g (2-taile
Pair 1	comfort re comfort gr	-,3897	1,28513	13049	-,6487	-,1307	-2,986	96	,004
Pair 2	comfort re comfort w	-,6155	1,40218	14237	-,8981	-,3329	-4,323	96	,000
Pair 3	comfort gr comfort w	-,2258	1,32879	13492	-,4936	,0420	-1,673	96	,098

Table F2.5. Paired T-test for differences between red, green and white lightings in terms of spaciousness

Paired Samples Test

	Paired Differences					t	df	g. (2 taile
				5% Confidence Interval of the Difference				
	Mean	d. Deviati	td. Erro Mean	Lower	Upper			
Pair 1 spaciousness spaciousness	,6856	1,16048	11783	-,9195	-,4517	-5,818	96	,000
Pair 2 spaciousness spaciousness	,9948	1,21941	12381	,2406	,7491	8,035	96	,000
Pair 3 spaciousness - spaciousne	,3093	1,04381	10598	-,5197	-,0989	2,918	96	,004

Table F2.6. Paired T-test for differences between red, green and white lightings in terms of lighting quality

Paired Samples Test

	Paired Differences					t	df	. (2-taile
				% Confiden nterval of the Difference				
	Mean	. Deviat	d. Err Mean	Lower	Upper			
Pair light red - li	3866	,92563	9398	5732	2000	4,113	96	,000
Pair light red - li	0180	,90445	9183	2003	8358	1,086	96	,000
Pair light green	6314	,94586	9604	8221	4408	6,575	96	,000

Table F2.7. Independent Samples T-test for gender difference in the perception under red lighting

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
[illegible]	Equal variances assumed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Equal variances not assumed			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Equal variances assumed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Equal variances not assumed			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Equal variances assumed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Equal variances not assumed			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Equal variances assumed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Equal variances not assumed			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Equal variances assumed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Equal variances not assumed			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	Equal variances assumed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Equal variances not assumed			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table F2.8. Independent Samples T-test for gender difference in the perception under green lighting

Independent Samples Test

		[illegible] Equality of Variances		[illegible]					[illegible]	
		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] Difference	[illegible]	Upper
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table F2.9. Independent Samples T-test for gender difference in the perception under white lighting

Independent Samples Test

		[illegible]		[illegible]						
		F	Sig.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix F3. Mean Values of the Adjective Groups

Table F3.1. Mean values of the adjective groups under red, green and white lightings

	Pleasantness	Aesthetics	Use	Comfort	Spaciousness	Lighting quality
Red	3,2804	3,3856	2,3289	3,5928	3,1701	3,1314
Green	3,2536	3,4036	3,1546	3,9588	3,8557	3,5180
White	3,0557	3,0206	4,0902	4,1134	4,1804	4,1495

Table F3.2. Mean values of lighting quality under white lighting according to genders

	Female	Male
White-lighting quality	4,2542	3,9868