THE EFFECTS OF COLOR SCHEME ON THE APPRAISAL OF AN OFFICE ENVIRONMENT AND TASK PERFORMANCE

A THESIS
SUBMITTED TO THE DEPARTMENT OF
INTERIOR ARHITECTURE AND ENVIRONMENTAL DESIGN
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IN PARTIAL FULFILLMENT OF THE REQURIMENTS
FOR THE DEGREE OF
MASTER OF FINE ARTS

By
Elif Öztürk
July, 2010

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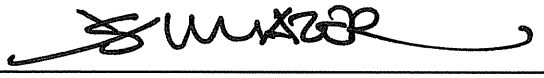

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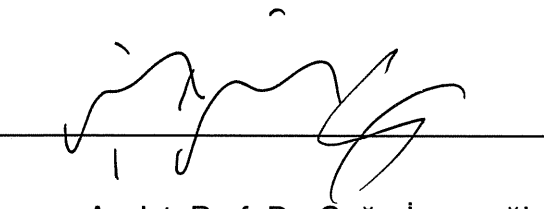

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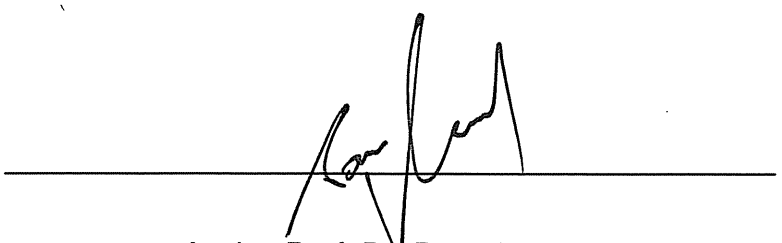

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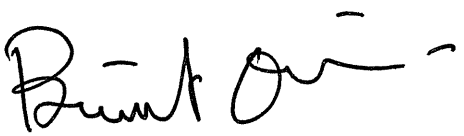

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ABSTRACT

THE EFFECTS OF COLOR SCHEME ON THE APPRAISAL OF AN OFFICE ENVIRONMENT AND TASK PERFORMANCE

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The purpose of this study is to explore the differences between achromatic and chromatic schemes in the appraisal of an office environment and task performance. To investigate only the hue effect on the subjective impressions of the offices and participants' performance, it was important to use the colors with the same value (lightness) on the surfaces of achromatic and chromatic scheme. The study has two phases. In the first phase, a field survey was conducted at the Fine Arts Faculty of Bilkent University to obtain data in order to determine the artificial lighting and color specifications of the experiment room that was to be used in the experimental study. In the second phase, an experimental study was conducted. The same sample group participated in the experiment for two color schemes which were achromatic and chromatic. The participants were sixty office workers who are academic and administrative staff from different departments of Bilkent University in Ankara. The study was carried out in an office room at the Department of Interior Architecture and Environmental Design at Bilkent University, and the room was redesigned according to the purposes of the study. In the first stage of the experiment participants were tested for color vision deficiencies and after a few minutes of adaptation, they were given performance tasks consisting of problem-solving and proofreading tests while the coordinator of the experiment was timing this process. Later, the participants evaluated the task they performed (self-report of the task) and the presented office setting by filling out the questionnaire, consisting of a set of bipolar adjective pairs, preference and association questions in 5 point scale likert-type and open-ended questions. In the second stage, the same procedure was followed for the other color scheme (achromatic or chromatic). Statistical Package for the Social Science (SPSS) 13.0 was used to analyze the data. It was found that the office environment with chromatic scheme was found more pleasant, attractive, satisfying and dynamic than the achromatic scheme. In terms of task performance the results showed that participants' performances were better in the chromatic scheme than their performance in the achromatic scheme.

KEYWORDS: office environment, color scheme, environmental assessment, task performance.

ÖZET

RENK ŞEMASININ OFİS ORTAMININ DEĞERLENDİRİLMESİ VE İŞ PERFORMANSININ ÜZERİNDEKİ ETKİLERİ

Elif Öztürk
İç Mimarlık ve Çevre Tasarımı Yüksek Lisans Programı
Danışman: Doç. Dr. Semiha Yılmazer
Temmuz, 2010

Bu çalışmanın amacı akromatik ve kromatik renk şemaları arasındaki farkın ofis ortamının değerlendirilmesi ve iş performansının açısından incelemektir. Mekanların sübjektif değerlendirmesinde ve katılımcıların performansında sadece rengin etkisini inceleyebilmek için akromatik ve kromatik renk şemalarında renklerin ışıklık oranlarının (yansıtıcılıklarının) aynı olmasına dikkat edilmiştir.Çalışma iki aşama olarak planlanmıştır. İlk aşamada, ikinci aşamada kullanılacak olan deney odasının yapay ışıklandırma ve renk özelliklerini belirlemek üzere veri toplamak amacıyla Bilkent Üniversitesi Güzel Sanatlar Fakültesi'nde bir alan araştırması yapılmıştır. İkinci aşamada, deneysel bir araştırma yapılmıştır. Kromatik ve akromatik olan iki renk şeması için aynı örnek grup deneye katılmıştır. Katılımcılar Ankara'daki Bilkent Üniversitesi'nde farklı bölümlerde akademik ve idari görevli bulunan altmış ofis çalışanından oluşmaktadır. Deney, Bilkent Üniversitesi İç Mimarlık ve Çevre Tasarımı Bölümü'nün bir ofisinde yapılmıştır ve bu oda araştırmanın amaçlarına uygun olarak yeniden düzenlenmiştir. Deneyin ilk aşamasında katılımcılara renk körlüğü testi yapılmış ve birkaç dakikalık adaptasyon süresinden sonra, deney yöneticisi sure tutarken katılımcılara problem çözme ve hata düzeltme sorularından oluşan performans testleri verilmiştir. Daha sonra, katılımcılar yapmış oldukları performans testlerini ve sunulan ofis ortamını bir anket doldurarak değerlendirmişlerdir. Deneyin ikinci aşamasında aynı prosedür (kromatik veya akromatik) diğer renk şeması için tekrarlanmıştır. İstatistiksel incelemelerde Sosyal Bilimler İstatistik Paket Programı (SPSS) 13.0 kullanılmıştır. Elde edilen sonuçlara göre, katılımcılar kromatik şemalı ofis ortamını, akromatik şemalı ofis ortamından daha hoş, çekici, tatmin edici ve dinamik bulmuştur.İş performansı açısından sonuçlar katılımcıların kromatik şemadaki performansının akromatik şemaya göre daha iyi olduğunu göstermiştir.

ANAHTAR SÖZCÜKLER: ofis ortamı, renk şeması, çevresel değerlendirme, iş performansı.

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I am grateful to my parents Kadir Öztürk and Şükran Öztürk and my dearest sister Bilge Öztürk for their invaluable support, trust and encouragement throughout the preparation of the thesis.

I dedicate this thesis to my parents Kadir Öztürk and Şükran Öztürk.

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1. INTRODUCTION

Office buildings are the most common work environments among others and many individuals spend nearly one-third of their lives at offices. It has been demonstrated that the physical environment of an office has impacts on variables such as employees' health, comfort, satisfaction, performance and social relations (Galitz, 1984). According to Vischer (1989), to improve the quality of working life, the physical environment and the users who occupy it must be considered together as a whole. In addition, he claims that to achieve organizational success, designers and managers need to provide solutions that systematically integrate the information from users' complaints and perceptions, the technical building performance information, and the management philosophy of the organizations.

Numerous studies have shown that each one of or a combination of the environmental attributes, which are air quality, thermal comfort, spatial comfort, privacy, office noise control, building noise control, and lighting comfort, color and workstations, are influential variables to understand how office environments relate to the workers' perceptions and behaviors at work (Vischer, 1996; Sundstorm,1986). Most studies indicate that the more satisfied people are with their over all office environment, the more satisfied they are with their job; therefore, it becomes an essential topic to understand the workers' needs and perceptions to make more inviting and pleasant work environments (Spreckelmeyer, 1993; Crouch & Nimran, 1989).

Thanks to a number of surveys about office environments, it has been seen that light and color in workplaces are important factors contributing to the workers' comfort and satisfaction. According to Galitz (1984), "Poor or improper lighting can cause eyestrain or headaches while good lighting can increase a person's productivity" (p. 69). In terms of psychological conditions of workers, it is also demonstrated that color, as an environmental factor, has the potential to enhance the psychological conditions and productivity of workers (Sundstrom, 1996; Wineman, 1986). In the literature, there are initial studies conducted by psychologists to analyze whether particular colors excite particular feelings and can influence people's subjective impressions and preferences by showing them various hues from color slides or color pictures of interiors (Jacobs & Suess, 1975). The results of these studies can provide cues to enhance color design of interiors. However, as Kwallek, Woodson, Lewis & Sales (1997) stated, simply viewing color pictures or slides of interiors were not realistic, so people need to be exposed to real interior environments that can be more representative for subjective evaluations. In addition, there were initial studies about the relation between color and human performance conducted in sets with isolated stimulus or restricted objects (Jacobs &Hustmyer, 1974) which were not enough to examine the detailed relation between the color in real environment and human performance.

Therefore, the following studies regarding color in office environment intended to involve realistic office settings in the experiments, which would provide more reliable inferences. In that sense, there are recent studies searching how color, color attributes or combination of colors affecting workers' mood, subjective

impressions and productivity in office environments (Kwallek, Lewis & Robbins, 1988; Kwallek, 1996; Ainswort, Simpson & Cassell, 1993). Moreover, in the recent studies, the relations between color and individual environmental sensitivity, gender, age and culture have also been investigated (Kwallek, et al., 1997; Kwallek, Soon, & Lewis, 2007).

The recent studies about color in workplaces have mostly been conducted to analyze the effects of different hues (red, green, blue, etc) on workers' mood and performance. In that respect, there is still a progressive process to consider and understand all three dimensions of color: hue, saturation and value in workplaces. In the literature, there is not any study comparing achromatic and chromatic schemes in terms of environmental appraisal and task performance in the offices. Therefore, this study can be a progressive approach to contribute to the literature in that context.

1.1. Aim of the Study

The main purpose of this study is to understand the effects of color scheme on the appraisal of a private office environment and task performance. The aim is to investigate the differences between achromatic and chromatic schemes in the subjective impressions of offices and task performance. In this study, it was crucial to use the colors with the same value (lightness) on the surfaces of achromatic and chromatic schemes to understand the effect of hue on the environmental appraisal and task performance.

Understanding the differences between achromatic and chromatic schemes of a private office environment in terms of environmental appraisal and task performance can help to provide physically and psychologically sufficient working environments that can enhance workers' well-being and productivity. In addition, technical requirements for surface colors in office environments were considered in this study to ensure visual comfort and energy saving.

The findings of the study can be helpful for architects, interior designers, light and color designers who are studying on methods to improve workers' satisfaction and productivity office environment while considering technical specifications of light and color together.

1.2. Structure of the Thesis

The thesis consists of five chapters. The first chapter is the introduction, in which the importance of physical environment in workplaces and the variables of physical environment that affect workers health, comfort, satisfaction, performance and social relations are stated. In addition, the contribution of light and color quality to workers' general situation is mentioned.

The second chapter explores light and color conditions in office environment. The first part of this chapter explains the lighting design considerations in offices. The conditions which affecting the human visual comfort, mood and productivity are analyzed under the headings of *luminous environment conditions*, concerned with determining luminance differences, surface color and light source; *visual task considerations,* concerned with determining luminaries, and illuminance level, and

the psychological aspects of Lighting, concerned with the recent studies about the effects of lighting on workers' general situation in workplaces. The second part of this chapter explains the color use in office environment. In this part, firstly, the basic theory of color is stated with respect to *color attributes*; hue, saturation and lightness, *color contrast*, *color harmony or color schemes*; achromatic, monochromatic, analogous and complementary, and *color order systems* like Munsell and NCS color systems. In the second and third parts, color vision, and color and space perception are discussed regarding how color is perceived biologically and how it effects perception of interior spaces. The next part is color design in offices explaining the functions of color in an office environment as a design element. The other parts are psychological responses to color in offices, and color and human performance. In these parts, the effects of color on human response (their mood and evaluations) and human performance is explained with respect to recent studies.

In the third chapter, the experimental study is described with the aim, research questions and hypotheses. This chapter consists of two phases of the experimental study. In the first part of the chapter, the phase I which is a field survey is explained. The method of phase I is described regarding the sample group, the site of the survey and the questionnaire. The results of this phase are statistically analyzed so that they will be the basis for conducting the experiment room of phase II. In the second part of this chapter, the experiment is described with identification of the sample group, description of experiment room and the design of the experiment by the sub-titles: preparation of questionnaire,

preparation of performance task, process of the experiment and the phases of experiment.

In the forth chapter the statistical analysis and evaluation of the data obtained from the experiment are explained then the findings are discussed in relation to previous studies related to the subject.

The fifth chapter is the conclusion in which major points and results of the study are stated and suggestions for further researches are generated.

2. LIGHT AND COLOR IN OFFICE ENVIRONMENTS

2.1. Lighting in Office Environments

Office spaces are primarily task-oriented work environments that are obviously related to the performance of visual tasks such as reading, typing, accounting, clerical works, data processing, drafting, and computer operations. Therefore, designing lighting for office environments require an understanding of human visual system and visual performance (Rea, 2000). According to Katzev (1992), designing lighting for an office environment not only involves technical issues for the individuals' work related task, but it also influences workers' general motivational state, psychological well-being and comfort.

Standard Practice Subcommittee of Office Lighting Committee of the Illuminating Engineering Society of North America (IESNA) (1993) mentions that the major purpose of a good lighting design in the office environment is to provide the effective human visual comfort, to recognize human perception about the appearance of space, and to consider energy efficient applications all together.

Lighting design conditions, which affect the human visual comfort, mood and productivity, will be analyzed in following parts under the headings of the luminous environment conditions, visual task considerations, and psychological aspects of lighting.

2.1.1. The Luminous Environment

The visual impression of an office space depends on variations in perceived luminance, brightness, and color. These different effects can be achieved by the variations in surface reflectance, color and illuminance. Accurate design of these lighting parameters can produce interesting solutions without distracting or uncomfortable luminance differences (Rea, 2000).

Both surface color and light source color play an important role in the office lighting environment. Color has the potential to create more interesting, inviting or pleasant workspaces. In the offices, where workers are exposed to the same environment for long periods, the color in the surrounding surfaces can have influences on workers' performance and self-impressions of space. Technically, the color selected for large surfaces should have recommended reflectance values (ceilings: 80% or more, walls: 50-70%, furniture: 25-45% and floors: 20-40%) for visual comfort, and energy considerations (see Figure 2.1). The other variation is the light source color that determines the appearance of the people, furnishing and room surfaces and can specify the general atmosphere of the office environment. The two distinct application considerations of light source color are the chromaticity (correlated color temperature or CCT) and color rendering index (CRI) properties of the light source. Chromaticity refers to the color appearance of the lighted source and is designated by its color temperature in Kelvin (K). Color rendering refers to the appearance of colored objects; the perceived color of an object is affected by the color rendering properties of the lamp (IESNA, 1993).

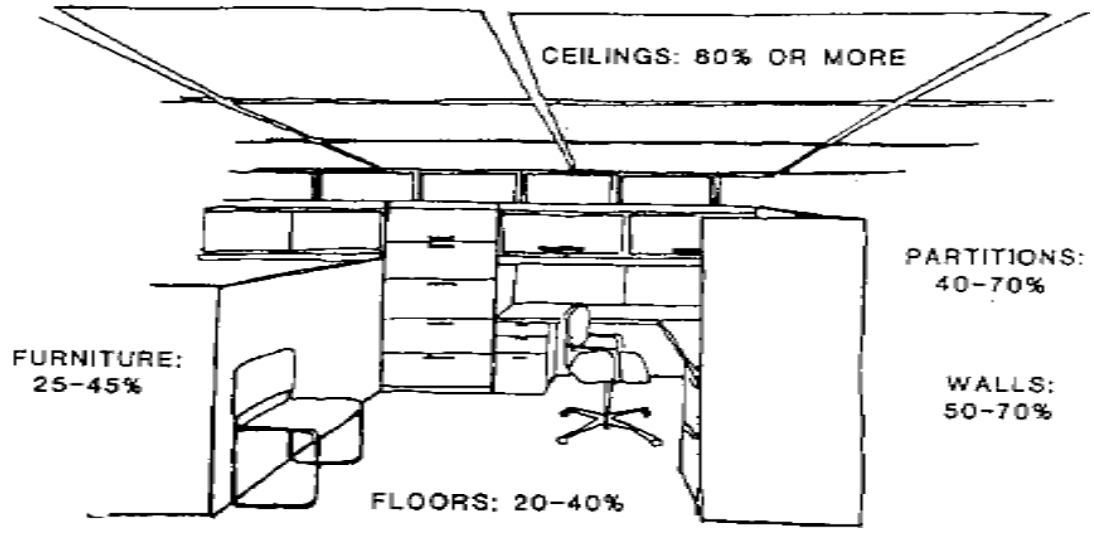

Figure 2.1. Recommended reflectance for room and furniture surfaces in offices

One of the crucial points in the luminous environment is the luminous differences and color contrast that are necessary for good vision. An interior space is visible because of the brightness differences of the surfaces. Large brightness variations within the field of view can cause a distracting glare. On the contrary, uniform illuminance with no variations on the brightness of surfaces can cause complete disorientation. Therefore, it is important to provide enough variations in luminance or color on surfaces to contribute to a stimulating environment with proper visibility (The Charted Institution of Building Services Engineers (CIBSE), 1984). Moreover, for an office environment, luminance near each task and in other parts of the office interior within the field of view should be balanced against the task illuminance (see Table 2.1). The transient adaptation (light and dark adaptation) and disability glare are two aspects of luminance ratio limits that should be considered in the recommended values for good visibility of the task by the proper eye focus. In addition, the other problematic issue in office environments

is the existence of the direct glare that can be controlled by using Visual Comfort Probability (VCP). It takes into account the proper application of the number of luminaries within the visual field, the luminaries light distribution, size and locations and the room size and reflectances (IESNA, 1993).

Table 2.1. The recommended luminous ratios between task and the other surfaces

Between paper task and adjacent VDT screen	3:1	or	1:3
Between task and adjacent dark surroundings	3:1	or	1:3
Between task and remote (nonadjacent) surfaces	10:1	or	1:10

Examining these luminous environment considerations is important for the proper lighting design of an office environment. On the other hand, ignoring the luminous environment can cause annoyance, discomfort, or loss of visual performance and visibility.

2.1.2. Visual Task Considerations

Varieties of visual tasks are required in office work. Thus, lighting design of the offices should provide optimum conditions the various visual tasks that are performed. Contrast with the background, size of the task, the absolute illuminance of the background, and time duration of the viewing determine the visibility of the details of the task. In general, the higher level of visual performance entails a great contrast and large size of the task details, a high background luminance and a long viewing duration. Visibility also depends on the

age of worker. The illuminance selection procedure should provide solutions that take the age of the worker into account. The main subjects about the visual task considerations are quality of lighting, quantity of illumination, illuminance selection, and recommended illuminance levels (Rea, 2000).

Quality of lighting is related with the proper visibility of the task. The lighting quality can be affected by the location of the luminary relative to the task, the distribution of the luminaries, the specific properties of the task and work surfaces. Poor designing of these variables can cause veiling reflections, reflected glare, and shadows, which can result in reduced visibility. The degree of glossiness of the task surface, and the geometric relationship between the light sources, the task and the eyes are important issues for the visibility of the task. If an image of luminaries or bright ceiling reflects light into the viewers' eye or to the task, the contrast will be reduced and visibility will be impaired. This effect is called veiling reflections. The other effect that causes discomfort and loss in visibility is the reflected glare. It usually occurs through a mirror image of the light source in the offending zone reflected from the VDTS and polished or glass desk surfaces to the workers eye. Furthermore, in most office environments shadows cause high luminance ratios on desk surfaces by reducing the illuminance on the task that distracts for the visibility of the task (Rea, 2000).

Quantity of lighting is about deciding on the adequate illumination level for an efficient visual performance of the office task. Knowledge of visual tasks, their importance in the operation of the office and the age of the occupants are essential for the specifications of the lighting levels (IESNA, 1993). In addition,

energy considerations and economics are issues related with the quantity of the lighting. Light loss because of luminaries' dirt depreciation and lamp lumen depreciation should be considered in order to achieve the desired lighting levels for the tasks and to prevent high energy consumption (CIBSE, 1984). In determining an appropriate illuminance level, it will be helpful for the designer to analyze the future occupants' profile and the properties of the activities that will occur in the office. Besides, the designer should consider how the illuminance is to be delivered in the space, to what locations and the room surface conditions. There are recommended illuminance levels for different tasks and locations in office environments (see Table 2.2). Designers have the opportunity to use these values while determining the lighting specifications for offices (Rea, 2000).

Table 2.2. Required illuminance levels for visual tasks

Orientation and simple visual tasks	
Public spaces	30 lx
Simple orientation for	50 lx
Working spaces where simple visual tasks are performed	100lx
Common visual tasks	
Performance Of visual tasks of high contrast And large size	300lx
Performance of Visual tasks of high contrast and small size	500lx
Performance of visual tasks of low contrast and small size	1000lx
Special visual tasks	
Performance of visual tasks near threshold	3000lx-10.000lx

From *IESNA Lighting Handbook: Reference& Application.* (9th ed.). New York: Illuminating Engineering Society of North America.

2.1.3. Psychological Aspects of Lighting in Offices

In the past, the research on the effects of lighting mainly focused on functional aspects like visibility and visual comfort. During the 1960's and 1970's lighting designers and researchers started to remark that lighting also influenced people's subjective impressions of the environment surrounding them. Therefore, besides providing the proper quality and quantity of illumination for visual performance, it became important among designers considering alternative solutions which may provide different cues for subjective responses of users (Murdoch & Caughey, 2004).

Although office spaces are primarily task oriented, other effects of lighting on long-term user satisfaction and well-being should be considered in the design process. There is a body of literature that concentrates on the subjective responses to lighting. Flynn (1977) conducted an early study about the effects of lighting conditions on subjective impressions. Four characteristics of lighting have been found to be important in design process, which are overhead/peripheral, bright/dim, uniform/nonuniform, and visually warm/visually cool. Variations in intensity, distribution and color tone of the lighting exert some influences on subjective impressions about the environment such as spaciousness, relaxation, visual clarity, privacy, order and pleasantness. These influences should also be carefully considered as an integral part of the office lighting; by doing so, the designer has the opportunity to enhance characteristics of the workplace in an adequate way (Rea, 2000).

The presence of visual and psychological comfort conditions in an office environment increases motivation and well-being of the users, so the main purpose of the office lighting is to help to provide comfortable, satisfactory and efficient working environments that will enable higher performance and improved productivity. In this context, research has been conducted to clarify the relation between lighting quality parameters and aesthetic, emotional judgments, productivity and performance in office environments.

Veitch and Newsman (1998) studied on a model for the behavioral definitions of the lighting quality in an office setting. According to the study, the lighting quality exists, when the luminous conditions are suitable for the needs of people who will use it, and these needs include mood state and aesthetic judgments. The experiment was conducted to test if the designers' energy efficient lighting solutions are compatible with good quality lighting since a space can be accepted as appealing and high quality with regard to the aesthetic and emotional judgments and productivity of the participants. The results showed that energy efficient lighting design and impressions of lighting quality can be compatible. This may be the ideal solution, providing an efficient office environment.

Manav (2007) conducted an experimental study about the effects of color temperature and illumination level on the subjective impressions at an office setting. It was found in this study that high level illuminance (2000 lux) was preferred to low level illumiance (500 lux) for the impression of comfort, spaciousness, brightness, and saturation level. In addition, 4000K color temperature was preferred to 2700K for the impression of comfort and

spaciousness, yet 2700K was suggested for relaxation. A field study in a modern office setting was conducted by Akashi & Boyce (2006) to examine office workers' response to lowering the ambient illumiance level and brightness perception related with the color temperature. According to the study, office workers were generally satisfied with the lower level of ambient lighting after an initial adaptation period and they increased the use of task lighting at their task. In addition, applying 6500K lamp increased the perception of brightness with the lower ambient lighting.

In addition to the research related with the subjective impressions of participants in an office environment, there are studies particularly focused on the effect of lighting on performance in the offices. Manav & Küçükdoğu (2006) carried out a study inspired by the statement that productivity and performance at offices can increase as long as comfort conditions are satisfactory. The experimental study examined the effects of illuminance level and color temperature on the performance. After applying a variety of combinations, the test results indicated that the change in the illuminance level did not affect the performance of the participants. Yet, the change in color temperature affected performance. In addition, the most commonly preferred lighting scenarios were the settlements with mixed color temperature (the combination of 4000k and 2700K).

