

# **The Psychological Impact of Color on Users in Academic Library**

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## **ABSTRACT**

The psychological effects of color mean that color's impact on each and every individual are vast, however, people rarely have a clue of how these effects are even occurring. Color can influence health, and also personal and professional image of every person. Color and light are inextricably connected; color cannot come to existence without light. In its true sense, nearly every aspect of people's daily lives is affected by color and light and yet the majority of people go about their every day without giving it a second thought or ever really understanding how they are constantly being affected. This also includes architects and designers with years of working directly with color and light who are expected to know about how much it affects people physiologically, psychologically and sociologically.

When it comes to architectural point of view, there are many ways to use this potential in architecture and improve the efficiency of each building psychologically for the users. Also, by considering the function of library to make a convenient atmosphere and high level of motivation for a successful study; also, the possibility of monotony which might happen to students during the long time study in university library can be replaced with a pleasant and interesting one based on the psychology of colors. In point of fact, the strongest visual stimulus, included a vast range of affective attributes. In a natural manner, human have a significant sensitive to color, and colors may have applied even harmful effects. Thus, the aim of this study is investigating color, the most effective visual element which environment of human surrounded by. Whereas, biological effects of color only will be mentioned; from psychological point of view this matter will considered specifically. The general

psychological effects of colors on human analyzed. Further, colors have significant psychological effects on individuals when they come on three basic interior elements (walls, floor or ceiling). Thus, these effects can lead designers to prepare a convenient environment for the users of university libraries. This study can consider as a method to increase the efficiency of university libraries by using specific colors due to their psychological effects for each space in the library.

**Keywords:** Color- Color and Light- Psychological Effects of Color- Academic Library

## ÖZ

Rengin psikolojik etkileri, renklerin her bir birey üzerindeki etkisinin çok büyük olduğu anlamına gelir, ancak insanlar nadiren bu etkilerin nasıl meydana geldiğine dair bir ipucuna sahiptir. Renk, sağlığı ve ayrıca her insanın kişisel ve profesyonel imajını etkileyebilir. Renk ve ışık ayrılmaz şekilde bağlı; renk ışık olmadan varolamaz. Gerçek anlamda, insanların günlük yaşamlarının neredeyse her yönü renk ve ışıktan etkilenir ve yine de insanların çoğunluğu her gününü bunu düşünmeden ya da sürekli olarak nasıl etkilenmekte olduklarını anlamaya çalışmadan devam etmektedir. Bu aynı zamanda yıllar boyu doğrudan renkle çalışmış mimarları ve tasarımcıları da içerir, bunlar renk ve ışığın insanların fizyolojik, psikolojik ve sosyolojik açıdan ne kadar etkilediğini bilmeleri beklenenlerdir.

Mimari açıdan bakıldığında, bu potansiyeli mimaride kullanmanın ve kullanıcıların psikolojik olarak her binanın verimliliğini artırmanın birçok yolu var. Ayrıca, kütüphanenin uzun süre çalışmak için uygun bir atmosfer ve yüksek seviyede motivasyon yaratma işlevini göz önüne alarak; akademik kütüphanenin monoton atmosferi renk psikolojisine dayanan hoş ve ilginç bir atmosfer ile değiştirilebilir. Aslında, en güçlü görsel uyarı, geniş bir duygusal nitelik aralığını içeriyordu. Bu nedenle, bu çalışmanın amacı, çevrenin insan tarafından kuşatılmış en etkili görsel öğesi olan rengi araştırmaktır. Buna karşılık, rengin biyolojik etkileri sadece belirtilmiş; özellikle psikolojik açıdan bu konu dikkate alınmıştır. İnsanların renkler üzerindeki genel psikolojik etkileri analiz edilmiştir. Ayrıca, renklerin üç temel iç öğe (duvar, zemin veya tavan) bir araya geldiğinde bireyler üzerinde önemli psikolojik etkileri vardır. Böylece, bu etkiler tasarımcıları üniversite kütüphaneleri

kullanıcıları için uygun bir ortam hazırlamaya yönlendirebilir. Bu çalışma, kütüphanedeki her alan için psikolojik etkileri nedeniyle belirli renkleri kullanarak üniversite kütüphanelerinin verimliliğini artırmak için bir yöntem olarak düşünülebilir.