Ödemiş, Yener & Camgöz (2004) have composed a study investigating whether different types of lighting have an effect on the visual performance of office workers. The experiment was conducted in a controlled environment with wall washing, cove lighting and up lighting types. According to the data collected,

there is not a relation between different types of lighting and human performance. Knez (1995) has investigated two experiments concerning the effects of indoor lighting on cognitive performance and mood occurring in office-like settings, and gender is introduced as an additional grouping factor. In the first experiment, the two varied lighting parameters were illuminance level (bright or dim) and color temperature (cool white or warm white) at high color rendering index (CRI). In the second experiment, the two lighting parameters were identical except the CRI. Results of the first experiment shows that the color temperature that induces the positive mood also enhances the performance in the long-term memory and problem-solving tests. On the other hand, in the results of experiment two, it is observed that subjects' mood and their cognitive performance vary significantly with the gender differences. Thus, Knez suggests that the criteria for good indoor lighting may be revised towards females' and males' emotional and cognitive responses as well. In addition, some studies signify that lighting systems that enables occupants to adjust as many aspects of their lighting conditions as possible without disturbing other workers in the space make them feel more comfortable (Vischer, 1989).

Admittedly, there are variables of different results of these experiments in nature, and the psychological effect of a particular lighting design solution may not be the exact truth for any other situations. However, these studies can establish guidelines for designers to make better predictions about lighting quality during the design process.

2.2. Color in Office Environments

Color is used in interior design for different purposes since it is a flexible and powerful design element that serves as a tool of communication between people and the built environment (Holtzschue, 2006). Color plays an important role for the variables of environmental design such as theme, ambiance, image, function, built form, location, and direction. Therefore, the correct use of color can reinforce users' ability to interact with their environment properly. In addition, color as a design tool is relevant for presenting the aesthetical, symbolic or cultural meanings of environments by the appropriate usage of the color combinations (Smith, 2003). It is evident that there are different criteria, and design objectives for different environments that require distinct ambiences and serve for varied functions. Hence, the color design of the spaces should be specified in accordance with the desired impression and function. Furthermore, colors can have strong influences on people's moods, emotions and preferences. Thus, it is influential on the people's perceptions and subjective impressions about their surrounding environment. For instance, it is reported that while red represents energy and power, blue represents relaxation and calmness (Mahnke, 1996).

The functions of color in an office environment are varied, such as to define the space atmospheres or the character of the companies by the accurate color harmony (Faulkner, 1972). Particularly in recent years, color specification of offices has also been considered with its psychological effects on workers, since people spend an increasing amount of time in their offices. In terms of psychological conditions of workers, there is research focusing on how color and

color combinations as an environmental factor affect workers mood, productivity, and subjective impressions about their environment.

2.2.1. Basic Theory of Color

To make use of color effectively, designers need to understand the basic terminology of color. Hue, saturation and lightness (value) are three attributes of color, which are used to distinguish one color from all other perceived colors. *Hue* is the quality or characteristic of color that is usually associated with names such as red, blue, yellow, green, violet, etc., which are determined by wavelength (see Figure 2.2). White, black and gray are perceived as colorless and this lack of color (chroma) causes them to be termed as achromatic. *Saturation* is the other attribute that refers to relative purity, strength, intensity or chroma of a given color that distinguishes it from a grayed or weaker color. Two colors may be exactly the same hue, but the difference in saturation will appear different in color strength. *Lightness* of a color is a measure of how much light is reflected from its surface, and the quality that generates the light or dark color. Sometimes, the terms brightness or value are used as a synonym for lightness. In this dissertation the term *value* will be used in the other parts (Mahnke, 1996; Ferhman & Ferhman, 2000).

Figure 2.2. Color Wheel devised by James Maxwell

From .Wise, B. K., & Wise, J. A. (1988). *Human factors of color in environmental design: A critical review*. California: Ames Research Center.

For effective color design, comprehending the *color contrast* is essential to determine how a color is perceived, how a color scheme is developed and how objects are highlighted or concealed. “In everyday experiences, contrast is a comparison that emphasizes differences. Seeing detail and transmitting information are mediated in the visual world by contrast “(Camgöz, 2000, p.29). When there is an inherent contrast caused by chromatic information, the attribute of saturation of the color is called *color contrast*. For interior design, color contrast may be used to create different impression such as emphasizing contours with hue, value and saturation contrasts, or the contrast between walls and furnishings will make the furnishings more prominent (Mahnke, 1996). Colors are chosen in order to create definite harmonious color schemes of environments. Designers should consider the psychological and physiological effects of color in the environment taking into account both the functional and aesthetical role of the color. Understanding what makes a combination of color pleasing and the other one unattractive can be difficult. Today, many designers

reject rigid rules in favor of applying innovative works. However, awareness of traditional color harmonies can be useful in understanding why certain colors work together and why some of them do not (Ladau, Smith & Place, 1988).

There are four basic color harmonies or schemes which are achromatic, monochromatic, analogous, and complementary (see Figure 2.3). *Achromatic* schemes occur when only neutrals- white, gray, black and beige- are used. In *monochromatic* color scheme, only shades and tints of one color family are used in color plan; for example pale green with pure green and dark green can be used together. Yet, in such an arrangement, designer should consider the risk of a monotonous atmosphere. *Analogous* or related harmonious combine a limited number of (no more than two or three) adjacent (colors next to each other) hues on the color wheel, such as the usage of red, yellow-red and yellow together. *Complementary* schemes are based on hues directly opposite to each other on the color wheel. These schemes introduce both warm and cool colors into the environments. The options are the combinations of red and green, orange and blue, or yellow and violet (Ferhman & Ferhman 2000).

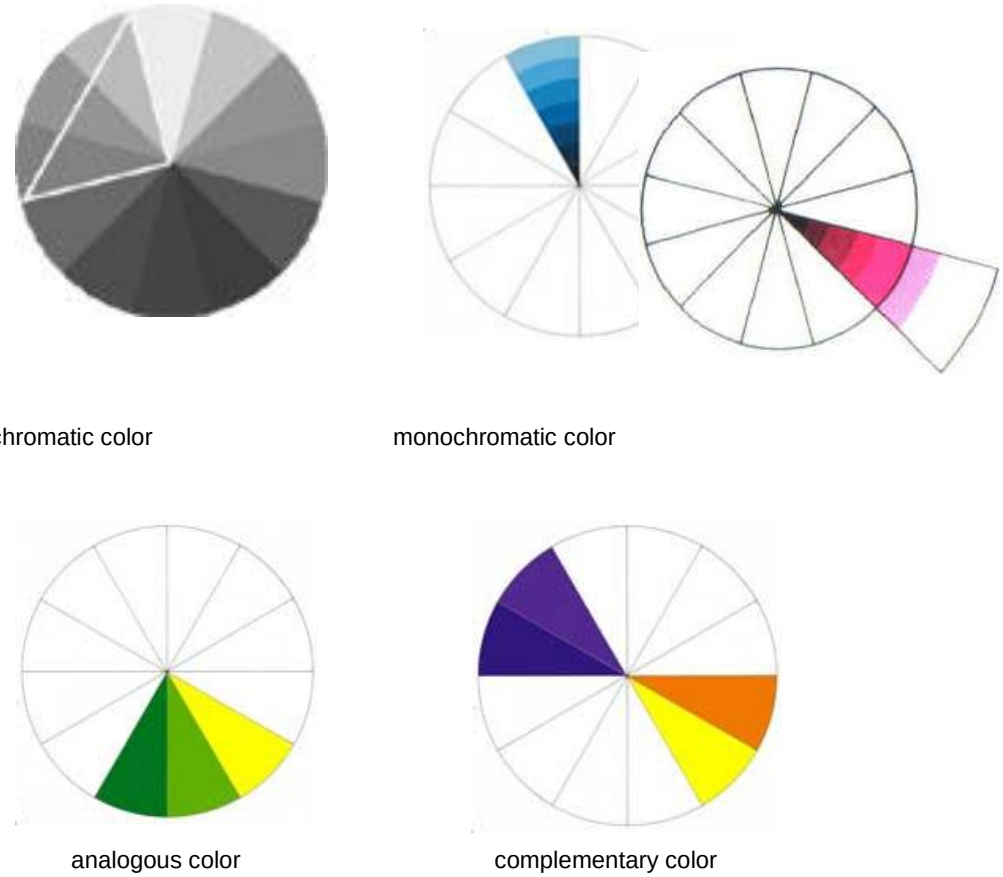

Figure 2.3. Examples of Color combinations of color schemes

From Fehrman K. R., & Fehrman, C. (2000). *Color: The Secret Influence*. New Jersey: Prentice-Hall. (http://www.color.interiordezine.com/colorschemes/how-to-use-the-color-wheel-1.html)

Anyone working seriously with color needs to understand color classification systems to identify color in a systematic manner. These color order systems have been developed to bring an organization into the confusion of the color range towards presenting the colors in sequence, and according to their relationship to each other (Mahnke, 1996). There are different color ordering systems that are developed such as the CIE Lab System, HSB Color System, the Ostwall System, the Munsell System and Natural Color System (NSC). Mahnke (1996) stated that one of the most widely used methods for color notation is the American Munsell

System (see Figure 2.4, 2.5).This system uses five principal and five intermediary hues which are arranged clockwise on the color wheel by the name such as red (R), yellow-red (YR), yellow (Y), green-yellow (GR), green (G), etc. Then, each named hue is subdivided into four sections displayed as 2.5R, 5R, 7.5R, 10R. In addition, the value scale of the Munsell system extends from absolute black (value symbol is 0) to absolute white (value symbol is 10) and the value symbol of 5 stands for the middle value of gray.

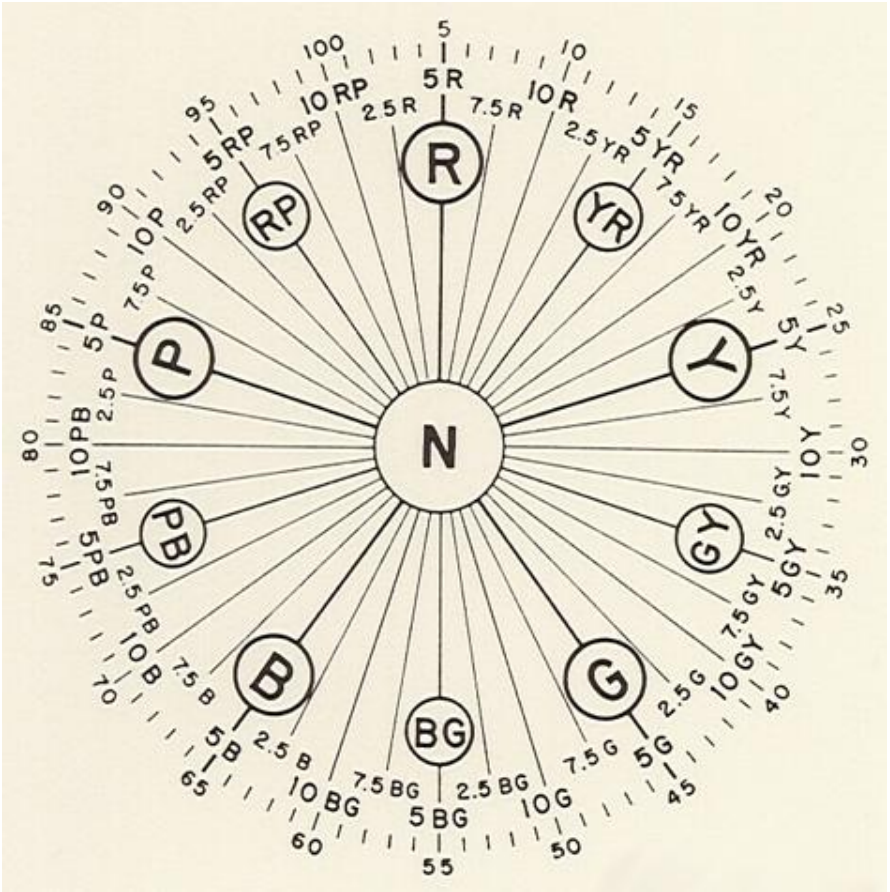

Figure 2.4. Munsell's Arrangement of colors

From Kollmorgen Instruments Corporation. (1991). *Munsell Book of color: Glossy finish collection*. Baltimore, Maryland.

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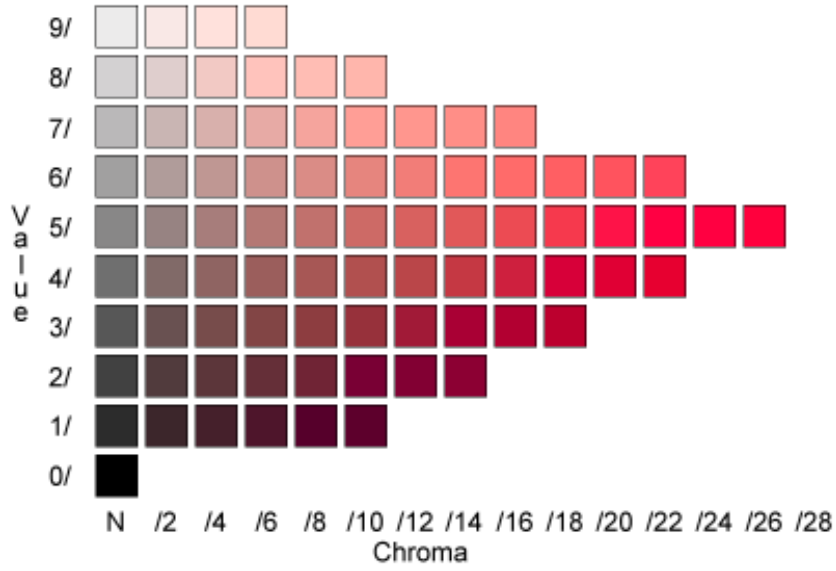


Figure 2.5. Munsell's value (vertical) and chroma (horizontal)

From Kollmorgen Instruments Corporation. (1991). *Munsell Book of color: Glossy finish collection*. Baltimore, Maryland.

In this study, Natural Color System (NSC) was used for the arrangements of the color schemes for the experiment room (see Figure 2.6, 2.7). It is based on defining six natural color sensations, which are red, yellow, green, blue and black, and white. "In the NSC system, the chromatic hues are arranged in a circle with nine intermediate steps between each, totaling forty hues. Then, for each hue, a triangular chart is developed showing the pure hue and its relationship to white and black "(Ferhman & Ferhman 2000, p.205). The NSC color atlas includes 1750 color samples designated in NCS color triangles in each page with different hues and their relationships with white and black (Swedish Standard Institution, 1996).

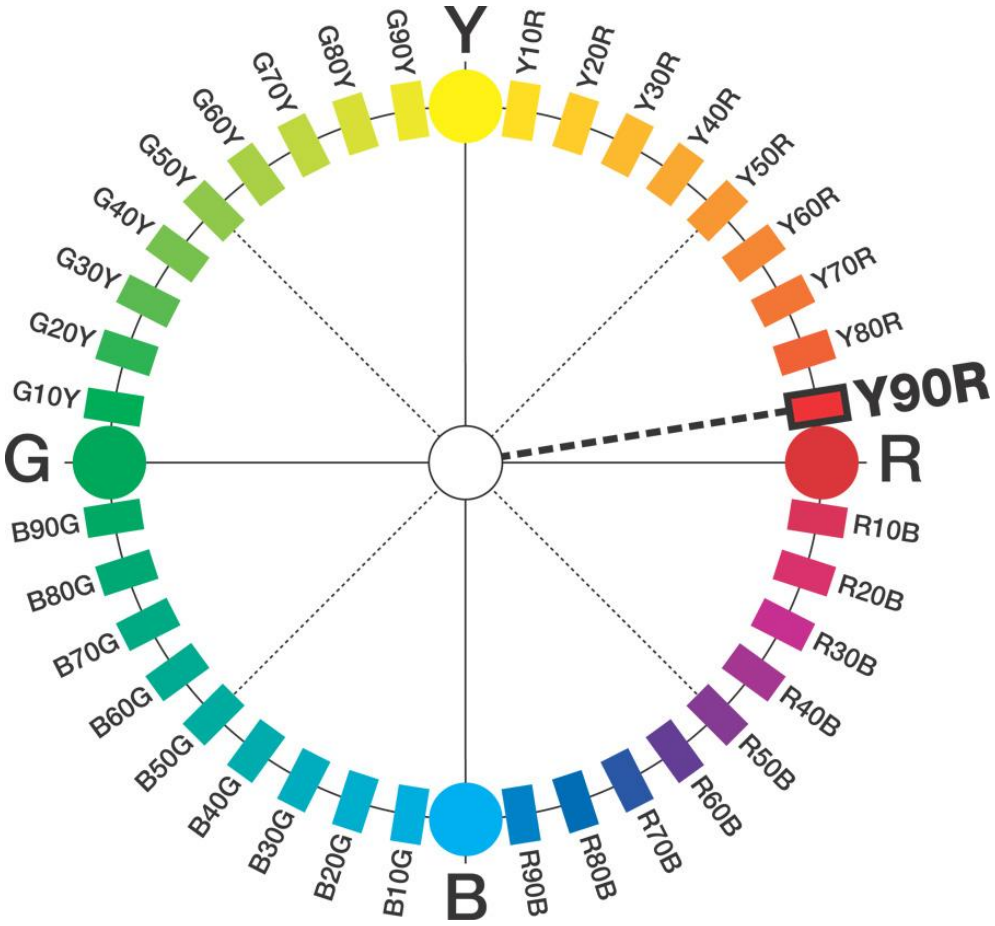


Figure 2.6. NSC Color Circle

From Swedish Standard Institution. (1996). *Natural Color System Atlas*. Stockholm, Sweden.

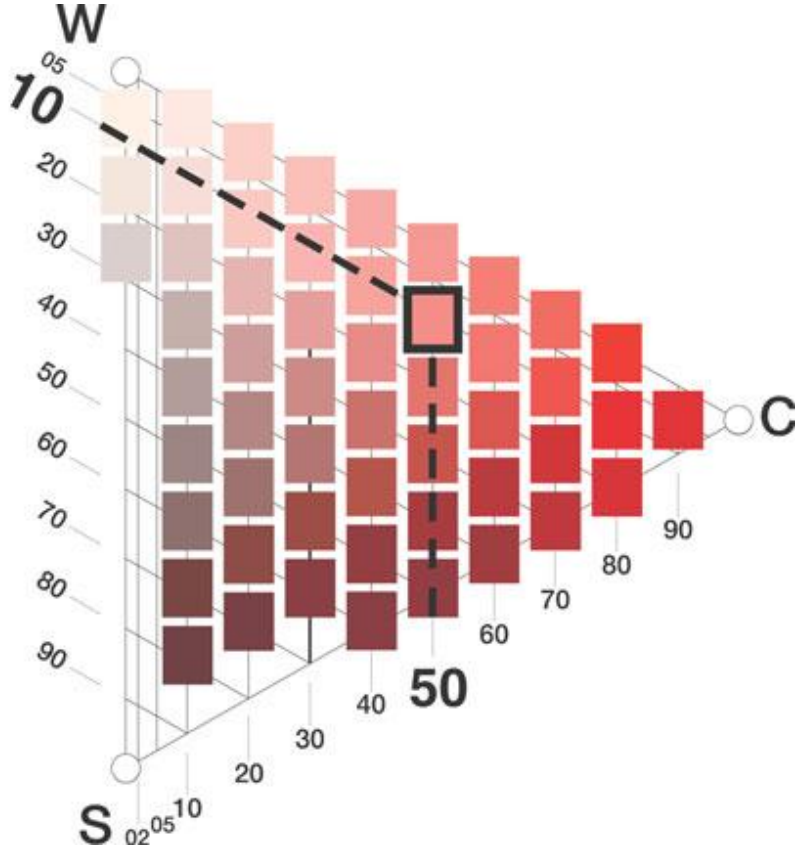


Figure 2.7. NSC Triangle

From Swedish Standard Institution. (1996). *Natural Color System Atlas*. Stockholm, Sweden.

2.2.2. Color Vision

In order to gain a true understanding of color, it is essential to know how humans see color. Color does not exist without light, humans see color when different wavelength of light stimulating certain parts of the brain. It has been proposed that color vision is based on three types of cone in our eyes containing three types of visual pigment. These human cone pigments are sensitive to three different ranges of the spectrum, which are called red, green and blue, and all the other colors are seen through combinations of them. On the other hand, there are color blind people who are not able to see or differentiate between some colors.

This is caused by either a lack or reduced number of cones of a given type. Designers should be sensitive to the situation of defective color vision problems when working with clients (Holtzschue, 2006). It was also demonstrated that the world is colored by reflections and absorptions; it is not an inherent property of an object (see Figure 2.8). Ladau, Smith &Place (1988) explains this situation as following

> When light hits an object some of the light waves absorbed by the molecules of the objects surface, while others are completely or partially reflected off the surface. These reflected light waves are picked up by our eyes and transmitted to the brain as color information. To appear red, for example, an object will absorb almost all of the spectral wavelengths except the reds which will reflect (p. 46).

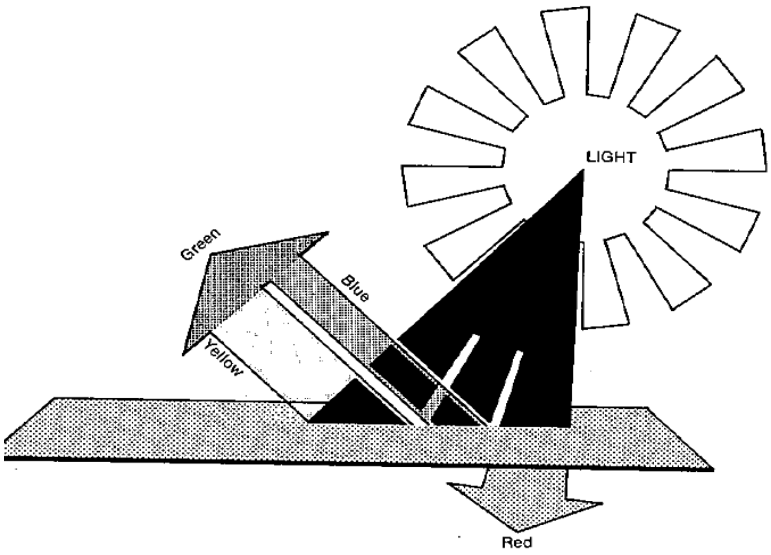


Figure 2.8. The perceived color reflected from the surface

From Ladau, R. F., Smith, B. R., & Place, J. (1988). *Color in Interior Design and Architecture.* New York: Van Nostrand Reinhold.

Therefore, the experience of color depends on the intensity of light, the spectral characteristics of light falling on a surface, the reflectance characteristic of the surface and the color of surrounding objects. All light sources, whether natural or, variables of artificial such as incandescent, fluorescent, sodium, or vapor, creates

differences in the vision of color. In addition, it is important to consider the combinations of light sources, such as natural daylight with incandescent or natural daylight with fluorescent that affects the way color is viewed. When considering lighting, designers should be aware that if they choose to use colored light, this will distort the vision of all the colors in the space except its own. For instance, red light converts pale and warm colors into a uniform red and makes dark colors look black (Mahnke, 1996; Ferhman & Ferhman, 2000).

Beside these biological and technical issues affecting the way color perceived, there are some other complex factors including the observer into the process such as the viewing direction, observer characteristics, observer adaptation, time of seeing, what was seen last and how attention was focused on the process (Camgöz, 2000).

2.2.3. Color and Space Perception

The primary aspect for designers to consider for interior color design is to start with understanding the fundamentals, and from there, to find the ultimate color solutions for specific design situations. Throughout the design process, designers should consider both the psychological properties of color and the effects of color on spatial dimensions. Whether it is possible to measure the psychological responses to color accurately has been questioned since cultural, geographical, economical, or educational differences will affect generalizations on this issue. However, collective findings have shown that there are basic reactions to specific colors common to most people, which make the color a universal language.

Thereby, color impressions, associations, and the character of each major hue can guide designers to understand how people perceive a space to be impressive by the color applications (Birren, 1978).

As mentioned above, color choice and the way of its applications are effective design parameters to create the required and desirable space atmosphere. For instance, red as an arousing, exciting and stimulating color with the associations of passion, strength, and activity, will seize all the attention and defuse all other hues. It creates dynamic interiors. On the other hand, blue with its relaxing, retiring, and cool effect, creates impressions of calmness, security, comfort, and contemplation. Moreover, it was stated that warm and luminous colors produce cheerful, high-spirited and expansive environments, but they may also create a centrifugal action that directs the attention outward, toward the environment. Conversely, cool and lower level of illuminance is accepted as producing centripetal action that encourages inward orientation and enhances the ability to concentrate (Wilson, 1966; Jacobs & Hustmyer, 1974; Mahnke, 1996).

Furthermore, there are reliable studies that clarify the color's psychological alphabet including the significant relationship among the color attributes (hue, saturation, value) and perceived volume, weight and size, temperature, noise and sound, complexity, distance, arousal, spaciousness, etc. These associations play an essential role in the design of environments especially where color is used to inform and communicate. About the perceived volume of the spaces, it is indicate that value (lightness) of the color is an important factor in the perception of the openness in interior space. For instance, light and pale colors are admitted to be

colors that increase the apparent room size, yet dark or saturated hues are admitted to be the ones that decrease the volume of the room (Mahnke, 1996; Ferhman & Ferhman 2000).

Across a variety of research, it has been proved that value (lightness) and saturation of colors are attributes that evoke different impressions of weight. In general, darker colors appear heavier, while lighter and less saturated colors seem less heavy, and there is a tendency to perceive the warmer hues as heavier. Considering these general concepts for interiors, extremely high ceilings painted in darker and warmer hues will seem lower. Likewise, low ceilings will be perceived higher if painted in light and cool colors. In addition, to decrease the height to width ratio of an enclosed space, perceived heavier color can be placed above perceived lighter colors that may also enhance the furniture appearance. It is stated that at constant distance, bright colors appear nearer that dark ones. In this case, brightness or darkness of a color is the operative cue for apparent color distance. In addition, objects showing high contrast with their backgrounds will be in apparent positions. In this case, spaciousness of a space is enhanced by increasing the lightness of the surfaces and decreasing the contrasts between objects and background. Perception of spaciousness can also be enhanced by the uniformity of the colors in a harmonious balance obscuring the appearance of the interior space as a whole that will reverse the desired solution (Wise & Wise, 1988).

Additionally, several studies exist about the relation between the color and the association of the temperature. For instance, Itten (as cited in Mahnke, 1996)

stated that according to the results of their experiment on the subjective feelings of heat and cold between two workrooms, occupants of the blue-green room felt cooler than the occupants of the red-orange room, even though they were adjusted at the same degree of Fahrenheit. In another study by Norwegians, similar results have been obtained about the perception of temperature with regard to color of the space since it was seen that people tended to set the thermostat of the heater four degrees higher in a blue room than in a red room . Some other studies also showed a strong relationship between existing room temperature and color preference of people. For example, when the indoor temperature was low people preferred warm colors like red, but when temperature was high, people preferred cool colors like blue. With regard to these findings about color and temperature perception, research indicates that interior colors can aid thermal comfort concerning energy conservation since perception of temperature changes in relation to interior colors (Wise & Wise, 1988).

In that sense, Pedersen, Johnson & West (1978) have conducted a study about the effects of room hue on ratings of self, other and environment, requesting size and temperature estimations. 51 subjects were exposed to one of three rooms, which were decorated using either warm (yellow, orange, red), neutral (white), or cool (blue, green) hues. The semantic differential was used to rate the room, and the results showed that the neutral room and the cool room were found smooth and light whereas the neutral and warm rooms were found good and pleasant. However, no significant differences were found between three rooms in terms of the estimations of temperature and size.

The other case among the color and perception related issues is the relation between color and noise-sound perception. According to the psychologists, such as Werner, Krakov, and Schwartz (as cited in Mahnke, 1996), loud noises, strong odors and tastes make the eye more sensitive to green and less sensitive to red. Therefore, for design purposes, the designers may benefit from the relationship between color and noise, especially to compensate for noise problems in work environments such as industrial plants. For instance, it has been claimed that a noisy atmosphere painted with glaring yellows or reds will be experienced as noisier and more bothersome; thus, such noisy environments with shrill and high-pitched sounds can be compensated by the applications of light blue-green colors. In addition, it has been found that muffled sounds are more striking in darker-hued environments, so light colors such as light clean greens can be used to treat the undesired results (Mahnke, 1996).

2.2.3. Color Design in Offices

Color serves many purposes in the office design. It may function to define the space atmospheres or areas and territories between different departments of companies, to facilitate visual recognition in wayfinding and, to define the character of the company by different impressions of the colors. Besides, in terms of physical and psychological conditions of workers, color is also considered as an environmental factor affecting workers visual health, mood, and productivity (Marberry & Zagon, 1995).

In addition to providing an aesthetical look, the color choice of an office environment should subject the functional aspects such as improving illumination,

reducing glare, making seeing easier, lessening contrast, minimizing constant eye adjustment, drawing concentration to task and drawing attention to any possible hazards (Reyes, 1986). Birren has stated that (as cited in Reyes, 1986) skillfully selected colors can create healthier and more comfortable working conditions, since color has the ability to control brightness, adding efficiency and comfort to seeing, while preventing fatigue and eyestrain. Addressing the functional role of color design in office environments, Kaufman & Christen (1972) mentioned that

> A positive contribution to the pleasantness of any office interior is the proper selection of color combinations. These should be selected in consultation with the architect or interior designer, but should have the reflectances necessary to provide the proper luminance ratios for efficient seeing (pp.13).

The luminance on the task should not differ greatly differ from the luminance within the field of view, especially from the surrounding area. The luminance ratios between the task and the adjacent surroundings should not exceed 1 to 1/3, and luminance ratios between the task and the more remote surfaces, should not exceed 1 to 1/10. As the illumination reflected from ceilings, walls, floors, the furniture and office equipments influence these ratios; the surfaces should be at the recommended reflectance levels (IESNA, 1993).

Color selection for offices may have an impact on energy costs of the buildings by supporting the artificial lighting, since according the recent research, artificial lighting is one of the major electricity consuming items in office buildings, accounting for about 20-40% of the total building energy load (Li and Tsang, 2008). Room surfaces including walls, floors and ceilings have a considerable effect on the utilization of light through their reflective qualities. If the recommended reflectances are applied on these areas (applications of light

colors), they will act as secondary light sources and will increase the utilization of the light in the environment (Reyes, 1986).

For years, designers have preferred to use white and off white for the walls of offices regarding the energy efficiency and the neutral trend that present a high-tech, clean, impersonal, and unadorned image. By contrast, according to some other studies, white walls are an optical strain and psychological hazard; they describe the color white as empty, neutral and lacking vitality. It is claimed that many complaints of eyestrain are often because of the glare of white walls. The recommend light reflection levels of wall surfaces are 40 to 60 percent and this can be strengthen up to 70 percent depending on the lighting conditions. However, it is evident that the minimum light reflection level of white or off-white is about 81 percent; that is, not matching with the recommendations for visual comfort (Mahnke, 1996).

For color specifications in offices, Birren stated (as cited in Marberry, 1994) that “Color for the sake of color is hardly sufficient” (p.26). He argued that designers need to appraise color in both functional and human preference terms to improve the comfort and pleasure and he concludes that “Where workplaces are concerned, simplicity is the keynote. Soft colors, which lack distraction, are modified in tone and get less dirty than clean colors” (p.27). Birren’s color palette for working environments include white for ceilings, and softer hues such as pale blue-green, light green, pink/coral, pale yellow, light gray, sandstone ,beige for wall finishes. All these colors are aesthetically, and physiologically desirable and they prevent monotony and provide a temporary rest and relaxation of the eyes.

He warns designers against using bright colors since this choice may distract workers from their tasks (Marberry, 1996).

To enhance the color design of offices, determinations of the color schemes and hue selections should be in accordance with the lighting design that will help avoid the problem of significant color shifts and of failures in metameric matches. The luminous reflectances of colored surfaces will differ according to the SPD (Spectral Power Distribution) of the light sources (the attributes related with CRI and CCT of the light sources). For instance, with illuminations from incandescent sources, which have long-wavelength portions of the visible spectrum, warm color surfaces such as yellow ones appear lighter and the cool colors such as blue surfaces appear darker than they do under daylight illumination (Rea, 2000). Furthermore, in many office interiors, the absence of natural light need to be compensated with full-spectrum artificial lighting with proper color rendition index (CRI) and a full- spectrum color palette for accessories and office equipments may also enhance the quality of the environments (Marberry & Zagon, 1996).

In office buildings, the appropriate usage of color can assist orientation and define territory. For instance, color can be used to designate a pathway system in a complex environment or it can be an orientating cue by defining different floor levels and corridors. Moreover, by the symbolic meanings of different hues, color may be useful to identify the atmosphere and can define different departments of the companies. For instance, it has been claimed that using bright, rich colors applied to trims in combination with moderate colors or neutrals can create visual

interests for visitors, define workspaces, and distinguish between various business divisions (Reyes, 1986).

2.2.4. Psychological Response to Color in Offices

Workplace environment has been shown to be strongly correlated with workers' psychological well-being. In this context, the colors on the surfaces are considered as an environmental factor affecting workers mood, satisfaction, and subjective impression of the spaces. Psychologist have tested whether particular colors excite particular feelings and influence one's emotional state and preferences by showing people various hues and asking for associations. The results generally support the idea that different colors elicit different responses, even inconsistent ones. In a study by Hevner (as cited in Sundstrom, 1986) red was associated with excitement and happiness, while blue connoted serenity and dignity. According to some later studies, warm colors were linked to anxiety and stress, while cool colors continued to exhibit tranquility and very inconsistently, even depression (Jacobs & Suess, 1975). Furthermore, saturation and value have been cited as important factors for determining the color pleasantness. Guilford & Smith (as cited in Kwallek, Woodson, Lewis & Sales, 1996) found that as value or saturation increased perceived pleasantness increased independently from color itself. In a study conducted by Brill, Margulis & Konar (as cited in Kwallek et al., 1996), dealing with the color preference, pastel cool colors (blue-green) were rated as most preferred among 1000 respondents.

Although all these results of the studies can be useful cues for designers to enhance color applications in interiors they were not as realistic as possible,

since judgments were rendered from subjects by viewing color slides, swatches, light or color pictures from a room. This is not how color is seen in the interior environment; individuals need to be exposed in a real, three-dimensional environment with all its inherent complexities such as color combinations on the different surfaces, different furniture styles, accessories and textures. When research is done in settings that closely stimulate a real interior environment, results will be different from those run in isolation. Regarding these circumstances, recent studies dealing with human responses to color in office environments aimed to create realistic office settings that would provide possibilities to make measurements more reliable. In that sense, there are studies, investigating how color, color attributes or combination of colors affect workers' well- being, satisfaction and subjective impression of the spaces.

Kwallek, Lewis & Robbins (1988) have designed an experiment to examine the effect of office interior color on workers' mood and productivity. 36 subjects were asked to fill out the Eight State Questionnaire, measuring mood in either monochromatic red or blue office spaces. The experiment consisted of two phases, and in the second phase, subjects were guided to continue the experiment at the same colored office or move to the different colored office. According to the results of the questionnaire, group differences were not statistically significant, but the mean anxiety and stress scores were higher for the subjects who were always in the red office; the mean depression scores were higher for the subjects who were always in the blue office, and the mean arousal scores were higher for the subjects who moved to the different colored office during the experiment.

Kwallek (1996) has conducted a study examining the effects of office wall colors on the assessment of spaciousness and preference. In the study, three offices painted with red, green and white were evaluated by 124 undergraduate students. The results showed that the white office was perceived as more spacious, compared to red and green offices, and white was chosen as the most appropriate and preferable color for an office interior. Another study by Kwallek, Lewis, Lin-Hsiao & Woodson (1996) was designed to determine the effects of nine interior office colors on subjects' performance, mood and color preference. A total of 675 subjects participated in the study and gender was introduced as an additional grouping factor. The statistical analyses showed that subjects were least likely to work in the orange and purple colored offices and preferred to work in the beige and white offices. Further, females indicated more depression, confusion and anger in low-saturated offices' colors such as white, gray and beige whereas males reported more depression, confusion and anger in high-saturated office colors such as green, blue, red, yellow, and orange. In one of the studies, it was also realized that interior office colors might affect the perceived performance and job satisfaction. Three different color schemes were applied in three laboratory office settings where workers performed specific office tasks for four consecutive days. According to the results, those in the white and predominantly blue-green offices reported higher perceived performance and job satisfaction than those in the predominantly red office (Kwallek, Soon, Woodson & Alexander, 2005).

A cross-cultural study of indoor work environments directed by Küller, Ballal, Laike, Mikellides & Tonello (2006) aimed to determine whether indoor lighting and

color would have any systematic impact on the mood of people working indoors. The study was carried out in real work environments at different seasons, in countries with different latitudes, and with a total of 988 persons participating to the all of the parts of the study. The results indicated that the color of the workspaces stands out as a rather important environmental factor for the workers. It was specified that the index of emotional status was higher throughout the year for those who had the most colorful work environments. According to the results, the use of good color design might contribute to a more positive mood.

2.2.5. Color and Human Performance

Human beings always perform some activities in some contexts in their daily lives, which are the main concept of human to be a living (Bailey, 1982). Human performance can be improved or degraded by the effects of physical and social environment. For instance, poor design decisions may impair the activity being performed including the tools being used or even the context in which an activity is performed (Sundstrom, 1986). Other factors such as motivation, stress, fatigue, etc., play an important role on human performance and must be taken into account. In this respect, Bailey (1982) developed a human performance model that requires an understanding of the human, the activity being performed, and the context in which it is performed (see Figure 2.9). According to the model the following elements must be taken into account for an acceptable level of human performance: the general state or condition of the human, the specifications of the activity including any required tools or equipments, and the context including the psychical environment such as lighting, temperature, noise, etc. and the social environment such as crowding, isolation, etc.

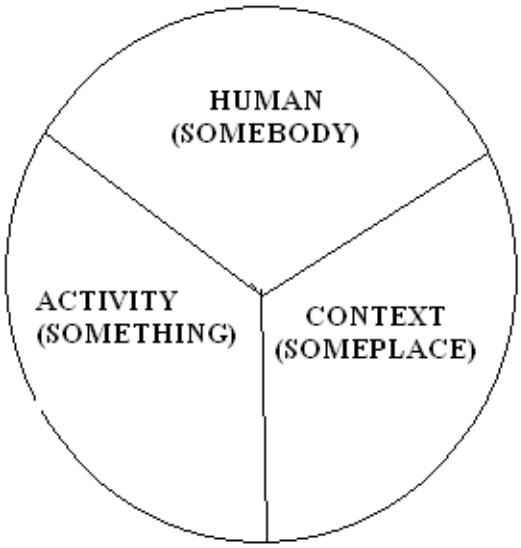


Figure 2.9. Robert W. Bailey Human Performance Model

From Bailey, R. W. (1982). *Human performance engineering: A guide for system designers*. New Jersey: Prentice-Hall, Inc.

Office environments are the spaces where people perform a pattern of actions carried out to satisfy an objective according to some standards. Office workers keep records and files, conduct conferences and discussions, perform calculations, compose written texts and do other tasks involving details about planning and directing the activities. Studies indicate that improvements to the work environment could result in a substantial increase in workers' comfort and satisfaction, which are directly proportional with their productivity that could be measured by the quality of the productions, resignation rate, time spent in the office, and attendance (Vischer, 1989; Gifford, 2002).

Color is considered as one of the environmental aspects of workspaces, that may affect the performance, yet as mentioned before, very little quality research that directly relates to workplaces has been conducted. Research on the influence of

color on performance indicates that colors create arousal which, in turn, stimulates faster work (Sundstrom, 1986). Some earlier research confirms the stimulating effect of red against green by measuring the psychological index of arousal (galvanic skin response or GSR) while students were watching the green and red colored slides (Jacobs & Hustmeyer, 1974). On the other hand, Birren as a color expert (as cited in Sundtrom, 1986) advised cool colors that would be best for the tasks requiring visual quality and mental concentration. In one of the early studies on this topic by Hammes & Wiggins (as cited in Kwallek, Soon & Lewis, 2007) high and low anxiety participants were exposed to three different color illuminations, including red, blue and white, while performing a perceptual motor steadiness task. The results did not indicate any differences among three color illuminations on motor performance test. In another study by Gofellow and Smith (as cited in Kwallek, et al., 2007), twenty-five female participants performed psychomotor tasks in five different colored tabletops in a booth, and no significant differences were found among the five color conditions.

Later studies have focused on investigating color as an environmental effect in more realistic interior settings rather than as an isolated stimulus, since early studies examining the color effects on human performance were on the restricted objects or surfaces that failed to detect the detailed relation between color and human performance. One of the studies related to this issue has been conducted by Ainsworth, Simpson & Cassell (1993) about the effects of red, green and white office interior colors on participants' mood and performance. The given task was to type words and the work performance was measured by typing errors and the ratio of errors to words typed. They found no significant performance difference

between the groups and suggested that this was because of the short-term measurement of the performance. The other study was by Kwallek & Lewis (1990) and it was designed to assess the effects of red, green and white office environments on workers' productivity and mood. Participants performed a proofreading test in three settings. The results indicated that participants in the white office made significantly more errors than the participants in the red office. However, the subjects who worked in the red office found the color of the office distracting and reported more tension while the subjects in the white office reported that they would like to work in this environment and considered this color most appropriate for an office. The authors commented that participants focused more on the tasks in red and green offices to cope with environmental stress but this may have an opposite detrimental impact in the long run.

Kwallek and her colleagues have conducted a large-scale series of studies that examine the relation between individual environmental sensitivity, office color and worker productivity. Participants were assigned to one of the three offices colored with red, green or white, and performed office tasks for four consecutive days. Productivity was measured through workers' task performance and task accuracy, taking into account the individual differences in environmental sensitivity. The findings showed that high screeners who are most adept at screening out the relevant stimuli of their environments performed better in office tasks in the red office and poorer in the blue-green office than low-screeners who are typically can not screen out incoming stimuli. In that context, it was suggested that the influences of interior colors on worker productivity depended upon

individuals' stimulus screening ability and time of exposure to interior colors (Kwallek, Woodson & Lewis, 1996; Kwallek, Soon & Lewis, 2007).

Another study by Küller, Mikellides & Janssens (2009) has examined the relation between color, arousal and performance. They found that red color and patterns in the interior space put the brain in a more excited state and introverted persons, who are also in a negative mood became more affected by the environmental stimulus than others became, which caused severe changes in their performance.

From these studies of color, dealing with its possible effects on human performance, it can be seen that, performance indicators, type of stimuli, duration of exposure and individual differences such as sensitivity to the exposure of environmental stimuli, age, gender and preferences are all factors affecting the relation between color and human performance.

3. EXPERIMENTAL STUDY ON THE APPRAISAL OF AN OFFICE ENVIROMENT AND TASK PERFORMANCE

3.1. Aim of the Study

The aim of the study is to understand the differences between achromatic and chromatic schemes in terms of environmental appraisal and task performance. In this experimental study, to investigate the effect of *hue* on the subjective impressions of the offices and task performances, the colors with the same value (lightness) on the surfaces of achromatic and chromatic schemes were used. Understanding the differences between achromatic and chromatic schemes in users' appraisal of the office environment and their task performance can be helpful to enhance the environmental quality and comfort conditions while designing office interiors.

This study also aims to point out the technical requirements (reflectance ratios) for surface colors while applying the color schemes that are required for visual quality and energy saving in workplaces. It is important for designers to regard light and color together to provide technically more efficient working environments.

3.1.1. Research Questions & Hypotheses

The research questions of the study are as follows:

1. Are there any differences between achromatic and chromatic color schemes in the appraisals of an office environment?

2. Are there any differences between achromatic and chromatic color schemes of an office environment in terms of task performance and self-reports of the tasks?

The hypotheses of the study are as follows:

1. There are differences between achromatic and chromatic color schemes in the appraisals of an office environment.

2. There are differences between achromatic and chromatic color schemes of an office environment in terms of task performance and self-reports of the tasks.

3.2. Phase I: Survey in Field

3.2.1. Method of the Study

In the first phase of the experiment, a field survey was conducted at the Fine Arts Faculty of the Bilkent University. The aim was to obtain data for the settlement of the experiment room with regard to users' evaluations of their offices considering artificial lighting and color mood associations. Among Fine Art Faculty staff, a total of 30 office users participated in the survey voluntarily. In the office rooms where the surveys were conducted, the specifications of the artificial lighting, the material, and the color of the surfaces and the furniture specifications were similar (see Figure 3.1, Table 3.1). The office rooms that were differentiated from others by personal identification such as different furnishings, posters, and floor coverings were eliminated for the reliability of the survey.

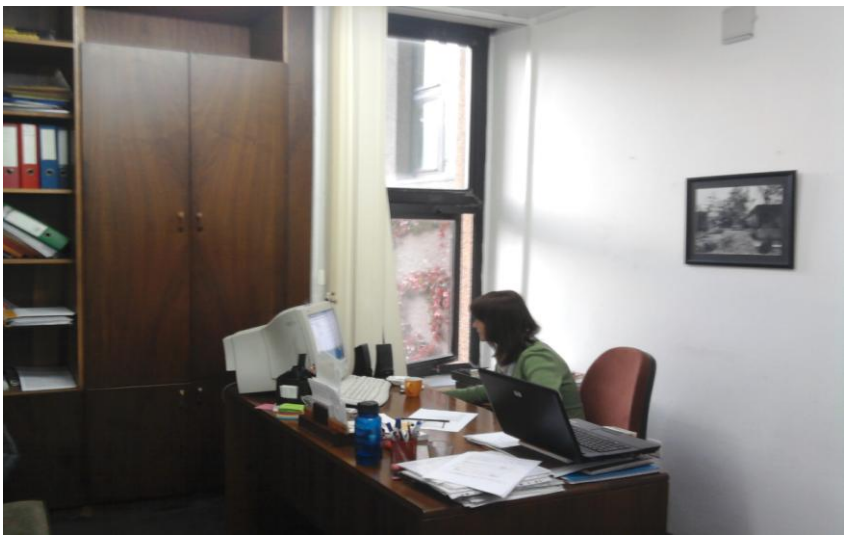


Figure 3.1. A view from an office room

Table 3.1. Phase 1: Artificial lighting and surface specifications of the office rooms

Lighting type:	General Lighting
Light source :	Philips TL-D 36W/54 TS183 2500LM
Color temperature of the light source	6200 Kelvin.
Color rendering index of the light source	72 Ra
Illuminance level on the desk surface	The average level= 400 lx
Color and reflectance values of the surfaces	Ceilings and walls : white paintings, 85 % reflectance Floors: blue gray carpeting, 20 % reflectance Furniture: dark brown wooden veneering, 30 % reflectance

A questionnaire was prepared as the method of the field survey to obtain data that consisted of open-ended questions, bipolar adjective pairs of semantic differential method and multiple choices questions based on evaluating the

lighting and color scheme conditions of the office rooms, and suggestions for a better working environment (see Appendix A1.1, A1.2). In order to prepare the questionnaire, bipolar adjective pairs about lighting and color from previous studies were gathered, and the ones that would be suitable for this study were chosen among them. The survey was conducted in a process of visiting each office room one by one and conducting the questionnaires orally, to get feedback form the participants. Each questionnaire took about 15 minutes and they were in late afternoon when the artificial lightings were on.

3.2.2. Results

Statistical Package for the Social Science (SPSS) 13.0 was used to analyze the data collected through the questionnaires. For analyzing the data, frequencies of each adjective pair from the descriptive statistics were used. Firstly, from the analysis of the evaluations of lighting conditions, it was remarked that respondents mostly found the lighting level sufficient, around adequate brightness, and appraised the vision as clear. However, they appraised the lighting quality mostly as static, tense and cool (see Appendix A2, Table A2.1). In addition, analysis of the open-ended questions indicated that participants evaluated the color of lighting as unnatural and crude and they mentioned that it disturbs the general comfort. Secondly, according to the results of the analysis of the adjective pairs for evaluating the color scheme, respondents found the color scheme in their offices cool, hard, dark, dull, unattractive, unsatisfying, usual, static, boring, gloomy, and unharmonious (see Appendix A2, Table A2.2). Moreover, chi- square for goodness of fit (also referred as one sample chi-square) was performed to analyze the questions about the participants' preferred

color attributes and color chips (the color chips were categorized as warm and cool colors to be able to perform a statistical analyze). The results indicated that there is a significant difference between the participants' preferences about color attributes and color chips (for the preferred color attributes p= .000, for color chips p= .001) (see Appendix A, Table A2.3, A2.4). The frequency distribution of participants' responses showed, they mostly preferred warm and light colors for their working space (see, Figure 3.2, 3.3, 3.4).

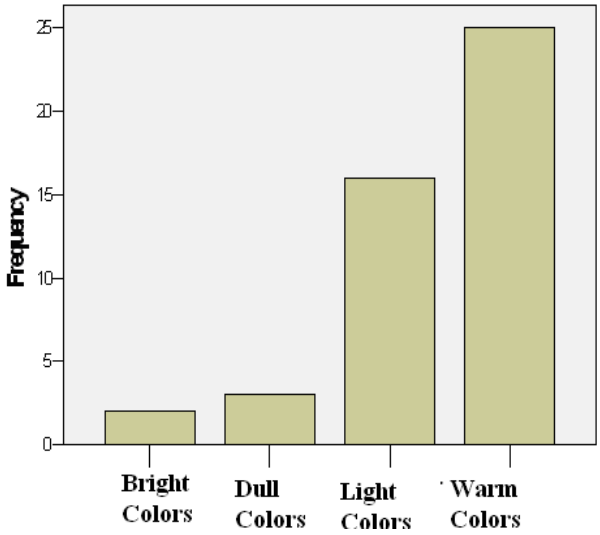


Figure 3.2. Bar chart of preferred color attributes.