**Anahtar Kelimeler:** Renk-Renk ve Işık- Rengin Psikolojik Etkileri- Akademik Kütüphane

## **DEDICATION**

I dedicate this thesis to my mother who is sick while I am write my thesis and I cannot be beside her during these tough days, however she has always kept her faith in me and pretended she is fine not to demotivate me for finishing my master.

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In addition, I would like to thank my family, who stood next to me and supported me in every possible ways and motivated me.



## PREFACE

There were marvels buried within the packs of information in access- people capable of “seeing” color with their skin, or those who experienced healing powers of certain colors after exposure, people whose physiological conditions were dramatically affected by being in rooms colored a certain way. There were found mysteries in the many myths which are totally believed by the general population as truth even though there is not a single shred of evidence as support. Phrases such as “red excites you” or “blue is calming” were frequently used by people without a faintest idea why they thought that way and most of them were somehow vehement, not having a clue or fact to support their belief. This strengthened the move to sort out the myths from the facts in order to show how color/light truly affects us, and use this knowledge that help us to get the right colors to improve our lives.

Technically, everyone can benefit from a better knowledge of color and light by collecting enough information and data for anyone who is interested in color and its usage, but it is an essential skill for designers since they affect people every day by the colors they choose in their work. One of the important public buildings that designers have to be really thorough with their design ideas is library as a bank of information and data and also an efficient and pleasant place to study where users spend long periods of time. So, library has to be considered in details by designers because of its very specific function.

*“Color is a wonderful evolution given to this planet as a gift to infuse it as life into  
the survival of all kinds of life,”*

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# Chapter 1

## INTRODUCTION

Technically, everyone can benefit from a better knowledge of color by collecting enough information and data for anyone who is interested in color and its usage, but it is an essential skill for designers since they affect people every day by the color they choose in their works. One of the important public buildings that designers have to be really thorough with their design ideas is library as a bank of information and data and also an efficient and pleasant place to study where users spend long periods of time. So, library has to be considered in details by designers because of its very specific function.

Since color and light are undeniably interconnected, without light there will be no color to see. However, human's brain is constantly and rather unconsciously separating the two entities, giving less attention to the connection between color and light playing around in the surroundings and even passing through people. In reality, color and light are present in every aspect of daily life, affecting it in numerous ways while people continue to neglect this huge effect and not try to understand how complicated these effects are. Even at the level of artists and designers, or people who have had a great course of their lives working directly with color/light, it is quite rare to find someone who is well aware of biological, psychological and sociological effects of the issue (Fehrman & Fehrman, 2004). The use of color is an important element in design. Decisions about how to use color in any project is a key to success



regardless who the involved person might be; whether a designer, an architect or an interior architect or simply a householder (Pile, 1997). Making decisions on color can be quite a complex task and of a unique essence. It can come with surprises, hazards and pitfalls regardless the level of professionalism of people. Good flair cannot be a solely essential element for making the right decisions for color usage, especially when dealing with a construction which will serve a diversity of people or purposes. Apart from adequate information and good reasoning, one requires prompt knowledge along with technical expertise to develop a good understanding of psychological effects of color (Miller & Barbara, 2005). Thus, awareness of the uncountable nuances of color will strengthen one's ability to make better and more impressive choices regarding the use of color.

Also, a university's library is not only valued by the resources of knowledge laid on its shelves, but also depends on how satisfactory it is spending time in it. Users' satisfactions is a key factor in the evaluation of any public place; here in particular: Libraries. This term cannot be restricted to only facilities and services (Balanli et al., 2005). Moreover, environmental conditions and related requirements play an important role in the efficiency of any library. These conditions are of inevitable influence on users activities in university library.