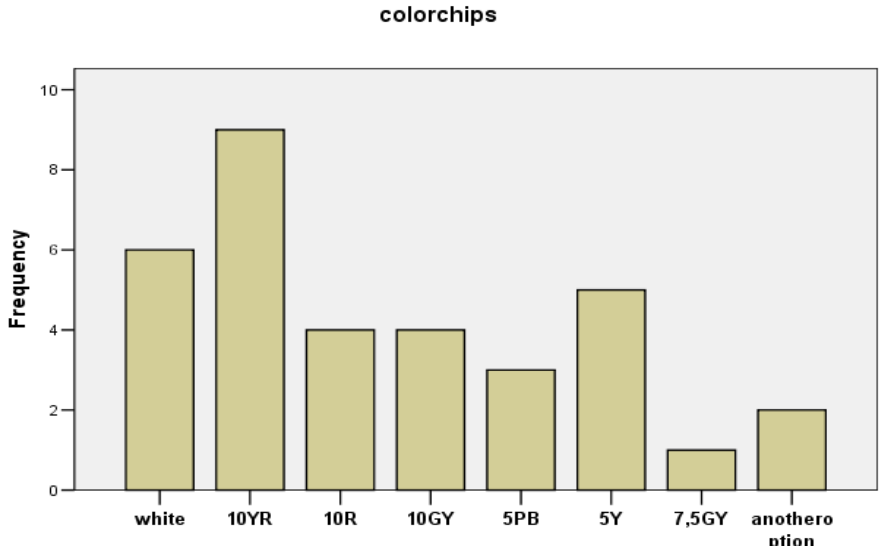


Figure 3.3. Bar chart of preferred color chip for the Office walls

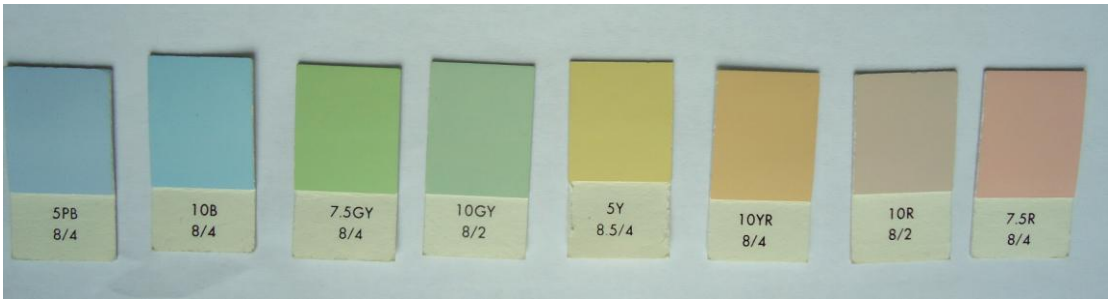


Figure 3.4. Color chips from Munsell Color System

With respect to the inferences from the field survey, and the technical requirements for an office environment (Rea, 2000), artificial lighting and surface specifications of the experiment room of the phase II were decided to be as following: (see Table 3.2).

Table 3.2. Specifications of lighting and surface conditions for experiment room

Lighting : Color temperature : Color rendering index:	 3000K-5000K 85Ra- 100Ra
Surface reflectance:	Ceilings:80% or more Walls:50-70 % Working surface :25-45% Floors:20-40%
Wall color in chromatic scheme:	Yellow-Red 

3.2. Phase II: Experiment

The experimental study is explained under the following sections: sample group, experiment room and procedure. The method of the study is detailed considering the specifications of the participants, the construction phase of the experiment room and how the experiment is to be conducted.

3.2.1. Sample Group

The sample group was 60 office workers who are the academic and administrative staff from different departments of the Bilkent University in Ankara, Turkey (see Table 3.3). They were selected randomly among all the office workers of different departments and they participated in the experiment voluntarily. The mean ages of the participants was 30, 50 (see table 3.4) and among these participants 36 of them were female and 24 were male. The experiment did not concentrate on the effects of age and gender on the

independent variables. The same sample group participated in the experiment in office settings with different color schemes.

Table 3.3 Distribution of office workers according to their departments

Department	Number of participants
Interior architecture and environmental design	21
Management	7
Communication and design	5
Graphic design	4
Physics	4
Chemistry	2
History	2
Fine arts	1
Mathematics	1
Political science	1
International relations	1
Material science and nanotechnology	1
Others	
BCC laboratory technicians	6
Faculty secretaries	4
TOTAL	60

Table 3.4 Age and gender of participants

	Number	Minimum	Maximum	Mean
AGE	60	22	65	30,5
	Number	**Male**	**Female**	
GENDER	60	24	36	

3.2.2. Experimental Set-up

The study was carried out in an office room at Department of Interior Architecture and Environmental Design, at Bilkent University in Ankara. The room measures were 4 x 4.10m, which makes 16, 4m² and ceiling height is 3.20m. The windows of the room were covered with thick and black insulating material preventing the penetration of daylight to control its effect on the perception of the room. The

existing general direct (downward) lighting by the luminaries of recessed troffer with parabolic louvers was used as artificial lighting of the experiment .All of the wall surfaces and the ceiling were painted in matte white and the floor is covered with a pale pink-blue carpet. The existing light sources of the experiment room were changed according to the inferences from phase I and the technical requirements (see table 3.5).

Table 3.5. Specifications of the artificial lighting of the experiment room

Light source:	Four Philips fluorescent lamps (TL-D36W 840)
The color temperature:	4000K
The color rendering :	85 Ra
Luminary of the experiment room	

After the renovation of the luminaries, the illuminance level was measured 400 lux by using Minolta Illuminance meter on the working surface which is in the range of recommended values (300- 500 lux) for the general office tasks as the experiment room was arranged in the form of a study room where such activities are likely to carried out (Rea, 2000). The experiment room was redesigned according to the purposes of the study. Achromatic and chromatic color schemes were applied by painting the surfaces and using fabric coverings on the furnishing and the floor. Firstly, all of the wall surfaces were painted with gray color of the

achromatic scheme. Then, plywood sliding panel system was constructed on two sides of the room to achieve flexibility in applying color schemes. One side of the panels was painted for the chromatic scheme and the other side of the panels was painted for the achromatic scheme. To change the wall color, the panels were slid to the corner and they were inverted to other side which was painted with a different color (see Appendix B1, Figure B1.1 - B1.8).

The hue yellow-red was decided to be used for chromatic scheme of the experiment as it was the most preferred hue among other hues in the phase I which is a field survey. Moreover, monochromatic color scheme was chosen for the chromatic scheme of the experiment. Natural Color System was (NCS) was used in specification and selection of the surfaces' and furniture's colors for both color schemes as it was available on the market. It was important to use the colors with the same lightness (reflectance) values on the surfaces of achromatic and chromatic schemes to control the variables and measure only the *hue* effect. Moreover, the selected colors were considered to be in the range of recommended reflectance values for an office environment (see Appendix B2, Figure B2.1 - B2.8) (see figure 3.8, 3.9, Table 3.6).

The furniture consisting of an office table, an office chair, two armchairs and an office file (file cabinet) was arranged according to the purpose of the study (see Figure 3.6, 3.7). Furthermore, the position of the participants was arranged according to visual field; by the way, they were able to see the three sides of the room during the experiments (including the colored wall in chromatic scheme). As shown above, the binocular visual field (vision by both eyes) extends vertically

130º and horizontally more than 120º when both eyes are focused (Egan & Olgyay, 2002) (see Figure 3.5).

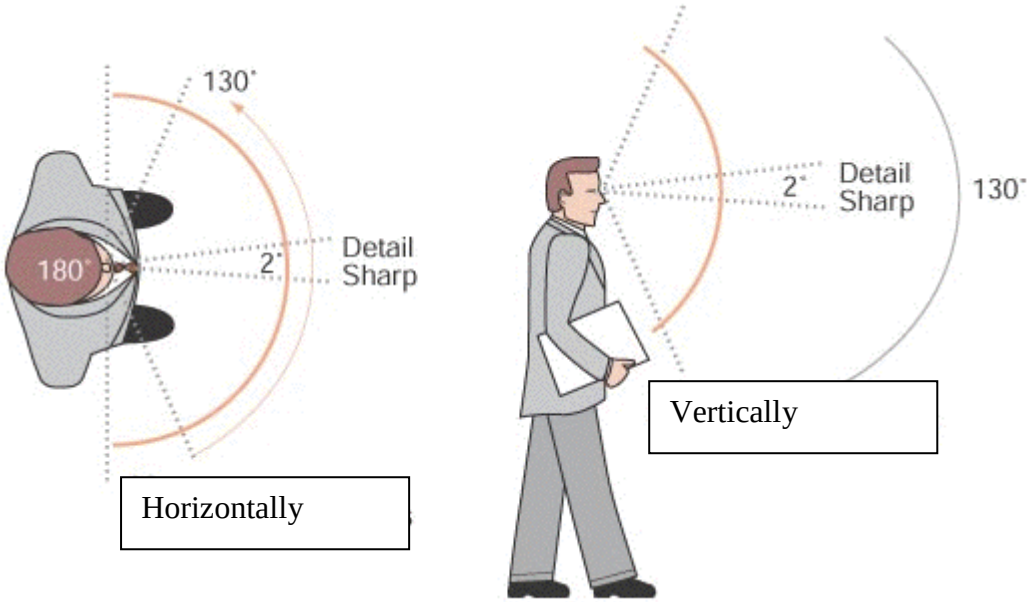


Figure 3.5. Binocular visual view profiles

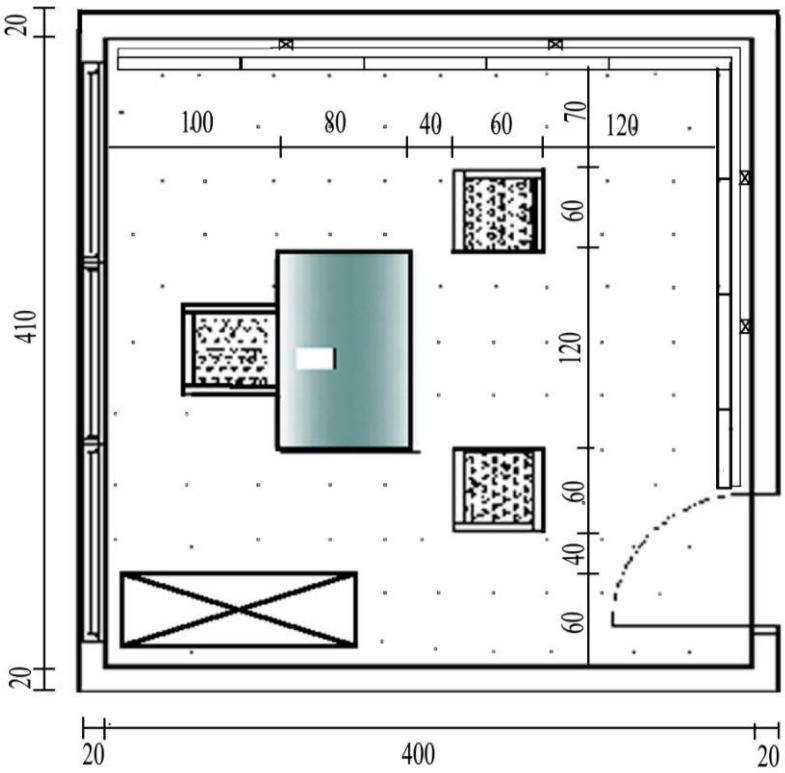


Figure. 3.6. The plan of the experiment room

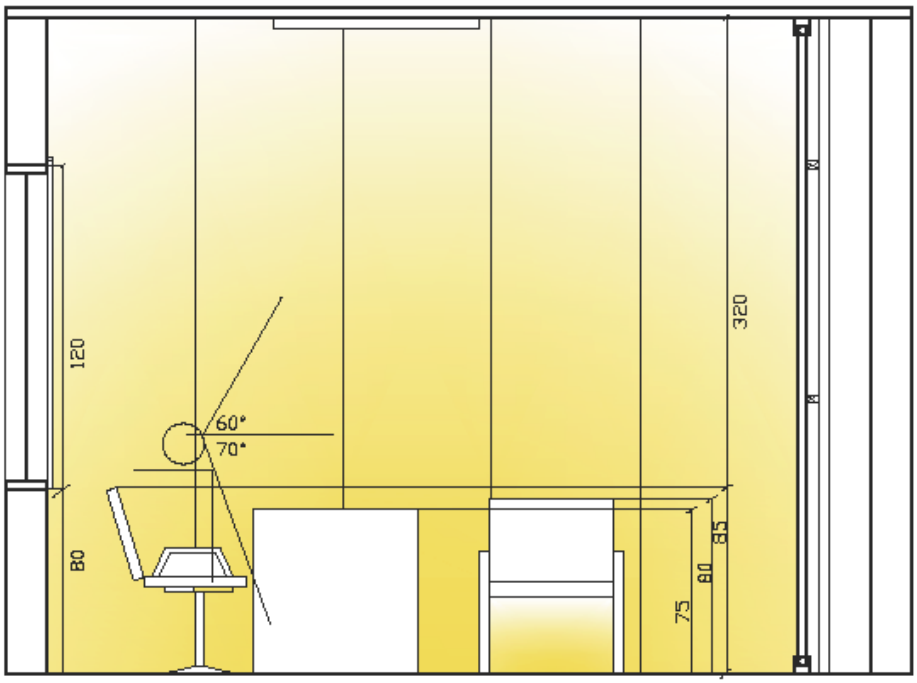


Figure 3.7. The vertical section of the experiment room

Figure 3.8. A view from experiment room with achromatic scheme

Figure 3.9. A view from experiment room with chromatic scheme

Table 3.6. NSC codes and reflectance of the surfaces (measured by NSC color scan)

Ceiling:	S 0500N	Y1= 87%
Walls: 1- 2- 3-	S 0530- Y30R S 3000N S1500N	Y1= 68% Y1= 50% Y1= 68%
Furniture Table: Armchair:	 S 3050 Y20R S 4050 Y30R	 Y1= 30% Y1= 19%
Floor:	S 5020 Y30R	Y1= 24%

Ceiling:	S 0500N	Y1= 87%
Walls: 1- 2-	S1500N S 3000N	Y1= 68% Y1= 50%
Furniture Table: Armchair:	 S 4000N S 6500N	 Y1= 35% Y1= 19%
Floor:	S 5500N	Y1= 24%

In the selection phase of the colors, NCS color scan was used as it contains all the 1950 NCS original colors to identify the lightness (reflectance) values of the colors. “It works by placing the scanner on the material’s surface and pressing the button, then you receive the closest NCS standard color, LRV and lightness values for the material and the page number in the NCS Index on which to find the scanned color” (NCS Color Tools-Color Readers, 2004, para. 3) (see figure 3.10).

Figure 3.10. NCS color scan

From http://83.168.206.163/webbizz/mainPage/main.asp

3.2.3. Design of the Experiment

The design of the experimental study is explained in the following sections titled as preparation of the questionnaire, preparation of task performance, experimental process, and phases of the experiment.

3.2.3.1. Preparation of the Questionnaire

To understand how individuals think and feel about the two office environments where different color schemes have been applied, the study was conducted on the basis of *environmental appraisals*: personal impressions of places. Environmental appraisals embody individuals' judgments about places from their own world of experience and psychological constructs (such as meaning, concern, preference). The variety of personal and environmental characteristics and interactions of them influence appraisals. The Personal characteristics include culture, age, gender, familiarity with the space, etc and the environmental characteristics that influence the appraisals include room design, complexity, contrasts, architectural style, contents, etc (Gifford, 2002). Therefore, the goal of

this study involves appraising the office environments on the perceptual abilities of human to judge the characteristics of the settings. The questionnaire consisted of four parts. In the first part, participants were asked to evaluate their performance on the given tasks to obtain self-reports of the task or perceived performances. The second part includes the evaluation of the office environment by the use of semantic differential method with a set of bipolar adjective pairs. Osgood (1978) described the semantic differential as a technique for measuring the meaning of objects, events or concepts. In terms of describing the physical environment, Kasmar (as cited in Nasar, 1992) stated that if people are expected to describe environments and architectural spaces, they need a scale appropriate for the description of the physical environment. Therefore, he has developed a lexicon of environmental descriptors for the architects and users trying to describe architectural spaces with the relevant and meaningful descriptors. Subsequently, many studies were conducted to develop a semantic differential tool to understand human impressions of interior environments associated with different design aspects like lighting systems, color design, etc. (Flynn, Hendrick, Spencer & Martynik 1979; Hogg, Goodman,Porter, Mikellides &Preddy, 1979; Houser, Tiller, Bernecker & Mistrick, 2002) In order to determine the adjective pairs of this study, bipolar adjective pairs from previous studies related with subjective impression of the interior spaces were analyzed. The adjective pairs which will be suitable to evaluate a private office environment, focusing on the general interior quality were chosen for the questionnaire. Furthermore, the adjective pairs were translated into Turkish by means of dictionaries, and the ones that were the same or similar in meaning when translated into Turkish were eliminated.

The questions of the third part were arranged to measure the preference of participants and how they appreciated the presented color scheme in the office setting. For the evaluation of the office room by adjective pairs and preference questions 5-point scale likert-type question form was used. The last section of the questionnaire consisted of open-ended questions to obtain detailed knowledge about the participant's general opinion, complaints and suggestions about the presented office setting (see Appendix C).

3.2.3.2. Preparation of the Task Performance

Human performance measurement was defined as a model for investigating man-environment relationship since it was proved that environmental quality has impacts on the human performance. The studies about the productivity in work environments measured performance to understand the environmental impacts on the workers' productivity. In these studies, a variety of clerical tasks were used for the measurements such as typing tasks, proofreading tasks, comparison tasks, cognitive performance in memory and problem-solving tasks (Knez, 1995; Veitch & Newsham, 1998; Kwallek, Soon & Lewis, 2007).

According to Bailey (1982) adequate human performance can be measured using accuracy, speed of performance and user satisfaction. Thus, the collected data from performance tasks of this study were analyzed by measuring the accuracy depending on performing an action with the fewest errors; measuring the speed of performance depends on performing the activities in the shortest possible time; and measuring self-report of the task that concerns whether the human receives satisfaction while performing an activity.

In this study, in order to determine the tasks of performance measurement, the tasks from previous studies were analyzed. Finally, two different kinds of tasks were used: the Raven's Progressive Matrices was used as a problem solving task that was also used by Sansal (2007) to understand the impacts of lighting on cognitive performance. The Raven's Progressive Matrices was designed to measure a person's ability to form perceptual relations and to reason by analogy. It was prepared to be used with persons ranging in age from 6 years to adult independent of language, educational background, career experiences, etc. and the reliability of the test was measured by test-retest correlations at the median coefficient value of 82. It consists of 60 items arranged in five sets of 12 items, each in increasing order of difficulty. (The Raven's Progressive Matrices, 2010). In this study, totally 30 items were used. Each item contains a figure with a missing piece, and involves a different principle or theme for obtaining the missing piece. Below the figure there are either six or eight alternative pieces to complete the figure, and there is only one correct answer (see Appendix C).

The other task used in this study was a proofreading task. Four different paragraphs were prepared to be solved for two experiments. Each participant was asked to solve two different paragraphs in each experiment. In one of the paragraphs, participants were asked to mark and then calculate the number of the specified word. In the other one, participants were asked to find out the typing errors in the given paragraph (see appendix C).

3.2.3.3. Process of the Experiment

In this study the experimental design approach was adopted. That is the technique which helps to identify cause and affect relationships by observing the effects of one or more systematically changing independent variables on the dependent variables under control conditions. It refers to the outline or plan of the experiment that determines the procedure in answering the research questions, and specifies how the data will be collected and analyzed and how unwanted variations will be controlled (Christensen, 1994). To be able to prevent the influences of extraneous variables that can affect the results of the experiment, and to ensure the validity of this study, some control techniques of the experimental methodology were considered in the design of this experimental study. Firstly, it was decided to conduct a *with-in subject design*; the same sample group participates in two color scheme conditions of the experiment room, to control the effects of the individual differences such as age, sex, intelligence and prior experience in the evaluation of the offices, and task performance. Yet, this design has a disadvantage of providing an *order effect,* in which the conditions are presented in the same order that might influence the outcome (Christensen, 1994). To control the order effect, a *counterbalancing* technique was designed. A sample group consisted of 60 participants was divided into two equal groups randomly; Half of the participants firstly experienced the office setting applied with achromatic scheme, then, they experienced the office setting with chromatic scheme, the other half of the group experienced the office settings in the opposite order (see Figure, 3.11). Moreover, participants were assigned to perform two different but parallel performance tests for each setting to control the learning effect of tests (see Appendix, C).

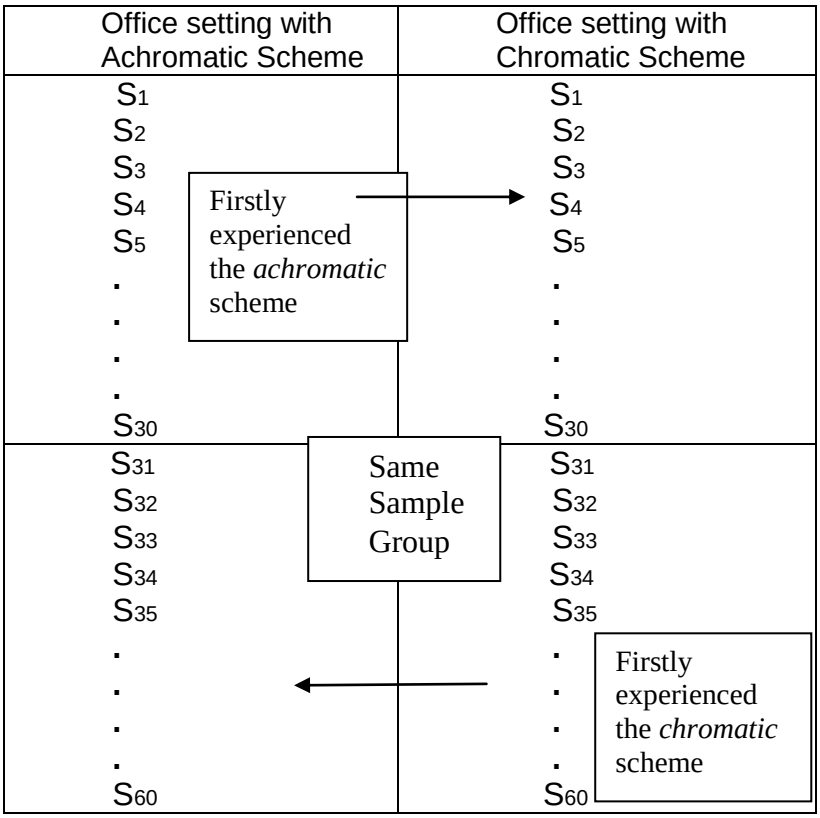


Figure 3.11. Process of Experiment

3.2.3.4. Phases of the Experiment

The experiment was conducted in the following phases; the participants were taken to the experiment room one by one on the dated hour of day. In the experiment room, participants were firstly tested for color vision with Isihara color blindness test, and there was no one who was color blind. After a few minutes for adaptation, the experimental procedure was explained to them. Each participant firstly performed the given task consisting of problem-solving and proofreading tests while the coordinator of the experiment was timing this process, and then they evaluated office setting with the presented color scheme by filling out the questionnaire consists of bipolar adjective pairs, preference and association questions and open-ended questions.

When these phases concluded, participants were asked when it would be possible for them to participate in the second experiment for the office setting with the other color scheme. Thus, second experiment was scheduled as there was going to be a four- day period between the two experiments. If the participants forgot their appointment, it was re-scheduled on the telephone or via e-mail. In the second experiment, participants performed the given task that was different from the first one yet, made up of parallel tests. They also evaluated the office setting with the presented color scheme by filling the same questionnaire.

4. RESULTS & DISCUSSION

4.1. Results

Statistical Package for the Social Sciences (SPSS) 13.0 was used to analyze the data of the study. Results of the statistical analysis were indicated with respect to the research hypotheses of the study (see hypotheses in Section 3.1.1). In order to look at the differences between the evaluations of office environment with achromatic or chromatic scheme, Wilcoxon Signed Rank test, which is a non-parametric technique to compare two different variables, was used. It was demonstrated that when you have data that are measured on nominal (categorical) and ordinal (ranked) scales, it will be ideal to use non- parametric techniques. Moreover, Wilcoxon Signed Rank test is designed for use with related samples, so it is the non-parametric alternative to the paired-sample t-test, but instead of comparing means, it compares medians, then evaluates whether the ranks for two groups differ significantly (Gravetter & Wallnau, 2000). In this study, there is an ordinal data (because of 5-point-scale question type), and the same sample group participated in the experiments; therefore, Wilcoxon Signed Rank test was deemed suitable for analyses. Furthermore, to identify groups or clusters among the adjective pairs, factor analysis, which is a technique for exposing the clumps or groups among the intercorrelations of a set of variables, was performed (Gravetter & Wallnau, 2000).

In the analysis of the data for measuring the learning effect, the independent sample t-test, which is the statistical test to compare the mean scores of two different groups of people or conditions, was used. For measuring the effects of color schemes on the task performance, paired sample t-test, which is the

statistical test to compare the mean scores for the same sample group on two different occasions, was used (Gravetter & Wallnau, 2000).