These specific circumstances demand every reliable organization to attempt for fulfilling sublime environmental opportunities and think of solutions for limitations at immediate chance (Dayani, 2001). Libraries are required to provide a convenient place and bring out all feelings which are essential for a good and fruitful course of study and make users' study time as efficient and pleasant as possible. Such environment is expected to help people feel awake and thrive regardless the

psychological pressure they might be experiencing. Employees, their personalities and activities can easily be influenced by the interior environment they are resided in. The same can apply to libraries. The interior design of a library is of great influence on the effectiveness and usefulness of the place. Thus, it should be directly aimed at making a space which betters the quality and efficiency of studying. Everything else, including the tools, equipment, technological instruments, etc., is merely an inseparable part of the interior design. If seeking a beautiful and convenient result from interior design ideas, the above mentioned factors must be coordinated within the architecture of the building and be considered as a complementary part (Ta'avoni & Asefi, 1998). Design is usually known to be a collection of different elements- knowledge, techniques and art along with dependent elements of form and color- combined together for the sake of beauty and meaningfulness of places and spaces. The designer takes advantage of these tools and elements i.e. light, color and form to make a coordination to display a suitable and pleasant space. It could be said that color is the most influential visual element of all. It can greatly affect the environments, particularly those of a rather motionless space atmosphere like libraries. Considering the impact of color on students' study time in a university library, choosing the color of space elements (wall, floor and ceiling) correctly is a good way which can bring about some serious positive effects. In addition, color used in a library must definitely differ from the ones used in hospitals or prisons. Color is considered by some as an audiovisual attribute of the form. Technically, it means that form finds meaning in color because it is the color which can easily influence the mood and feelings of people and how the form is seen through their eyes. Psychological properties of color are of high importance in design (Majlesi, 2008).

Human's body shows various physiological reactions which are revealed as changes in blood pressure, rate of heart beat, breathing and body temperature. A neuropsychologist called Kurt Guldstein stated that people with color blindness disorder are capable of feeling color by their skins (Daggett, Cobble & Gerfel, 2008).

Taking all the above into consideration, a library of university cannot be evaluated only by the resources, services and facilities, but also what scale of satisfaction its environment gives to the users. Facilities and services are only a part of the overall evaluation. The space and how it makes the people feel play a very important role too. Although everything is nowadays pushed in the shadows of sophisticated electronic and technological facilities and services, the physical and social characteristics of a library remain among the relevant features to facilitate the use of libraries (Balanli, et al, 2005).

As it is obvious if there is no light, there will be no such thing as color; and also, the light enters the visual system through the eye so for achieving the main purpose of this study in first step understanding the human vision system is essential, and then color and its psychology, and in the last step library and its convenient situation for more efficient study

## **1.1 Problem Statement**

The primary function of a building is to deal with biological, social and psychological requirements of users. Those requirements are dealt by social and physical features of outdoor and indoor environments of the building. Negative characteristics of physical and psychological indoor and outdoor environments will cause fail to meet the requirements of users. Thus they turn into negative

environmental factors which might impact all users' well-being and lead to possible health problems, psychologically and biologically (Balanli, et al, 2005).

Recently, people's focus and attention is mainly on the effects of their environment. In this case, one desires to feel calm and at peace when sitting in a library. Moreover, there are other psychological effects people demand from a library: a place to build cultural exchanges and connections, where their stress and anxiety is minimized as their motivation to study and work hard elevates at the least level of distraction. As a person walks into a library, there is the risk that he might feel confused or at all the gigantic amount of information piled up in a limited space. Moreover, the motionless and silent space of library can be a reason for losing the awareness of users during the study. This is why designing a space which looks attractive or interesting to sit in groups and share is crucial in eliminating that negative sense and replace it with positive feelings. In this context, color hold a key role in improving the audiovisual interactions and eliminate anxiety or stress. Color, if used in a proper way, is also capable of raising the level of creativity and concentration (Daggett, Cobble & Gerfel, 2008).