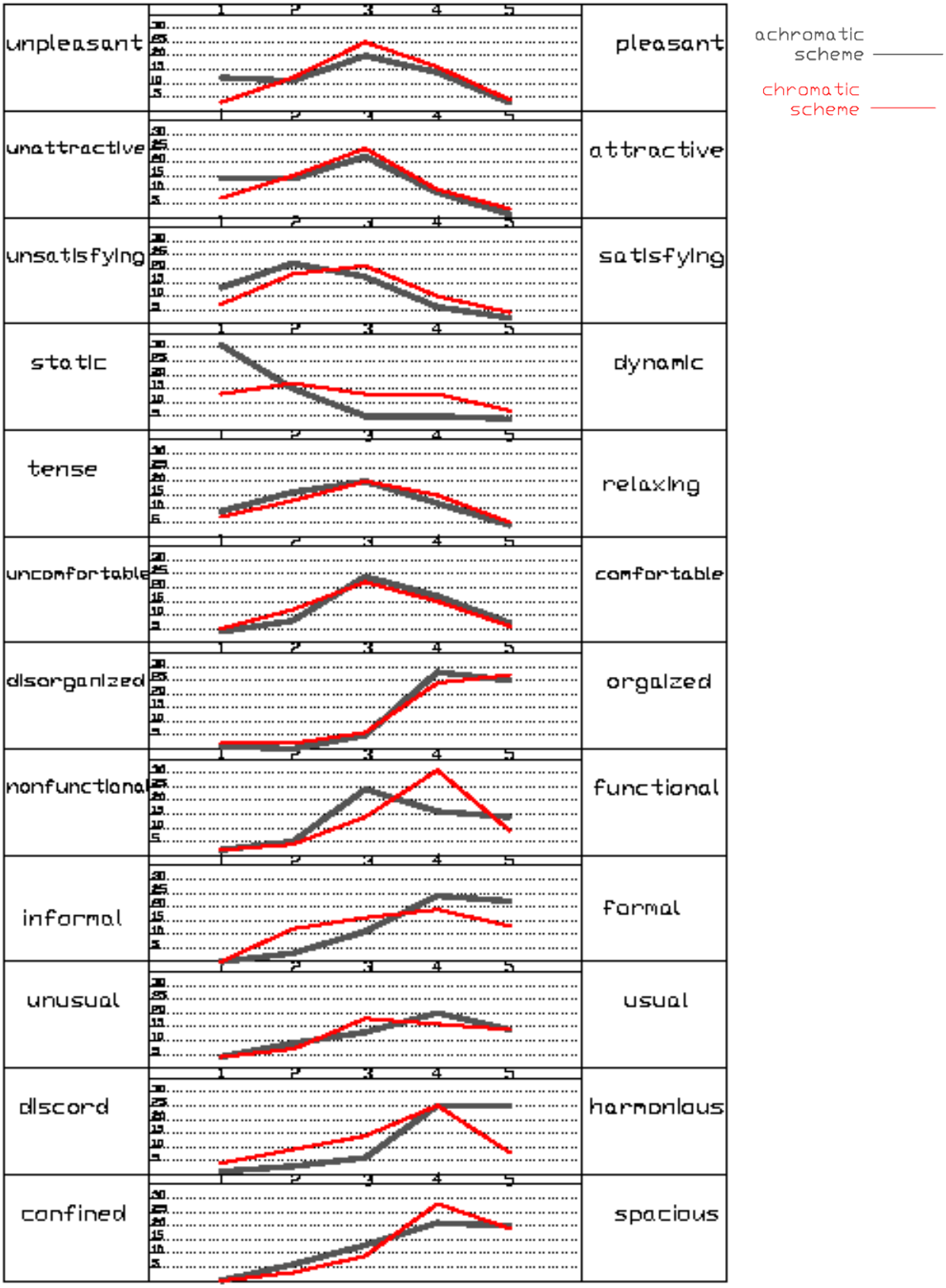
4.1.1. Effects of color scheme on the Appraisal of the Office Environment

The effects of color scheme on the appraisal of office environment were analyzed under three sections, namely analysis of the adjective pairs, analysis of preference and association questions, and analysis of open-ended questions. Firstly, the analysis of adjective pairs with the Wilcoxon Signed Rank test indicated that there is a significant difference between the achromatic and chromatic scheme in the appraisals of the office environment in terms of the bipolar adjective pairs: pleasant/unpleasant (z=-2.108, p=. 035), attractive/unattractive (z= -1.974, p= .048), satisfying/unsatisfying (z= -2.437, p=.015), static/dynamic (z= -3.214 p=. 001), formal/informal (z= -3.044, p= .002) and harmonious/ discordant (z= -4.328, p= .000) (see Appendix D, Table D.1) (see Table 4.1). When the frequency distribution of each adjective pair was compared in relation to achromatic and chromatic schemes, the results showed that the office environment with chromatic scheme was found more pleasant, attractive, satisfying, and dynamic than the office environment with achromatic scheme; on the other hand, office environment with achromatic scheme was found more formal and harmonious than office environment with the chromatic scheme (see Table 4.2).

Table 4.1. Wilcoxon Signed Rank test for significantly different adjective pairs

	Pleasant/ Unpleasant	Attractive/ Unattractive	Satisfying/ Unsatisfying	Static/ Dynamic	Formal/ Informal	Harmonious/ Discord
Z	-2, 108(a)	-1,974(a)	- 2,437(a)	-3, 214 (a)	-3,044(b)	-4, 328 (b)
Asymp. Sig. (2- tailed)	.035	.048	.015	.001	.002	.000

Table 4.2. Frequency distribution of adjective pair's evaluations



Then, among the adjective pairs factor analysis was performed. Firstly, the suitability of the data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of.3 and above for achromatic and chromatic schemes. The Kaiser-Meyer-Oklin value was 72 for achromatic scheme and 62 for chromatic scheme, exceeding the recommended value of .6, and the Barlett's Test of Sphericity reached statistical significance for both color schemes, supporting the factorability of the correlation matrix.

The results of factor analysis showed that there are both similarities and differences between achromatic and chromatic scheme in terms of the adjective pairs that go together and categorized. For both achromatic scheme and chromatic scheme, the first factor gathered the adjective pairs; pleasant/unpleasant, attractive/unattractive, satisfying/unsatisfying, tense/relaxing, static/dynamic, and comfortable/uncomfortable. The first factor accounted for %28 of variance for achromatic scheme and %29 of variance for chromatic scheme. For the achromatic scheme, the second factor accounted for %19 of variance and gathered the adjective pairs harmonious/discordant, formal /informal, usual/unusual, spacious/confined, and the third factor accounted for %16 of variance and gathered the adjective pairs functional/ nonfunctional, organized/disorganized. On the other hand, for the chromatic scheme the second factor accounted for %16 of variance and gathered the adjective pairs organized/disorganized, functional/nonfunctional, spacious/confined, harmonious/discordant, and the third factor accounted for %14 of variance and gathered the adjectives usual/unusual, formal/informal (see table 4.3 - 4.8).

Table 4.3. Factor Analysis of achromatic scheme: Total Variance

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4,154	34,615	34,615	4,154	34,615	34,615	3,468	28,901	28,901
2	2,200	18,331	52,947	2,200	18,331	52,947	2,357	19,645	48,546
3	1,444	12,037	64,984	1,444	12,037	64,984	1,973	16,438	64,984
4	,847	7,060	72,043						
5	,731	6,094	78,137						
6	,651	5,421	83,558						
7	,536	4,464	88,022						
8	,448	3,732	91,754						
9	,333	2,774	94,528						
10	,271	2,255	96,783						
11	,210	1,746	98,529						
12	,177	1,471	100,000						

Extraction Method: Principal Component Analysis.

Table 4.4. Factor Analysis of achromatic scheme: Rotated Component Matrix

Rotated Component Matrix (a)

	Component		
	1	2	3
Pleasant/Unpleasant	,850		
Attractive/Unattractive	,832		
Satisfying/Unsatisfying	,742		,315
Tense/Relaxing	,731		
Static/Dynamic	,651	,355	
Comfortable/Uncomfortable	,623		,540
Harmonious/Discord		,827	
Formal Informal		,801	
Usual/Unusual		,657	-,348
Spacious/Confined		,649	
Functional/Nonfunctional			,816
Organized/Disorganized			,805

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a Rotation converged in 4 iterations.

Table 4.5. Factor Analysis of chromatic scheme: Total Variance

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3,823	31,856	31,856	3,823	31,856	31,856	3,520	29,337	29,337
2	1,791	14,928	46,783	1,791	14,928	46,783	1,961	16,345	45,682
3	1,627	13,560	60,343	1,627	13,560	60,343	1,759	14,661	60,343
4	1,002	8,353	68,696						
5	,836	6,966	75,662						
6	,698	5,821	81,483						
7	,595	4,956	86,439						
8	,505	4,211	90,649						
9	,364	3,036	93,685						
10	,355	2,954	96,640						
11	,267	2,225	98,865						
12	,136	1,135	100,000						

Extraction Method: Principal Component Analysis.

Table 4.6. Factor Analysis of chromatic scheme: Rotated Component Matrix

Rotated Component Matrix (a)

	Component		
	1	2	3
Attractive/Unattractive	,824		
Satisfying/Unsatisfying	,773		
Pleasant/ Unpleasant	,772		
Comfortable /Uncomfortable	,762		
Tense/Relax	,661		
Static/Dynamic	,580		-,396
Organize/Disorganized		,748	
Functional/Nonfunctional		,744	-,449
Spacious/Confined		,669	
Harmonious/Discord	,384	,476	
Usual/Unusual			,815
formal/ informal			,734

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Table 4.7. Adjective pairs under each factor in achromatic scheme

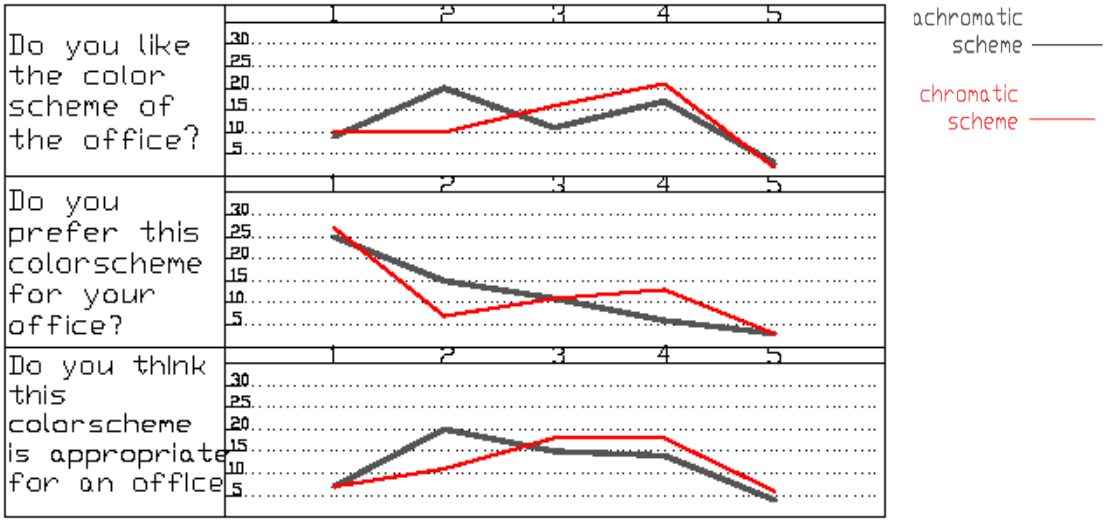
Factor 1	Factor 2	Factor 3
Pleasant/unpleasant	Harmonious/discordant	Functional/nonfunctional
Attractive/unattractive	Spacious/confined	Organized/disorganized
Satisfying/unsatisfying	Formal/informal	
Static/Dynamic	Usual /unusual	
Comfortable/uncomfortable		
Tense/relax		

Table 4.8. Adjective pairs under each factor in chromatic scheme

Factor 1	Factor 2	Factor 3
Pleasant/unpleasant	Harmonious/discordant	Formal/informal
Attractive/unattractive	Spacious/confined	Usual /unusual
Satisfying/unsatisfying	Functional/nonfunctional	
Static/dynamic	Organized/disorganized	
Comfortable/uncomfortable		
Tense/relax		

Secondly, the analysis of preference and association questions with Wilcoxon Signed Rank test indicated that there is not a significant difference between the achromatic and chromatic schemes in terms of preference and association of color schemes (For the first question; z= -1.281, p= .200, for the second question; z= -1.199, p=.231 and for the third question z= -1.756, p= .079) (see Appendix D, Table D2). From the frequency distribution of each question in achromatic and chromatic schemes, it can be interpreted that participants did not prefer any of the color schemes for their offices (see Table 4.9).

Table 4.9. Frequency distribution of preference and association evaluations



Open-ended questions were also analyzed by grouping the answers, and the answers were compared with frequency distribution bar chart. The results of bar charts showed that participants found the office environment with achromatic scheme organized, simple, tense, monotonous and boring, and they found the office with chromatic scheme cozy, pleasant, restful, yet, it was observed that participants who experienced the chromatic scheme in the first stage found the office environment calm and boring. For both of the color schemes, participants made complaints about lighting quality of artificial lighting, lack of daylight, lack of outside view, lack of personalization and decoration (see Figure 4.1, 4.2, 4.3).

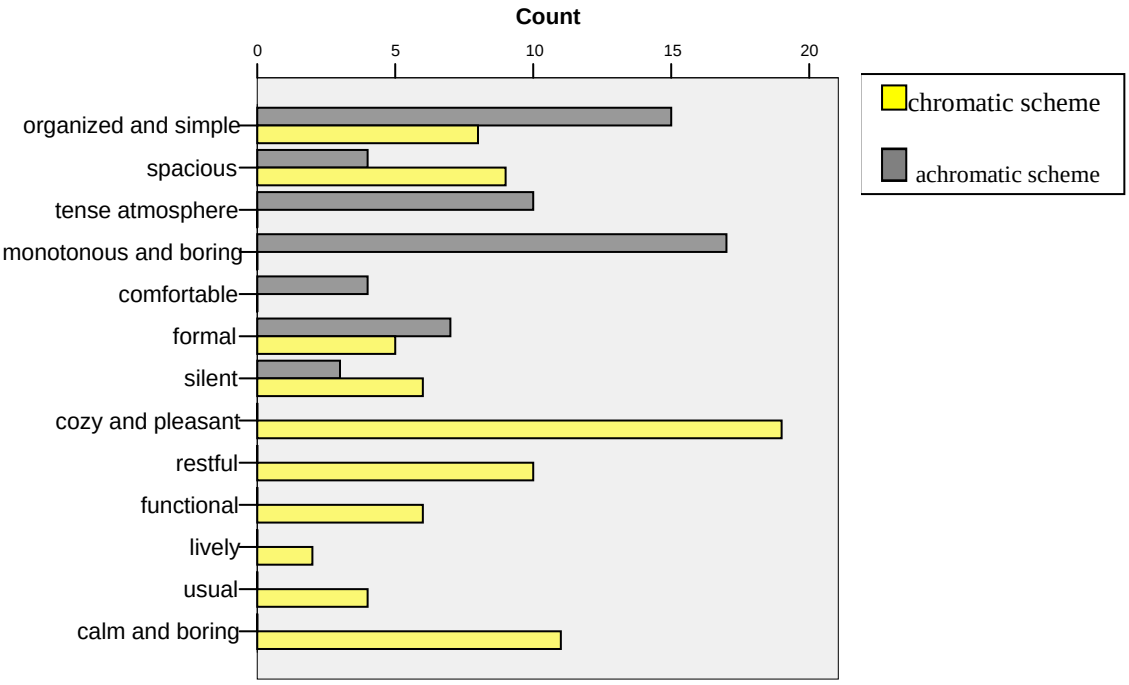
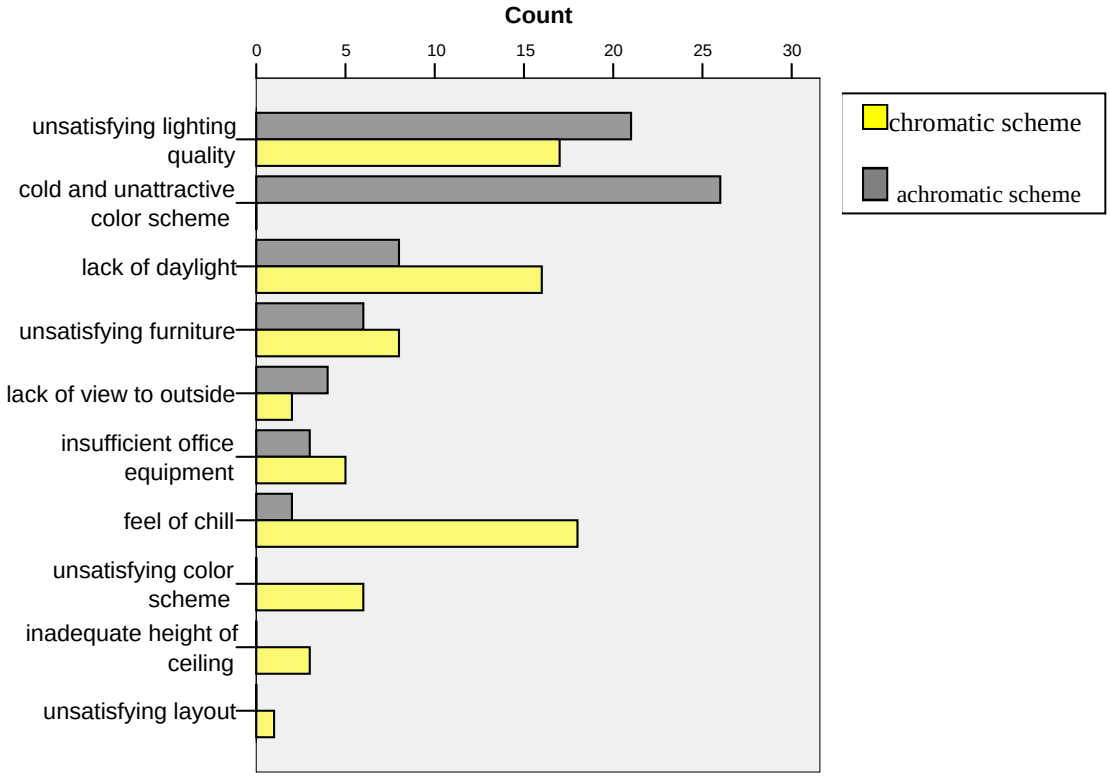


Figure 4.1. Frequency distribution of open-ended quesitons: 1: general idea



4.2. Frequency distribution of open-ended quesitons: 2: complaints

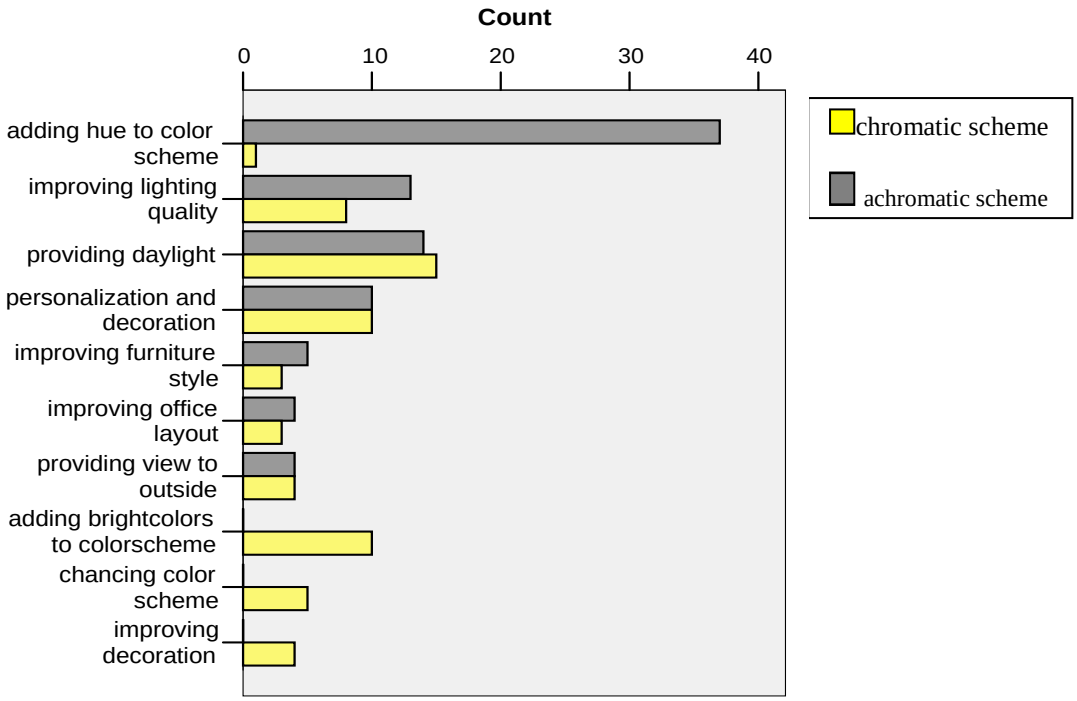


Figure 4.3. Frequency distribution of open-ended quesitons: 3: suggestions

4.1.2. Effects of Color Scheme on the Task Performance

First of all, since the participants were from the same sample group, whether there was a learning effect of the task performance that may influence reliability of measuring the hypotheses was measured. The learning effect on the group participating in the first experiment with the achromatic scheme and the group participating in the second experiment with the achromatic scheme was analyzed with an independent sample t-test. The same procedure was followed for the chromatic scheme too. The data collected from performance tasks was analyzed, measuring accuracy depending on error numbers, and measuring the speed of performance. The results of the independent t-test indicated that there is not a significant difference between the groups in terms of accuracy (for achromatic scheme; t=. 730, df= 58, p=. 468, for chromatic scheme; t=.786, df= 58, p= .435)

and speed of task performance (for achromatic scheme; t= 1,330, df= 58, p= .189, for chromatic scheme; t= -.872 df= 58, p= .189) (see Appendix D, Table D3.1- D3.4).

After it was found that there is not a learning effect of task performance, the effects of color scheme on the task performance was analyzed again by measuring accuracy, the success depending on performing an action with the fewest errors, and measuring the speed of performance depending on performing in the shortest possible time. The paired sample t-test was used for the analysis because the same sample group participated in the experiments as mentioned before. The results of the paired sample t-test indicated that there is a significant difference between achromatic and chromatic scheme in terms of accuracy (t= 3.889, df= 59, p= .000) and speed of task performance (t= 3.264, df=59, p=.002) (see table 4.10).The mean values of the number of errors and time showed that participants' performances were better in the chromatic scheme than in the achromatic scheme (see Table 4.11).

Table 4.10. Paired sample T-test for differences between achromatic and chromatic schemes in terms of task performance (accuracy and speed)

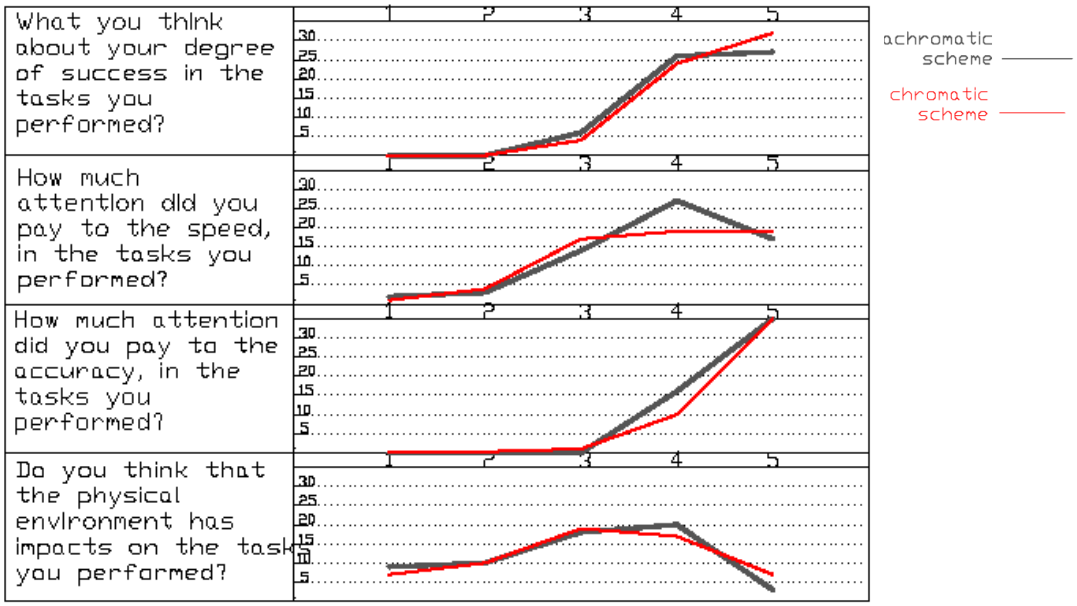
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	errornumber in achromatic errornumber in chromaitc	1,033	2,058	,266	,502	1,565	3,889	59	,000
Pair 2	time in ach - time in ch	,46550	1,10484	,14263	,18009	,75091	3,264	59	,002

Table 4.11. Mean values of error number and speed.

		Mean	N	Std. Deviation	Std. Error Mea
Pair 1	Error number in Achromatic scheme	1,90	60	2,113	,273
	Error number in Chromatic scheme	,87	60	,982	,127
Pair 2	Time (in minutes) Achromatic scheme	4,7952	60	1,58557	,20470
	Time (in minutes) Chromatic scheme	4,3297	60	1,33336	,17214

Furthermore, the self-report of the performance task that concerns the participants' perceptions about their success and attention was analyzed. The analysis with Wilcoxon Signed Rank test indicated that there is not a significant difference between achromatic and chromatic scheme in terms of self-report of the task performance. (for the first question; z= -1.519, p= .129, for the second question; z= -.723, p= .467, for the third question; z= -.539, p=.129, for the forth question z= -.972, p= .331) (see Appendix D, Table D4) (see Table 4.12).

Table 4.12. Frequency distribution of self-report of the task performance



4.2. Discussion

The effects of color scheme on the appraisal of office environment and task performance were studied in the experiment. The color specifications of surfaces in the office environment were examined in the literature in terms of its effects on the quality of luminous environment and its effects on the subjective impressions and productivity of the occupants. In this dissertation, it was hypothesized that there are differences between achromatic and chromatic color schemes in the appraisals of an office environment and that there are differences between achromatic and chromatic color schemes of an office environment in terms of task performance and in terms of self-reports of the tasks.

The appraisals of the office environment were conducted in three sections. Firstly, the participants were asked to evaluate the office environments (where achromatic and chromatic color schemes were applied) with 12 bipolar adjective pairs. According to the statistical analysis of this section, participants found the office environment with chromatic scheme more pleasant, attractive, satisfying and dynamic than the office environment with achromatic scheme. These results showed similarity when they were compared with the study examining the impact of light and color on psychological mood of indoor work environments. According to that study the index of emotional status was higher throughout the year for those who had the most colorful work environments (Küller, Ballal, Laike, Mikellides & Tonello, 2006). Yet, these results differed from a study about the arousal in multicolored and gray spaces. Küller, Mikellides & Janssens (2009) found that there was not a difference between multicolored and gray spaces in terms of pleasantness. The analysis of adjective pairs of this dissertation also

showed that achromatic scheme was found more harmonious and formal than the chromatic scheme. This result showed similarity with the study of Küller, Mikellides & Janssens (2009) which found that the ratings for unity were at high values for gray room and that the complexity scores were high in the colorful room. Furthermore, in this study, it was found that the achromatic and chromatic office rooms were rated as similar in terms of the adjective pairs spacious/confined, comfortable/uncomfortable, yet in the literature it was demonstrated that cool surface colors and cool colored lighting make the spaces appear more spacious and comfortable (Wise & Wise, 1988, Manav,2007). Achromatic and chromatic schemes of the experiment room were also rated as similar in terms of the adjective pairs tense/relaxing, organized/disorganized, usual/unusual, and functional/nonfunctional. It can be interpreted from all these results about the evaluation of the two office rooms that the existence of *hue* in the color scheme of an office environment is determinative in the evaluation of a space as pleasant, attractive, satisfying and dynamic; on the other hand, *hue* does not play an essential role in the evaluation of a space as comfortable, spacious, relaxing, organized, functional, and usual.

Furthermore, in this study, factor analysis was performed in order to observe which adjective pairs go together and how these adjectives are categorized in achromatic and chromatic schemes. The results of factor analysis showed that there are both similarities and differences between achromatic and chromatic schemes. For both the achromatic scheme and the chromatic scheme, the first factor gathered the adjective pairs pleasant/unpleasant, attractive/unattractive, satisfying/unsatisfying, tense/relaxing, static/dynamic, and

comfortable/uncomfortable. This classification also partly supports the first analysis of the adjective pairs since it was found that participants evaluated the color schemes significantly differently in terms of the adjective pairs pleasant/unpleasant, attractive/unattractive, satisfying/unsatisfying, static/dynamic. This means that these adjective pairs were considered together in both color schemes, and they represented pleasantness. Moreover, this result shows some similarities with the pervious research in the literature. In the studies by Flynn, Spencer, Martyniuk & Hendrick (1973) and Houser, Tiller, Bernecker & Mistrick (2002), the adjective pairs pleasant/unpleasant, satisfying/unsatisfying, and tense/relaxing were categorized together.

In the categorization of the other adjective pairs, a more complicated relation was observed between achromatic and chromatic schemes. For the achromatic scheme, the adjective pairs harmonious/discordant and spacious/confined, were categorized together with the adjectives formal /informal and usual/unusual, and the third factor gathered functional/ nonfunctional, organized/disorganized. On the other hand, for the chromatic scheme, the adjective pairs harmonious/discordant and spacious/confined were categorized together with the adjectives organized/ disorganized, functional/nonfunctional, and the third factor gathered the adjectives usual/unusual, and formal/informal.

In the second section of the evaluations, participants were asked if they liked the color scheme in the office, if they preferred that color scheme for their offices, and if that color scheme was appropriate for an office environment. The results indicated that there is a not significant difference between achromatic and

chromatic schemes in terms of the answers given to these questions, which is contrary to the results of previous analysis related with adjective pairs. This can be because participants are not used to seeing those kinds of color schemes in the ordinary office environments, which mostly have white or off-white painted walls (Mahmke, 1996).This result corresponds with the studies in the literature. Kwallek (1996) found that among the three offices with white, red, and green painted walls, subjects rated the white painted office as the office where they would most like to work and considered white as the most appropriate color for an office wall. Another study by Kwallek, Lewis, Lin-Hsiao & Woodson (1996) indicated that the individuals preferred to work in beige and white rooms significantly more than in the red, blue, yellow, purple, or orange rooms. Moreover, in one of the experiments examining the effects of red, green and white office environments on worker productivity and mood, it was found that the subjects in the white office reported that they would like to work in this environment because they regarded white environments as sterile and conducive to work (Kwallek & Lewis, 1996). Therefore, it can not be ignored that, to some extent, color preference is guided by environmental or social context with the predominance of white or off-white color palette in most commercial spaces, office-settings, and institutions.

Open-ended questions were also analyzed by grouping the answers, and the answers were compared with bar charts. The results of bar charts showed that in the experiments participants made complaints about the lighting quality of the artificial lighting, lack of daylight, lack of outside view, lack of personalization and decoration in the experiment room. These may have led the participants not to

prefer any of the color schemes. Since it was demonstrated in the literature that there is a strong preference for windows in offices that allow the penetration of daylight to the interior working area and provide view to the outside (Galasiu & Veitch, 2006; Menzies & Wherrett, 2005). In addition, it was observed that some participants who experienced the chromatic scheme in the first stage evaluated the office environment as calm and boring. The reason of this can be the unlikable appearance of a controlled experiment room, different from a natural office environment.

In this dissertation, it was also hypothesized that there are differences between achromatic and chromatic color schemes of an office environment in terms of task performance (measurement of accuracy and speed) and self-reports of the tasks. The results indicated that there is a significant difference between achromatic and chromatic color schemes of an office environment in terms of task performance but there is not a significant difference in terms of self-reports of the tasks. According to the analysis of task performance, it was found that participants' performance was better in chromatic scheme than their performance in achromatic scheme. This result shows similarities with the previous studies in the literature. Kwallek (1990) conducted a study about the workers' performance in white, green or red office interiors and the results indicated that participants made significantly more errors in the white office than the participants in the red and green offices. In another study on the effects of nine different hues on the workers productivity, the findings showed that participants performed worse in the white office interior than in offices with any of the other hues (Kwallek, Lewis, Lin-Hsiao & Woodson, 1996).

Moreover, the result of the task performance can be associated with the results of the appraisals of the office environment with adjective pairs. The analysis of adjective pairs showed that the office environment with chromatic scheme was found more pleasant, attractive, satisfying and dynamic than the office environment with chromatic scheme. Such impressions of the participants about the chromatic scheme possibly lead them to perform better in the chromatic color scheme. On the other hand, the results of self-reports of the task performance indicated that there is not a significant difference between achromatic and chromatic schemes. This result shows similarity with a previous study examining the effects of study environments on adult students' mood satisfaction, motivation and performance. It was found that task perception was not affected by the variables of environment (Stone, 2001).

5. CONCLUSION

The effects of color scheme on the appraisal of office environment and task performance were explored in an office room of the Interior Architecture and Environmental Design Department at Bilkent University in Ankara. As suggested in the literature survey, the quality of physical environment in workplaces is important for the workers' physical comfort and well-being (Galitz, 1984; Sundstrom, 1986; Visher, 1996). In this respect, color was expected to affect workers' visual health, subjective impression, and productivity in the office environment (Marberry & Zagon, 1995). In this experiment, the differences between achromatic and chromatic schemes in evaluation of an office environment were analyzed through bipolar adjective pairs, preference and association questions and open-ended questions. To analyze the differences between achromatic and chromatic schemes in task performance and self-report of the task, participants were required to perform problem-solving and proof-reading tasks.

In the literature, there are not any studies comparing achromatic and chromatic color schemes applied to all of the surfaces in an office environment. The studies generally focus on examining the effects of different wall colors (red, green, blue, white) in offices. Different from other color studies, the *hue* effect on the collective impressions of the offices and participants' performance was investigated in this study. Therefore, the colors on the surfaces of achromatic and chromatic schemes had the same value (lightness). In addition, light and color were

considered together in this dissertation. In this context, the technical recommendations for surface reflectance were taken into consideration while determining the color specifications (hue, lightness, saturation) for visual comfort and energy saving in a working space.

Furthermore, an analysis of the studies about color in office environment shows that most of the studies are about the effects of color on mood, emotion or arousal. However, mood and emotions can be affected by many non-environmental factors, so measuring mood and emotion might not be a proper tool to investigate the effect of the environment on people' experiences. Therefore, it might be better to ask people to evaluate the environment in terms of preference and atmosphere as it was done in this study. In that sense, while preparing the questionnaire of the study, several theories on environmental evaluation, and environmental appraisal and assessment models were investigated.

The data collected from the experiments was analyzed statistically and the results showed that there are similarities and differences between achromatic and chromatic schemes in terms of assessment and task performance. It was found that the office environment with chromatic scheme was evaluated as more pleasant, attractive, satisfying and dynamic than the office with chromatic scheme, and participants' performance was better in the chromatic scheme than their performance in the achromatic scheme. The results of this study can be useful for interior designers in general and for the designers who use color as a design element to enhance environmental quality in the office environment. The

ubiquitous uses of white colored walls and dark colored office furniture in workplaces need to be taken into consideration again by designers to create more dynamic and visually comfortable workplaces. In some experimental studies of color, the applications of very strong colors resulted in undesirable responses. In this study, however, it was initially seen that a moderate increase in the use of good color design can serve to improve the overall comfort and productivity of the workers.

For future studies and experiments, it is important to point out that the selection of colors that are planned to be used in the office environment experiments is an important issue. To understand whether the effect of a specific color is because of its hue, its saturation or its lightness, at least one of the three dimensions of color should be the same to be able to control the variables. This study concentrated on examining the effect of *hue* in the office environment; therefore, the other dimensions of color were controlled in achromatic and chromatic schemes. Thus, for further research, other dimensions of color can be measured. A limitation of this study is that only yellow-red monochromatic scheme was used in the comparison between achromatic and chromatic schemes. However, cool colors could also be added to the color schemes to achieve more extensive results.

Additionally, in the further studies, whether there are demographic effects such as age, gender, and profession on the assessment of different color schemes of an office environment and task performance can also be explored, which was not considered in this study. Moreover, in this study the age of participants were

ranged between 22 years old to 65 years old that was a big range to control the effects of variables on the impressions and performance. Therefore in the further studies, age range of participants should be lower to control the effects of age on measuring the hypothesis.

REFERENCES

Ainsworth, R. A., Simpson, L., & Cassell, D. (1993). Effects of three color in an office interior on mood and performance. *Perceptual and Motor Skills,* 76, 235-241.

Akashi, Y., & Boyce, P.R. (2006). A field study of illuminance reduction. *Energy and Buildings*, 38, 588-599.

Bailey, R. W. (1982). *Human performance engineering: A guide for system designers*. New Jersey: Prentice-Hall, Inc.

Barren, F. (1978). *Color and human response*. New York: Van Nostrand Reinhold.

Birren, F. (1988). *Light, color and environment*. Pennysylvania: Schiffer Pulishing Ltd.

Camgöz, N. (2000). Effects of hue, saturation, and brightness on attention and preference. Unpublished Ph.D Thesis. Bilkent University: Ankara.

Christensen, L.B. (1994). *Experimental Methodology* (6 th ed.). Boston: Allyn and Bacon.

Crouch, A., & Nimran, U. (1989). Perceived facilitators and inhibitors of work performance in an office environment. *Environment and Behavior*, 21 (2), 206-226.

Egan, M.D. & Olgyay, W.V. (2002). *Architectural Lighting*. New York: McGrawHill.

Faulkner, W. (1972). *Architecture and color*. New York: Wiley – Interscience.

Fehrman K. R., & Fehrman, C. (2000). *Color: The secret influence*. New Jersey: Prentice-Hall.

Flynn, J.E. (1977). A study of subjective responses to low energy and nonuniform lighting systems. *Lighting Design and Application*, 7(2), 6-15.

Flynn, J. E., Hendrick, C., Spencer, T.J. & Matyniuk, O. (1979). A guide to methodology procedures for measuring subjective impressions in lighting. *Journal of Illuminating Engineering Society*, 8, 95-110.

Hogg, J., Goodman, S., Porter, T., Mikellides, B., & Preddy, D. E. (1979). Dimensions and determinants of judgments of color samples and simulated interior spaces by architects and non- architects. *British Journal of Psychology*, 70, 231-242.

Houser, K. W., Tiller, D. K., Bernecker, C. A., & Mistrick, R. G. (2002). The subjective response to linear fluorescent direct/indirect lighting systems. *Lighting Research and Technology*, 34(3), 243-264.

Galitz, W. O. (1984). *The office environment*. Willow Groove, Pennsylvania: Administrative Management Society Foundation.

Gifford, R. (2002). *Environmental psychology: Principles and practice*. Canada: Optimal Books.

Gravetter, F. J., & Wallnau, L. B. (2000). Statistics for the behavioral science. (5th ed.). Belmont, CA: Wadsworth.

Galasiu, A.D., & Veitch, J.A. (2006). Occupant preferences and satisfaction with the Luminous environment and control systems in daylit offices: a literature review. *Energy and Buildings,* 38, 728-742.

Jacobs, K. W., & Hustmyer, F. E. (1974). Effects of four psychological primary colors on GRS, heart rate, and respiration rate. *Perceptual and Motor Skills,* 38, 763-766.

Jacobs, K. W., & Suess, J. F. (1975). Effects of four psychological primary colors on anxiety state. *Perceptual and Motor Skills,* 41, 207-210.

Katzev, R. (1992). The impact of energy-efficient office lighting strategies on employee satisfaction and productivity. *Environment and Behavior*, 24, 759-778.

Kaufman, J. E., & Christensen, J. F. (Eds.). (1972). *IES lighting handbook* (5th ed.). New York: Illuminating Engineering Society.

Knez, I. (1995). Effects of indoor lighting on mood and cognition. *Journal of Environmental Psychology*, 15 (1), 39-51.

Kollmorgen Instruments Corporation. (1991). *Munsell Book of color: Glossy finish collection*. Baltimore, Maryland.

Kwallek, N. (1996). Office wall color: An assessment of spaciousness and preference. *Perceptual and Motor Skills,* 83, 49-50.

Kwallek, N., & Lewis, C. M. (1990). Effects of environmental color on males and females: A red or white or green office. *Applied Ergonomics*, 21 (4), 275-278.

Kwallek, N., Lewis, M. C., Lin-Hsiao, J. M. D., & Woodson, H. (1996). Effects of nine monochromatic office interior colors on clerical tasks and worker mood. *Color Research and Application,* 21 (6), 448-458.

Kwallek, N., Lewis, C. M., & Robbins, A. N. (1988). Effects of office interior color on workers' mood and productivity. *Perceptual and Motor Skills,* 66, 123-128.

Kwallek, N., Soon, K., & Lewis, C. M. (2007). Work week productivity, visual complexity, and individual environmental sensitivity in three offices of different color interiors. *Color Research and Application,* 32 (2), 130-143.

Kwallek, N., Soon, K., Woodson, H., & Alexander, J. L. (2005). Effect of color schemes and environmental sensitivity on job satisfaction and perceived performance. *Perceptual and Motor Skills,* 101, 473-486.

Kwallek, N., Woodson, H., Lewis, C. M., & Sales, C. (1997). Impact of three interior color schemes on worker mood and performance relative to individual environmental sensitivity. *Color Research and Application,* 22 (2), 121-132.

Küller, R., Mikellides, B., & Janssens, J. (2009). Color, arousal, and performance-A comparison of three experiments. *Color Research and Application,* 34 (2), 141-152.

Küller, R., Ballal, S., Laike, T., Mikellides, B. & Tonello, G. (2006). The impact of light and color on psychological mood: a cross-cultural study of indoor work environments. *Ergonomics,* 49 (14), 1496- 1507.

Ladau, R. F., Smith, B. R., & Place, J. (1988). *Color in interior design and architecture.* New York: Van Nostrand Reinhold.

Li, D.H.W. & Tsang, E.K.W. (2008). An analysis of daylighting performance for office buildings in Hong Kong. *Building and Environment*, 43, 1446-1458.

Mahnke, F.H. (1996). *Color, environment & human response.* New York: Van Nostrand Reinhold.

Manav, B. (2007). An experimental study on the appraisal of the visual environment at offices in relation to color temperature and illuminance. *Building and Environment*, 42, 979- 983.

Manav, B., & Küçükdoğu, M.Ş. (2006). Aydınlık düzeyi ve renk sıcaklığının performansa etkisi*. Itüdergisi/a,* 5, 3-10.

Marberry, S. O. (1994). *Color in the office: Design trends from 1950-1990 and Beyond*. New York: Van Nostrand Reinhold.

Marberry, S. O., & Zagon, L. (1995). *The power of color: Creating healthy interior spaces*. New York: John Wiley & Sons, Inc.

Menzies, G.F., & Wherrett, J.R. (2005). Windows in workplace: examining issues of environmental sustainability and occupant comfort in the selection of multi-glazed windows. *Energy and Building, 37*, 623-630.

Murdoch, J., & Caughey, C. (2004). Psychological effects of lighting: the work of Professor John Flynn. *Lighting Design and Application*, 34 (8), 69-73.

Nasar, J. L. (Ed.). (1992). *Environmental Aesthetics; Theory, Research, & Applications.* New York: Cambridge University Press.

NCS Color Tools-Color Readers. (2004). Retrieved April 26, 2010 from http://83.168.206.163/webbizz/mainPage/main.asp

Osgood, C.E., Suci, G.J., & Tannenbaum, P.H. (1978).*The measurement of .meaning.* Urbana: University of Illinois Press.

Ödemiş, K., Yener, C., & Camgöz, N. (2004). Effects of different lighting types on visual performance*. Architectural Science Review*, 47, 295- 301.

Pedersen, D. M., Johnson, M., & West, JR, J. H. (1978). Effect of room hue on rating of self, other, and environment. *Perceptual and Motor Skills,* 46, 403-410.

Rea, M.S. (Ed.). (2000). *IESNA Lighting Handbook: Reference& Application.* (9th ed.). New York: Illuminating Engineering Society of North America.

Reyes, M. R. (1986). Experimental approach to lighting level: Color and Light in an office environment. Unpublished Masters' Thesis. Texas Tech University: Broadway.

Sansal, K. E. (2006). The impacts of ActiViva fluorescent lamps on affective states and cognitive performance. Unpublished Master's Thesis. The Bartlett School of Graduate Studies, University College: London.

Smith, D. (2003). Environmental coloration and/or the design process. *Color Research and Application*, 28 (5), 360-365.

Spreckelmeyer, K.F. (1993). Office relocation and environmental change: A case study. *Environment and Behavior*, 25 (2), 181-204.

Standard Practice Subcommittee of the Office Lighting Committee of the IESNA. (1993). *American National Standard Practice for Office Lighting. (RP.1).* New York: Illuminating Engineering Society of North America.

Stone, N. J. (2001). Designing effective study environments. *Journal of Environmental Psychology*, 21, 179-190.

Sundstrom, E. (1986). *Work Places: The psychology of the physical environment in offices and factories.* Cambridge: Cambridge University Press.

Swedish Standard Institution. (1996). *Natural Color System Atlas*. Stockholm, Sweden.

The Raven's Progressive Matrices (2010). Retrieved April 28, 2010 from http://en.wikipedia.org/wiki/Raven's_Progressive_Matrices

The Charted Institution of Building Services Engineers. (CIBSE). (1984).*Code for Interior Lighting.* London: Charted Institution of Building Services Engineers.

Veitch, J.A., & Newsham, G.R. (1998). Lighting quality and energy-efficiency effects on task performanccce, mood, health, satisfaction and comfort. *Journal of the Illuminating Engineering Society,* 27(1),107-130.

Wilson, G. D. (1966). Arousal properties of red versus green. *Perceptual and Motor Skills*, 23, 947-949.

Visher, C. J. (1989). *Environmental Quality in Offices*. New York: Van Nostrand Reinhold.

Visher, C. J. (1996). *Workspace strategies: Environment as a tool of work*. New York: Chapman & Hall.

Wise, B. K., & Wise, J. A. (1988). *Human factors of color in environmental design: A critical review*. California: Ames Research Center.

APPENDIX A

APPENDIX A1.1. The Questionnaire of Phase I (in English)

Please answer the questions in terms of lighting conditions in your office room.

Are you satisfied with the lighting conditions in your office? If not, please state the complaints.

……

……

C. Select the appropriate value for each adjective pair to evaluate the quality of artificial lighting in your office.

	1	2	3	4	5	
dim						bright
hazy						clear
insufficient lighting						sufficient lighting
poor lighting						good lighting
inefficient						efficient
cool						warm
static						dynamic
tense						relaxing
inappropriate						appropriate for offices

Note: The value 1 is for the bright situation and the value 5 is for the dim situation. Please answer all of this type of questions in that manner.

What are your suggestions to improve the lighting conditions in your office?

……

……

……
.

Please answer the questions in terms of color scheme conditions (surface and furniture colors) in your office room.

Are you satisfied with the color scheme in your office? If not, please state the complaints.

……

……

C. Select the appropriate value for each adjective pair to evaluate the color scheme in your office.

	1	2	3	4	5	
hard						soft
dark						light
dull						vibrant
cool						warm
weak						strong
unattractive						attractive
unsatisfying						satisfying
unusual						usual
static						dynamic
boring						interesting
gloomy						cheerful
exciting						calming
inharmonious						harmonious

What are your suggestions to improve the color scheme condition in your office?

……..

……

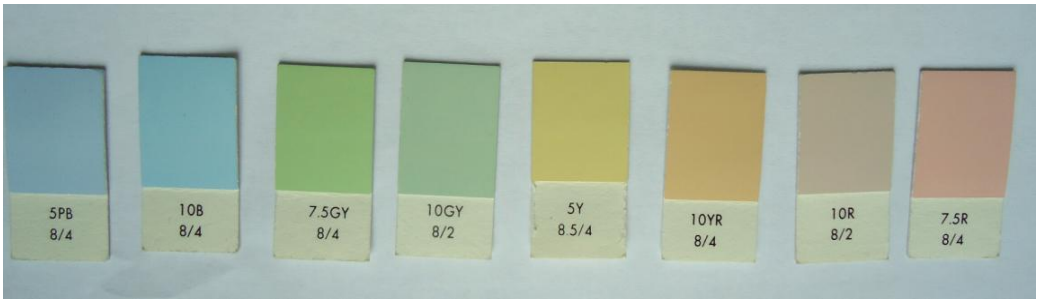
……....

.

Choose one or more of the following that you prefer for your color scheme in your office.

Bright colors	
Dull colors	
Light colors	
Dark colors	
Warm colors	
Cool colors	

Choose one or more from the following color chips that you prefer for the wall colors of your office.



APPENDIX A1.2. The Questionnaire of Phase I (in Turkish)

Aşağıdaki soruları ofis odanızın Aydınlatma **koşullarını düşünerek cevaplayınız.**

Odanızın **aydınlatma koşullarından** memnun musunuz? Varsa, şikâyetleriniz nelerdir?

……

……

Odanızdaki **yapay aydınlatma koşullarını** aşağıdaki sıfat çiftlerinden yaralanarak değerlendiriniz.

	1	2	3	4	5	
sönük						parlak
bulanık						net
yetersiz						aydınlık seviyesi yeterli
kötü aydınlatılmış						iyi aydınlatılmış
verimsiz						verimli
soğuk						sıcak
statik						dinamik
gerginleştirici						gevşetici
Uygun değil						Ofis ortamı için uygun

Not: 1 en parlak, 5 en sönük olduğu durumdur. Diğer sorulardaki sıfat çiftlerini de aynı şekilde düşünerek derecelendiriniz.

Odanızdaki mevcut aydınlatma koşullarının iyileştirilmesi için ne gibi değişikliler önerirsiniz?

……

……

……

Aşağıdaki soruları ofis odanızdaki Renk Şemasını (duvarlar, yer, tavan ve mobilya yüzeyleri) düşünerek cevaplayınız.

Odanızdaki renk şemasından memnun musunuz? Varsa, şikâyetleriniz nelerdir?

……

……..

Odanızın **renk şemasını** aşağıdaki sıfat çiftlerinden yaralanarak değerlendiriniz.

	1	2	3	4	5	
sert						yumuşak
koyu						açık
donuk						canlı
soğuk						sıcak
zayıf						güçlü
itici						çekici
tatmin edici değil						tatmin edici
sıradan						farklı
statik						dinamik
sıkıcı						ilginç
İç karartıcı						neşelendirici
Heyecan verici						sakinleştirici
uyumsuz						uyumlu

Mevcut renk şemasının iyileştirilmesi için ne gibi değişiklikler önerirsiniz?

……

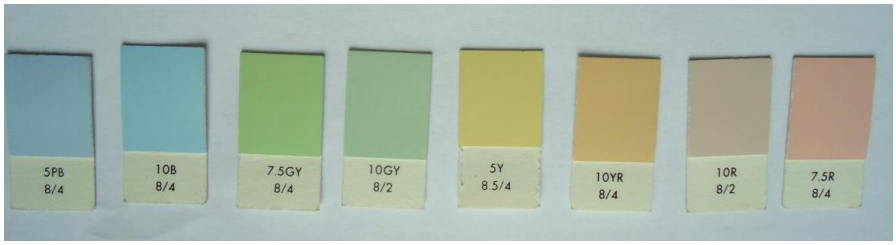
……

……

Ofis ortamında renk şeması için aşağıda önerilen değişimlerden tercih ettiğinizi işaretleyiniz veya sıralayınız?

Daha parlak renkler	
Daha donuk renkler	
Daha açık renkler	
Daha koyu renkler	
Daha sıcak renkler	
Daha soğuk renkler	

Aşağıdaki renk çiplerinden odanız renk şeması için (duvar yüzeyleri) tercih ettiğinizi veya ettiklerinizi seçiniz.



APPENDIX A2. Statistical Results of Phase I

Table A2.1. Raw data of lighting quality in offices

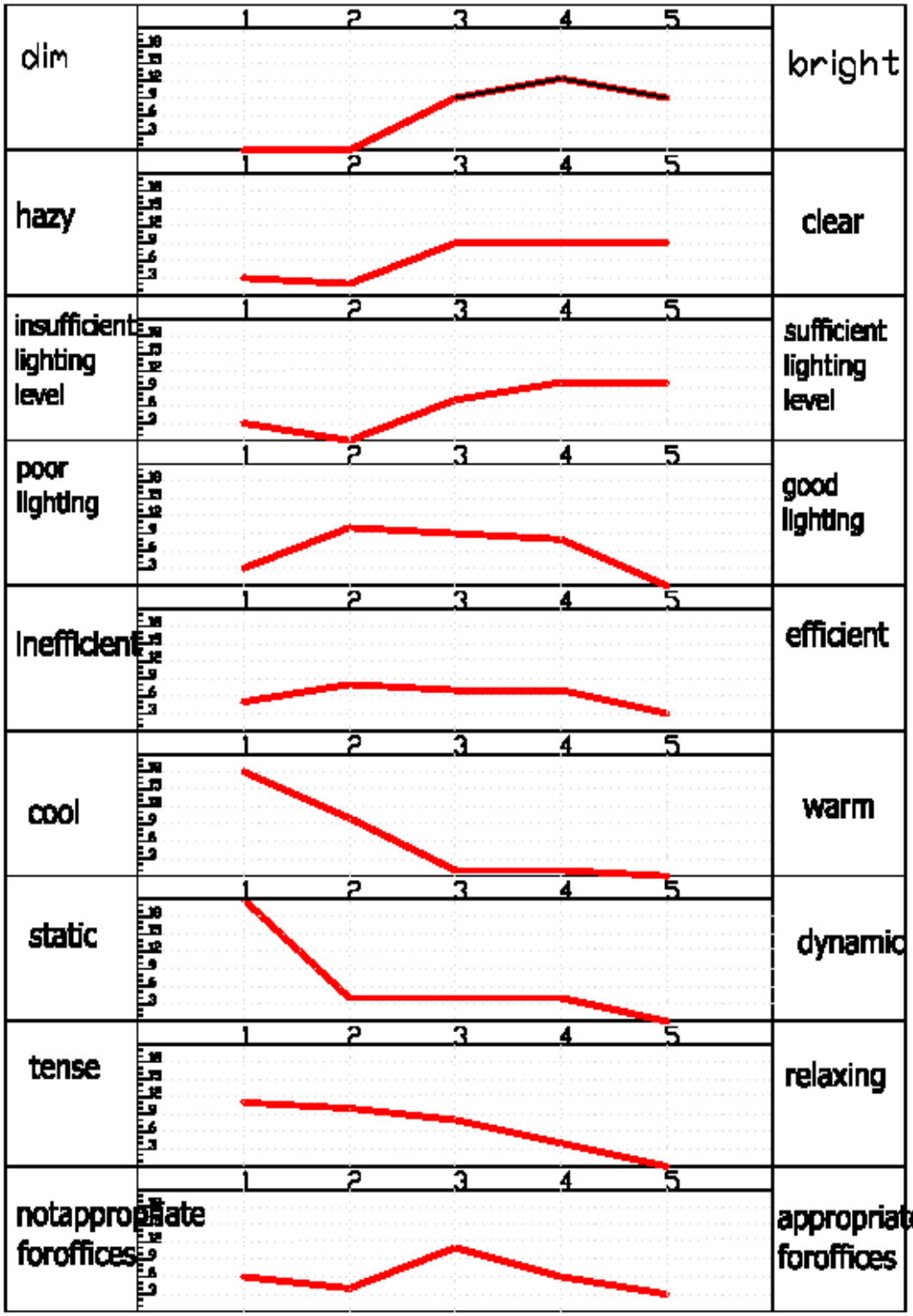


Table A2.2. Raw data of color scheme in offices

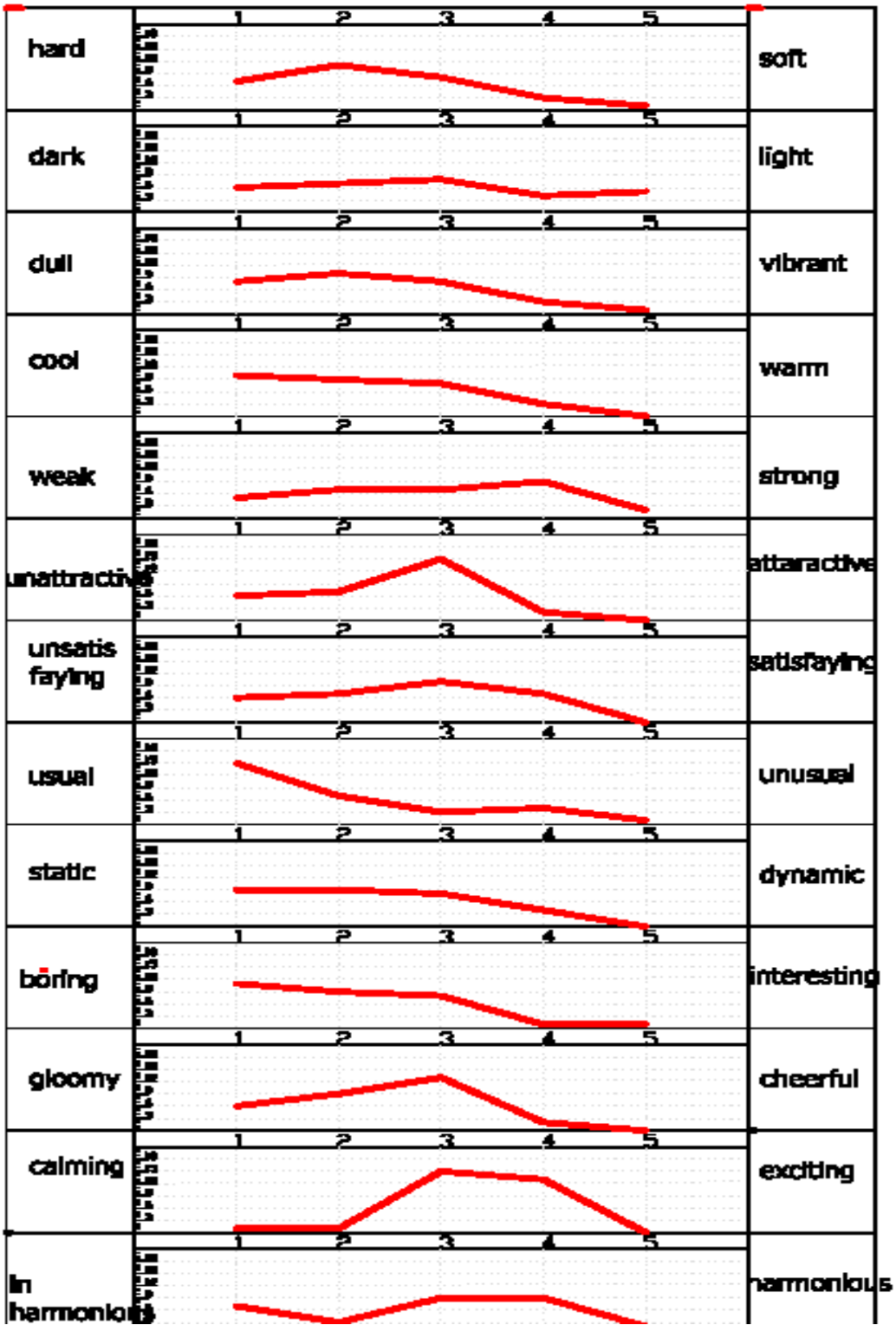


Table A2.3. Chi- square test to analyze the preferred color attributes

	Observed N	Expected N	Residual
bright colors	2	11,5	-9,5
dull colors	3	11,5	-8,5
light colors	16	11,5	4,5
warm colors	25	11,5	13,5
Total	46		

Test Statistics

	Color attributes
Chi-Square(a)	31,739
df	3
Asymp. Sig.	,000

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 11,5.

Table A2.4. Chi- square test to analyze the preferred color chips

Color chips

	Observed N	Expected N	Residual
white	6	8,5	-2,5
warm colors	18	8,5	9,5
cool colors	8	8,5	-,5
another option	2	8,5	-6,5
Total	34		

Test Statistics

	colorschip
Chi-Square(a)	16,353
df	3
Asymp. Sig.	,001

a 0 cells (,0%) have expected frequencies less than 5. The minimum expected cell frequency is 8,5.

APPENDIX B

APPENDIX B1. Photographs of the Construction phase of the experiment room

Figure B1.1. A view from construction phase 1

Figure B1.2. A view from construction phase 2

Figure B1.3 A view from construction phase 3

Figure B1.4. A view from construction phase 4

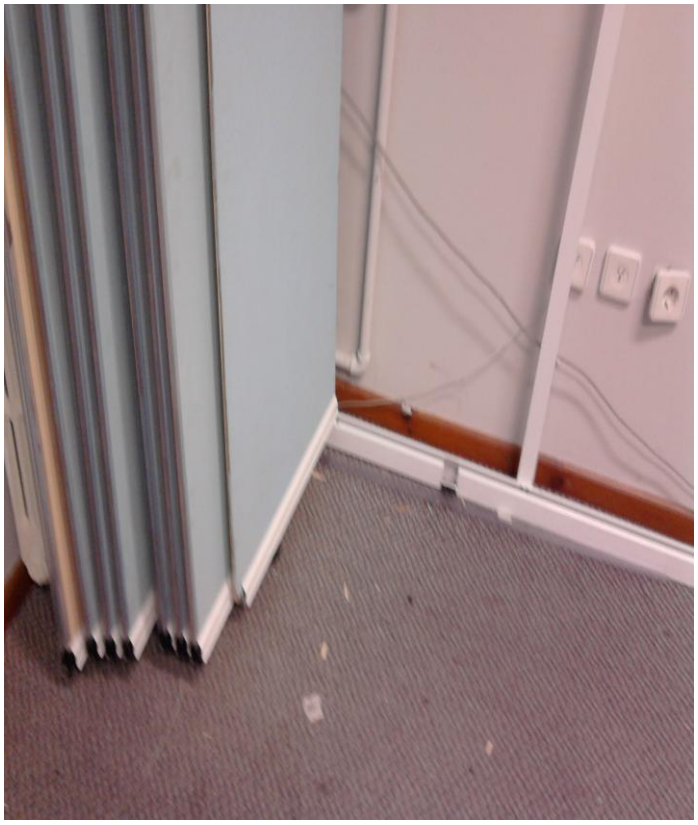


Figure B1.5 A view from construction phase 5

Figure B1.6 A view from construction phase 6

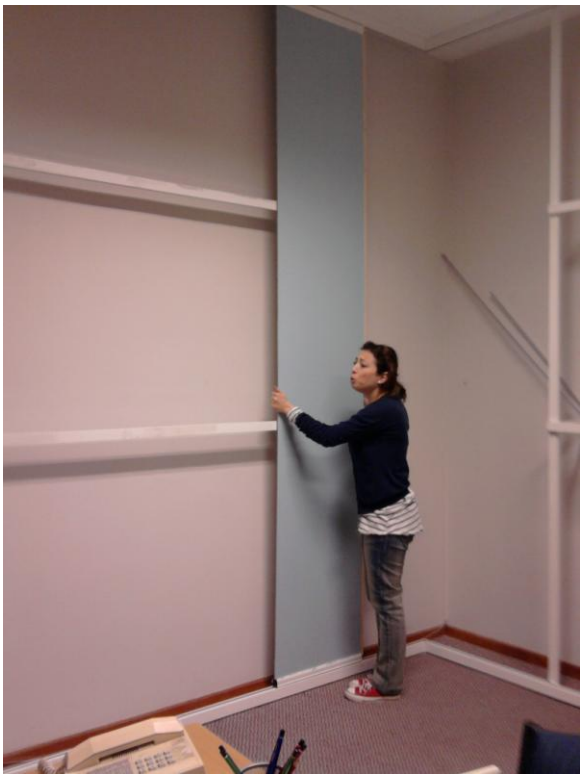


Figure B1.7. A view from construction phase 7

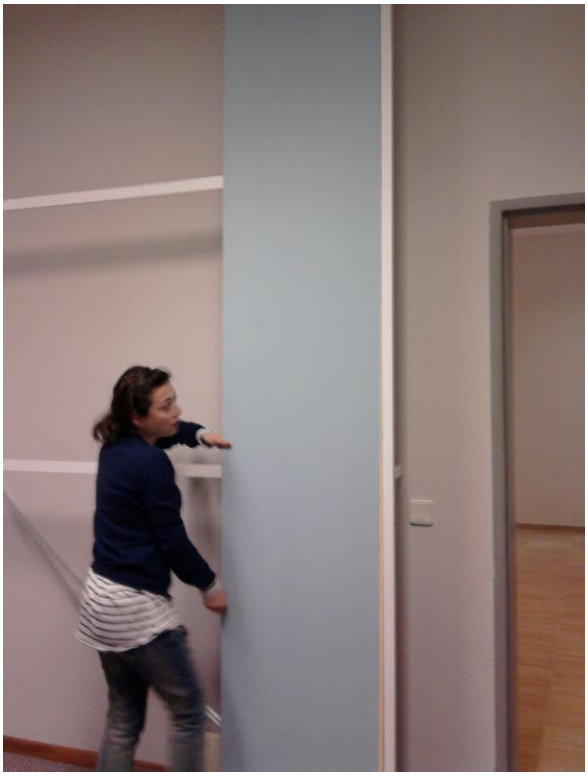


Figure B1. 8. A view from construction phase 8

APPENDIX B2. Photographs of the Experiment Room with Achromatic and Chromatic Color Scheme

Figure B2.1. A view from experiment room with chromatic scheme 1

Figure B2.2. A view from experiment room with chromatic scheme 2

Figure B2.3. A view from experiment room with chromatic scheme 3

Figure B2.4. A view from experiment room with chromatic scheme 4

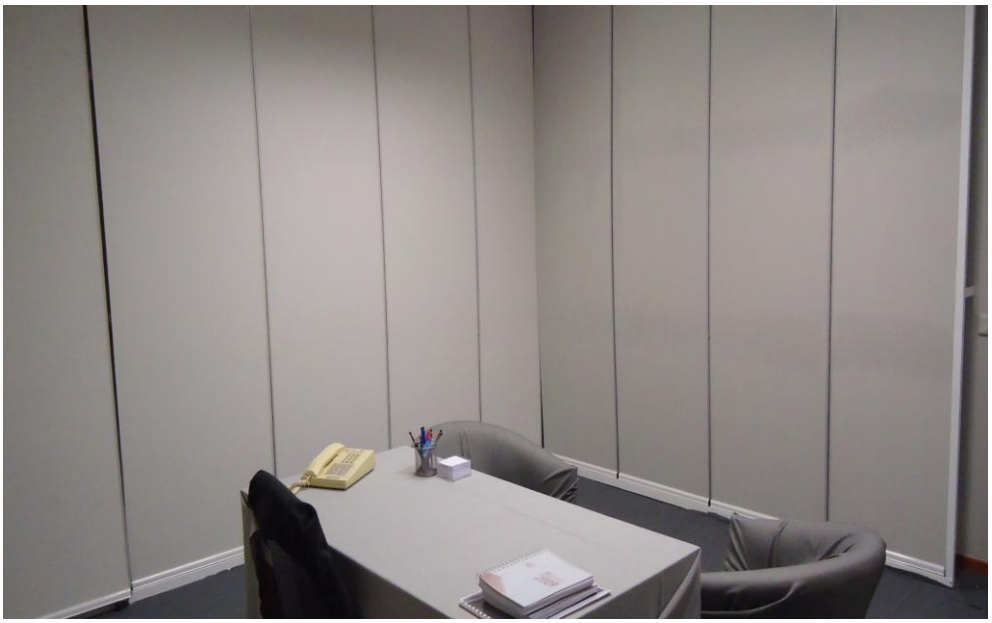


Figure B2.5. A view from experiment room with achromatic scheme 1

Figure B2.6. A view from experiment room with achromatic scheme 2

Figure B2.7. A view from experiment room with achromatic scheme 3

Figure B2.8. A view from experiment room with achromatic scheme 4

APPENDIX C

APPENDIX C1.1. Questionnaire of the experiment: Set 1 (in English)

This survey is to obtain data for a master thesis titled 'Effects of Color Scheme on the Assessment of Office Environment and Task Performance' at Bilkent University, Department of Interior Architecture. The date gathered will not be used for any other purposes and will not be published. Thank you for your participation.

The first part of the questionnaire consists of questions asked you to evaluate your own performance. The next part consists of questions related with evaluating the office environment and color scheme of the office.

A. Personal Info

Age:

Gender**:** F □ M □

Department**:**

Please find and write down how many typing errors there are in the following paragraph.

Bakırcılık da yorgancılığın kaderini paylaştı en sonunda. Oysa tarihte ilk olarak Anadolu'da başlayan bakırcılık, Osmmanlı döneminde doruğa çıkarak doğu sanatının en öneemli eserlerinin üretilmesini sağladı. Daha yirmif yıl öncesine kadar Sahaflar Çarşısı'yla Kapalı Çarşı arasındaki koca caddede onlarca dükkânıyla yer alian Bakırcılar Çarşısı'ndan geriye tek bir dükkân bile kalmadı.

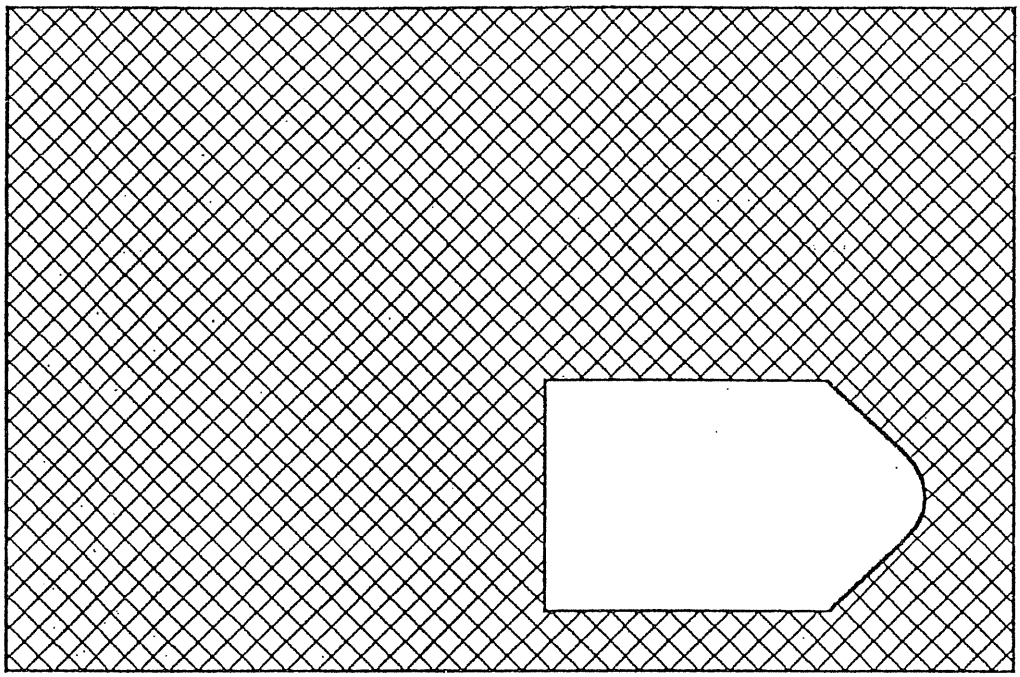
Bakırın çanak olarak kullanımının sona ermesi ve mutfak eşyalarının alüminyum ve plastikten üretilmeye başlamasıyla kalaycılık da bitti. Çzünkü bakır kapların kalaylanma zorunluluğu vardı. Ancak 70'li yıllarda turizmin gelişmesiyle diğers el sanatlarında olduğu gibi bakır da, hediyelik ve dekoratif eşgya olarak Türk motiflerini dünyaya tanıtmak üzere tezgâhlarda nyerini aldı; bununla da kalmadı önemli bir ihraç ürünü hâline genldi.

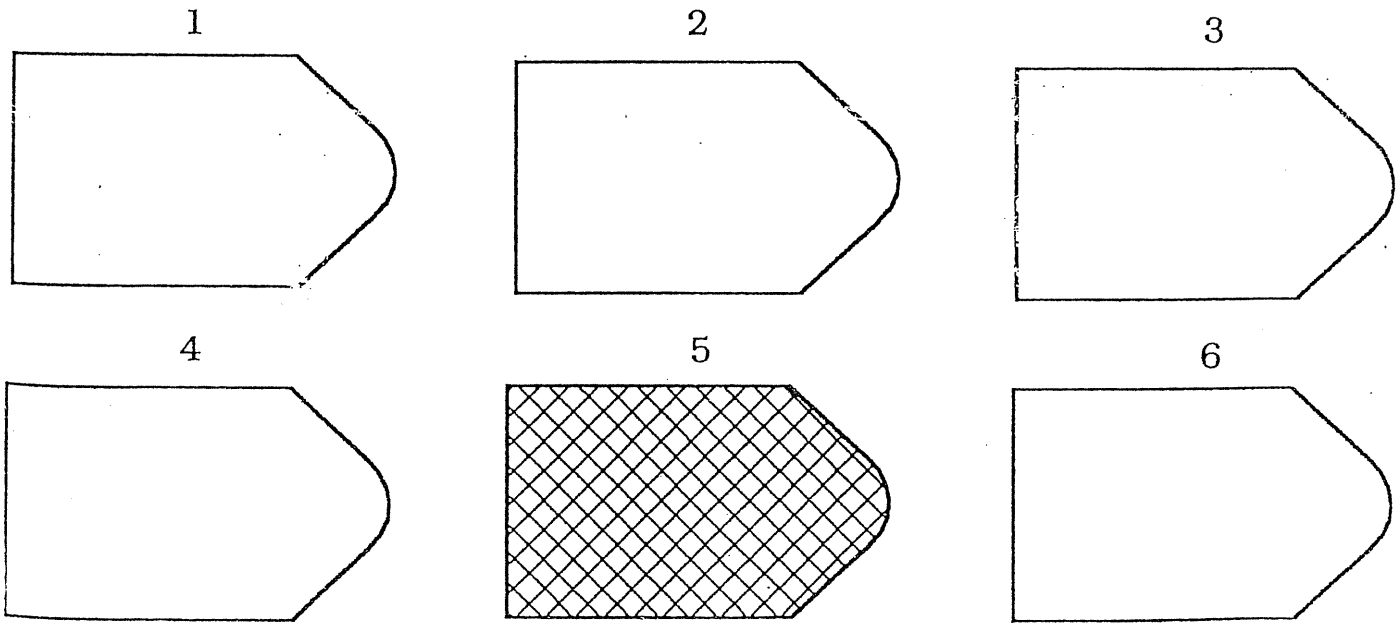
……..

Please find and write down how many times the word 'Harran' is used in the following paragraph.

Tarihi yüzyıllar öncesine uzanan Harran evlerinin benzerlerini Şanlıurfa dışında iki yerde görebilirsiniz: Halep'te ve İtalya'da. Şanlıurfa'yla aynı kültür ve coğrafyayı paylaşması nedeniyle Halep'te görülmesi doğal; ancak bu evlere İtalya'da rastlamak oldukça şaşırtıcı. Bunun öyküsü şöyle: Şanlıurfa'ya gelen İtalyan ressamlar Harran evlerinden çok etkilenmişler. Evlerin fotoğraflarını çekmişler ve İtalya'nın bazı bölgelerinde Harran evlerine benzer mimaride evler yapılmasına öncülük etmişler. Bugün İtalya'da da Harran'da olduğu gibi turistik amaçla kullanılan evler, restoran ve otel olarak hizmet veriyor. Harran mimarisinin uzantısı olan bu evlere İtalya'da "trulli" adı veriliyor. Harran'da toprağın bir parçasıymış gibi görünen evler, İtalya'da bir süs eşyası, bir biblo gibi duruyor.

A2





An example question from the Raven's Progressive Matrices

A. Select the appropriate value for each question to evaluate your performance.

	Very little				Very much
What do you think about your degree of success in the tasks you performed?	1	2	3	4	5
How much attention did you pay to speed in the tasks you performed?	1	2	3	4	5
How much attention did you pay to accuracy in the tasks you performed?	1	2	3	4	5
Do you think that the physical environment has impacts on the tasks you performed?	1	2	3	4	5

B.Select the appropriate value for each adjective pair to evaluate the office.

	1	2	3	4	5	
Unpleasant						Pleasant
Unattractive						Attractive
Unsatisfying						Satisfying
Static						Dynamic
Tense						Relaxing
Uncomfortable						Comfortable
Disorganized						Organized
Nonfunctional						Functional
Informal						Formal
Unusual						Usual
Discordant						Harmonious
Confined						Spacious

C. Select the appropriate value for each question to evaluate the color scheme.

	No				Yes
Do you like the color scheme of the office?	1	2	3	4	5
Do you prefer this color scheme for your office?	1	2	3	4	5
Do you think this color scheme is appropriate for an office environment?	1	2	3	4	5

D. What are your general observations about this office environment?

……

……..

Do you have any complaints about physical conditions (environmental factors) in the office? (Lighting, Color Scheme, Noise, Temperature, Office Layout)

.....

.....

- If yes, what are your suggestions?

.....

.....

APPENDIX C1.2. Questionnaire of the experiment: Set 1 (in Turkish)

Bu araştırma Bilkent Üniversitesi İç Mimarlık Bölümü Yüksek Lisans programı kapsamında "ofis ortamında renk şemasının mekan değerlendirmesi ve performansa etkileri" başlıklı tez çalışması için yapılmaktadır. Farklı bir amaçla kullanılmayacak ve yayınlanmayacaktır. Katılımınız için teşekkürler.

Anket içerisinde ilk önce performans testi ve testlerin değerlendirmesini içeren sorular yer almaktadır, daha sonra mekanı ve renk şemasını değerlendiren sorular bulunmaktadır.

A. Kişisel Bilgiler

Yaş:

Cinsiyet: K □ E □

Bölüm :

Aşağıdaki paragrafta kaç adet yazım hatası olan kelime bulunmaktadır? (işaretleyiniz).

Bakırcılık da yorgancılığın kaderini paylaştı en sonunda. Oysa tarihte ilk olarak Anadolu'da başlayan bakırcılık, Osmmanlı döneminde doruğa çıkarak doğu sanatının en öneemli eserlerinin üretilmesini sağladı. Daha yirmif yıl öncesine kadar Sahaflar Çarşısı'yla Kapalı Çarşı arasındaki koca caddede onlarca dükkânıyla yer alian Bakırcılar Çarşısı'ndan geriye tek bir dükkân bile kalmadı.

Bakırın çanak olarak kullanımının sona ermesi ve mutfak eşyalarının alüminyum ve plastikten üretilmeye başlamasıyla kalaycılık da bitti. Çzünkü bakır kapların kalaylanma zorunluluğu vardı. Ancak 70'li yıllarda turizmin gelişmesiyle diğers el sanatlarında olduğu gibi bakır da, hediyelik ve dekoratif eşgya olarak Türk motiflerini dünyaya tanıtmak üzere tezgâhlarda nyerini aldı; bununla da kalmadı önemli bir ihraç ürünü hâline genldi.

……..

Parçada kaç adet Harran kelimesi kullanılmıştır. (işaretleyiniz).

Tarihi yüzyıllar öncesine uzanan Harran evlerinin benzerlerini Şanlıurfa dışında iki yerde görebilirsiniz: Halep'te ve İtalya'da. Şanlıurfa'yla aynı kültür ve coğrafyayı paylaşması nedeniyle Halep'te görülmesi doğal; ancak bu evlere İtalya'da rastlamak oldukça şaşırtıcı. Bunun öyküsü şöyle: Şanlıurfa'ya gelen İtalyan ressamlar Harran evlerinden çok etkilenmişler. Evlerin fotoğraflarını çekmişler ve İtalya'nın bazı bölgelerinde Harran evlerine benzer mimaride evler yapılmasına öncülük etmişler. Bugün İtalya'da da Harran'da olduğu gibi turistik amaçla kullanılan evler, restoran ve otel olarak hizmet veriyor. Harran mimarisinin uzantısı olan bu evlere İtalya'da "trulli" adı veriliyor. Harran'da toprağın bir parçasıymış gibi görünen evler, İtalya'da bir süs eşyası, bir biblo gibi duruyor

B. Aşağıdaki her soru için yapmış olduğunuz testi nasıl değerlendirdiğinize dair size en uygun değeri işaretleyiniz.

	Az				En Fazla
Testlerde ne kadar başarılı olduğunuzu düşünüyorsunuz?	1	2	3	4	5
Test süresince hıza ne kadar önem verdiniz?	1	2	3	4	5
Test süresince doğruluğa ne kadar önem verdiniz?	1	2	3	4	5
Testlerdeki başarınızda fiziksel çevrenin etkisi olduğunu düşüyor musunuz?	1	2	3	4	5

C. Aşağıdaki her bir sıfat çifti için ofis ortamını nasıl değerlendirdiğinize dair size en uygun olan değeri işaretleyiniz.

	1	2	3	4	5	
Hoş değil						Hoş
İtici						Çekici
Tatmin etmeyen						Tatmin edici
Statik						Dinamik
Gerginleştirici						Gevşetici
Rahatsız						Rahat
Düzensiz						Düzenli
Fonksiyonel değil						Fonksiyonel
Resmi olmayan						Resmi
Alışılmışın dışında						Alışılmış
Uyumsuz						Uyumlu
Sıkışık						Ferah

D. Aşağıdaki her soru için ofisteki renk şemasını nasıl değerlendirdiğinize dair size en uygun olan değeri işaretleyiniz.

	Hayır				Evet
Ofisteki renk şemasını beğendiniz mi?	1	2	3	4	5
Bu renk şemasını kendi ofisiniz için tercih eder misiniz?	1	2	3	4	5
Sizce bu renk şeması ofis için uygun mu?	1	2	3	4	5

E. Bu ofis ortamı hakkındaki genel düşünceleriniz nelerdir?

……

……

…….

Ofisteki fiziksel koşullar ile ilgili herhangi bir şikayetiniz var mı? (aydınlatma, renk şeması, ses, ısı , plan)

.....

.....

- Evet ise, tavsiyeleriniz nelerdir?

.....

.....

APPENDIX C2.1. Questionnaire of the experiment: Set 2 (in English)

This survey is to obtain data for a master thesis titled 'Effects of Color Scheme on Assessment of Office Environment and Task Performance' at Bilkent University, Department of Interior Architecture. The data gathered will not be used for any other purposes and will not be published. Thank you for your participation.

The first part of the questionnaire consists of questions asked you to evaluate your own performance. The next part consists of questions related with evaluating the office environment and color scheme of the office.

A. Personal Info

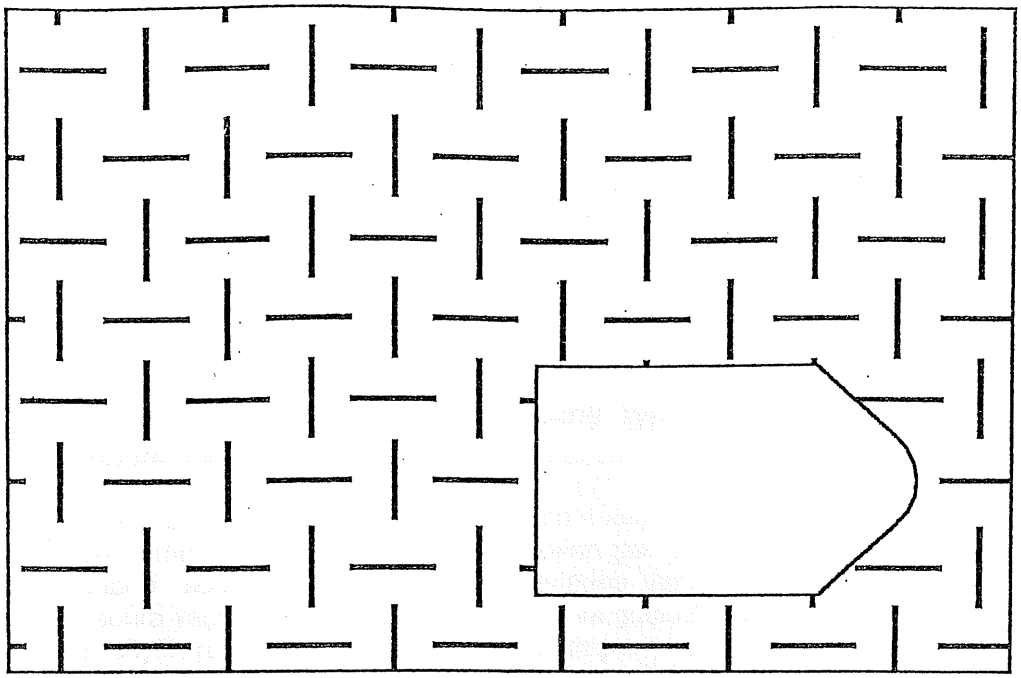
Age:

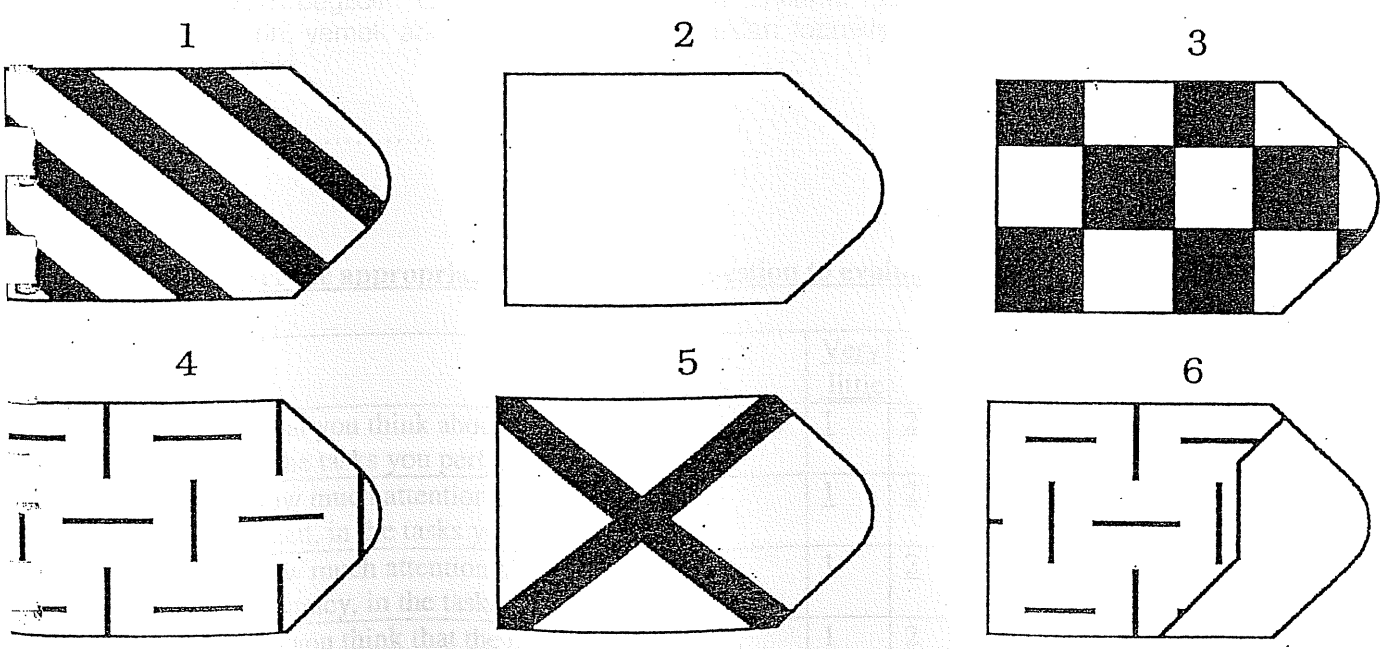
Gender**:** F □ M □

Department**:**

SET A

A1





An example question from the Raven's Progressive Matrices

Please find and write down how many times the word 'Keçe' is used in the following paragraph.

Keçe, yünün yada kılın su ve sabunla çiğnenip dövülerek liflerin birbirine kaynaştırılmasıyla elde edilen ve örtü, yaygı, çadır yada giysi yapmada kullanılan bir tür kaba kumaş olarak tanımlanabilir. Keçe geçmişi milattan önceki yüzyıllara dayanmaktadır. Koyun ve keçinin olduğu her coğrafyada yapılan kazılarda keçe buluntularına rastlanmıştır. Bulunan eşyalara bakıldığında, göçerlerde yaşamın her alanında keçe kullanıldığı görülür. Yündeki keçe dokuma ve giyim endüstrisinde, liflerin bir kusuru, bir sorun olarak görülmüş ve önlenmesi için çeşitli yöntemler geliştirilmiştir. Oysa göçerler, yünün bu özelliğinden yararlanmış, üretimi oldukça zahmetli olan ve beceri gerektiren keçe üretirken üzerine yaptıkları motiflerle duygu ve düşüncelerini aktarmışlardır.

……..

Please find and write down how many typing errors there are in the following paragraph.

Girit mutfağını ve Giritlilerin yeme içmme alışkanlıklarını Anadolu mutfaklarından farklı kılan temel öellikk, yabani otlardan yapılan çok çeşitli yemeklerin varlığıdır. Nüfus değişiminden sonra Anadolu'nun eeşitli yerlerine yerleştirilen Giritli Müslüman halkın bundan sonra yaşayacakları topraklarda yesni ve güçlü bir kimlik oluşturmasında mutfak kültürleri büyük rool oynamış; en önemli farklılaşmayı da yabani otların yoğun tüketimi ortaya koymuştur.

Aslında tutumlarında katı olmayan ve değişmeye açiik insanlar olan Giritliler, yemekleri söz konusu olduğunda kurallara son derece bağlı ve tutucu davranırlar. Onları, mevvcut bir tarifi değiştirmeye, ufak bir ekleme veya çıkarma yapmaya ikna etmek mümkün değildir. Geldikleri topraklara ait anılarını adteta yemeklerinde saklayan Giritlilerin, yemek adetlerine bu asşırı bağlılıkları topraklarına duydukları özlemden ileri gelir sanki.

…….

B. Select the appropriate value for each question to evaluate your performance.

	Very little				Very much
What you think about your degree of success in the tasks you performed?	1	2	3	4	5
How much attention did you pay to the speed, in the tasks you performed?	1	2	3	4	5
How much attention did you pay to the accuracy, in the tasks you performed?	1	2	3	4	5
Do you think that the physical Environment has impacts on the tasks you performed?	1	2	3	4	5

C.Select the appropriate value for each adjective pair to evaluate the office.

	1	2	3	4	5	
Unpleasant						Pleasant
Unattractive						Attractive
Unsatisfying						Satisfying
Static						Dynamic
Tense						Relaxing
Uncomfortable						Comfortable
Disorganized						Organized
Nonfunctional						Functional
Informal						Formal
Unusual						Usual
Discordant						Harmonious
Confined						Spacious

D. Select the appropriate value for each question to evaluate the color scheme.

	No				Yes
Do you like the color scheme of the office?	1	2	3	4	5
Do you prefer this color scheme for your office?	1	2	3	4	5
Do you think this color scheme is appropriate for an office environment?	1	2	3	4	5

E. What are your general observations about this office environment?

……

……

…….

Do you have any complaints about physical conditions (environmental factors) in the office? (Lighting, Color scheme, Noise, Temperature, Office Layout)

.....

.....

- If yes, what are your suggestions?

.....

.....

APPENDIX C2.2. Questionnaire of the experiment: Set 2 (in Turkish)

Bu araştırma Bilkent Üniversitesi İç Mimarlık Bölümü Yüksek Lisans programı kapsamında "ofis ortamında renk şemasının mekan değerlendirmesine ve performansa etkileri" başlıklı tez çalışması için yapılmaktadır.
Farklı bir amaçla kullanılmayacak ve yayınlanmayacaktır. Katılımınız için teşekkürler.

Anket içerisinde ilk önce performans testi ve testin değerlendirmesini içeren sorular yer almaktadır, daha sonra mekanı ve renk şemasını değerlendiren sorular bulunmaktadır.

A. Kişisel Bilgiler

Yaş:

Cinsiyet: K □ E □

Bölüm :

Parçada kaç adet keçe kelimesi kullanılmıştır? (işaretleyiniz)

Keçe, yünün yada kılın su ve sabunla çiğnenip dövülerek liflerin birbirine kaynaştırılmasıyla elde edilen ve örtü, yaygı, çadır yada giysi yapmada kullanılan bir tür kaba kumaş olarak tanımlanabilir. Keçe geçmişi milattan önceki yüzyıllara dayanmaktadır. Koyun ve keçinin olduğu her coğrafyada yapılan kazılarda keçe buluntularına rastlanmıştır. Bulunan eşyalara bakıldığında, göçerlerde yaşamın her alanında keçe kullanıldığı görülür. Yündeki keçe dokuma ve giyim endüstrisinde, liflerin bir kusuru, bir sorun olarak görülmüş ve önlenmesi için çeşitli yöntemler geliştirilmiştir. Oysa göçerler, yünün bu özelliğinden yararlanmış, üretimi oldukça zahmetli olan ve beceri gerektiren keçe üretirken üzerine yaptıkları motiflerle duygu ve düşüncelerini aktarmışlardır.

……..

Aşağıdaki paragrafta kaç adet yazım hatası olan kelime bulunmaktadır? (işaretleyiniz).

Girit mutfağını ve Giritlilerin yeme içmme alışkanlıklarını Anadolu mutfaklarından farklı kılan temel öellikk, yabani otlardan yapılan çok çeşitli yemeklerin varlığıdır. Nüfus değişiminden sonra Anadolu'nun eeşitli yerlerine yerleştirilen Giritli Müslüman halkın bundan sonra yaşayacakları topraklarda yesni ve güçlü bir kimlik oluşturmasında mutfak kültürleri büyük rool oynamış; en önemli farklılaşmayı da yabani otların yoğun tüketimi ortaya koymuştur.

Aslında tutumlarında katı olmayan ve değişmeye açiik insanlar olan Giritliler, yemekleri söz konusu olduğunda kurallara son derece bağlı ve tutucu davranırlar. Onları, mevvcut bir tarifi değiştirmeye, ufak bir ekleme veya çıkarma yapmaya ikna etmek mümkün değildir. Geldikleri topraklara ait anılarını adteta yemeklerinde saklayan Giritlilerin, yemek adetlerine bu aşşırı bağlılıkları topraklarına duydukları özlemden ileri gelir sanki.

…….

B Aşağıdaki her soru için yapmış olduğunuz testi nasıl değerlendirdiğinize dair size en uygun değeri işaretleyiniz.

	En az				En Fazla
Testlerde ne kadar başarılı olduğunuzu düşünüyorsunuz?	1	2	3	4	5
Test süresince hıza ne kadar önem verdiniz?	1	2	3	4	5
Test süresince doğruluğa ne kadar önem verdiniz?	1	2	3	4	5
Testlerdeki başarınızda odadaki fiziksel çevrenin(koşulların) etkisi olduğunu düşüyor musunuz?	1	2	3	4	5

C. Aşağıdaki her bir sıfat çifti için ofis ortamını nasıl değerlendirdiğinize dair size en uygun olan değeri işaretleyiniz.

	1	2	3	4	5	
Hoş değil						Hoş
İtici						Çekici
Tatmin etmeyen						Tatmin edici
Statik						Dinamik
Gerginleştirici						Gevşetici
Rahatsız						Rahat
Düzensiz						Düzenli
Fonksiyonel değil						Fonksiyonel
Resmi olmayan						Resmi
Alışılmışın dışında						Alışılmış
Uyumsuz						Uyumlu
Sıkışık						Ferah

D. Aşağıdaki her soru için ofisteki renk şemasını nasıl değerlendirdiğinize dair size en uygun olan değeri işaretleyiniz.

	Hayır				Evet
Ofisteki renk şemasını beğendiniz mi?	1	2	3	4	5
Bu renk şemasını kendi ofisiniz için tercih eder misiniz?	1	2	3	4	5
Sizce bu renk şeması ofis için uygun mu?	1	2	3	4	5

E. Bu ofis ortamı hakkındaki genel düşünceleriniz nelerdir?

……

……

Ofisteki fiziksel koşullar ile ilgili herhangi bir şikayetiniz var mı? (aydınlatma, renk şeması, ses, ısı , plan)

.....

.....

- Evet ise, tavsiyeleriniz nelerdir?

.....

.....

APPENDIX D

APPENDIX D. Statistical Results of the Experiment

Table D1. Wilcoxon Signed Rank test for differences between achromatic and chromatic scheme in terms of the bipolar adjective pairs.

	Pleasant/ Unpleasant	Attractive/ Unattractive	Satisfying/ Unsatisfying	Static/ Dynamic	Tense/ Relax	Comfortable/ Uncomfortable	Organized/ Disorganized	Functional /Nonfunctional	Formal/ Informal	Usual/ Unusual	Harmonious/ Discord	Spacious/ Confined
Z	-2,108(a)	-1,974(a)	-2,437(a)	-3,214(a)	1,398(a)	-1,033(b)	-,836(b)	-,674(a)	-3,044(b)	-,180(a)	-4,328(b)	-,878(a)
Asymp. Sig. (2-tailed)	,035	,048	,015	,001	,162	,302	,403	,500	,002	,857	,000	,380

a. Based on negative ranks.
b. Based on positive ranks.

Table D2. Wilcoxon Signed Rank test for differences between achromatic and chromatic scheme in terms of preference and associations of the color scheme.

Test Statistics (b)

	Do you like the color scheme of the office?	Do you prefer this color scheme for your office?	Do you think this color scheme is appropriate for an office environment?
Z	-1,281(a)	-1,199(a)	-1,756(a)
Asymp. Sig. (2-tailed)	,200	,231	,079

a. Based on negative ranks.
b Wilcoxon Signed Ranks Test

Table D3.1 Independent Samples T-test for differences in achromatic schemes in terms of accuracy in tasks (measuring learning effect)

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
errornumber in achromatic schemes	Equal variances assumed	,660	,420	,730	58	,468	,400	,548	-,696	1,496
	Equal variances not assumed			,730	48,926	,469	,400	,548	-,701	1,501

Table D3.2 Independent Samples T-test for differences in chromatic schemes in terms of accuracy in tasks (measuring learning effect)

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
errornumber in chromatic schemes	Equal variances assumed	1,827	,182	,786	58	,435	,200	,254	-,309	,709
	Equal variances not assumed			,786	50,566	,436	,200	,254	-,311	,711

Table D3.3. Independent Samples T-test for differences in achromatic schemes in terms of speed of performance (measuring learning effect)

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
speed of performances in achromaitc schemes	Equal variances assumed	3,716	,059	1,330	58	,189	,54100	,40675	-,27320	1,35520
	Equal variances not assumed			1,330	54,380	,189	,54100	,40675	-,27435	1,35635

Table D3.4. Independent Samples T-test for differences in chromatic schemes in terms of speed of performance (measuring learning effect)

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
speef of performance in chromatic schemes	Equal variances assumed	,628	,431	-,872	58	,387	-,30067	,34498	-,99121	,38988
	Equal variances not assumed			-,872	53,446	,387	-,30067	,34498	-,99247	,39113

Table D4. Wilcoxon Signed Rank test for differences between achromatic and chromatic scheme in terms of self-report of the tasks.

Test Statistics[b]

	What you think about your degree of success in the tasks you performed?	How much did you pay attention to the speed, in the tasks you performed?	How much did you pay attention to the accuracy, in the tasks you performed?	Do you think that the physical environment has impacts on the tasks you performed?
Z	-1,519[a]	-,539[a]	-,728[a]	-,972[a]
Asymp. Sig. (2-tailed)	,129	,590	,467	,331

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test