As a psychological fact, studying is quite a demanding and challenging task, especially when preparing for a paper, seminar, presentation or most importantly exam. It is not easy to spend hours and hours at a desk, reading, memorizing, practicing and exercising, and at the same time dealing with the level of stress, pressure, anxiety and also monotony which might accompany the above activities (Adekanye, 2004). Furthermore, color is an exciting part of interior design and tools to maximize function as they easily influence people's emotions and feelings.

Obviously, color is not a very simple subject due to its profound impacts on human's mentality, emotions and psyche (Rozegari, 2006).

Another important issue to address here is poor or lack of education on color in university library design programs, thus resulting in color implications and psychological harm due to little knowledge and poor understanding of color and its connections with the environment of students in academic libraries (Poore, 1994).

In addition, university library is different from other libraries: because, the users of university library are not just improving their knowledge in some fields, these users are planning to use their time efficient for preparing themselves for exam, presentation, collecting data for their studies or etc (Steele, 2002).

## **1.2 Research Objectives**

According to the function of each building, a building is expected to fulfill three basic requirements for its users: biological, psychological and social. For a library as an academic space, choice of color is a profound task. A library has a silent and motionless space but, it must not feel like a monotonous place, it has to reduce negative psychological phases and fill the users with positivity; and it can all be efficiently done with color. Color has a high potential as a main element of design which can be very influential. This research is aimed at investigating the effects of color in a university library as a heart of university and appropriate use of color to provide a convenient atmosphere for students.

## **1.3 Research Question**

According to literature what effects can color have on the psychology of students who are studying at the library? According to psychological effects of color how

better choice of color can decrease the possibility of monotony which might happen to students during the long time study? Also how can color reduce negative psychological symptoms of the students and give them more positive feeling? How can the efficiency of libraries and the students be optimized by choosing the right color?

## **1.4 Research Methodology**

The current thesis is based on a qualitative data analysis of psychological effects of color in general and in interior spaces to conduct a pattern for better choice of color for a university library. Mentioning public and university libraries as examples and the way that each one used color for its walls, floor and ceiling. Also, this study provide a theoretical basis for the future research ideas for a better choice of color for other university spaces or even all spaces according to psychological requirement of the users. In general, the research process involves four major parts: literature review, data collection and data analysis accordingly.

First of all, extensive studies through related literature is conducted, by in-depth examination of various documents, books, publications, journal articles, periodicals, reports, essays, internet sources, etc. Along these lines, desired data is collected, so to establish a theoretical foundation for research and gain understanding of historical development of human-color-environment relationships. In this way, essential knowledge of psycho-physiological basis of color perception by human is acquired for the next step. Furthermore, recent researches and experimental investigations are examined and analyzed to extract major effects of color in connection to human's perceptions and experiences of physical environment, as well as man's behaviors, performances, and psycho-physiological condition in general.

In addition, effects of color on human are analyzed specifically in the context of color implications within interior environments, with focus on functional requirements of the space, tasks to be performed and anticipated groups of the users.

As a final stage, according to psychological effects of color a pattern for a better choice of color within indoor environments will be derived, particularly for educational facilities such as libraries. In a specific way, these guidelines are delivered according to utilization of color specifically among space-defining elements, floors, walls, and ceilings.

### **1.5 Limitation of Study**

How spaces are set in terms of direction can cast significant effects on how color and light are perceived by people. Every room is unique and has to maintain its uniqueness through its color as well. Ignoring such important connection between space and color could lead to bad effects in structure and space.

The composition of color produced by natural light keeps changing from dawn to dusk, from season to season, from north to south and east to west. Sao Paulo light is different from London light. Color in bright sunshine of Sao Paulo days can look pretty startling on dim light of England. People living in the Mediterranean region are used to seeing the strong mellow light while the population of Europe is conditioned to muted color under the clouds of northern Europe (Wurtman, Baum & Potts, 1979).

In architecture, color is three-dimensional and color can easily be affected and manipulated by sunlight. Moreover, there is a potential in color being changed by weather conditions, due to materials color is used on and their resistance to the

sunlight or moisture, etc. A simple example is how the original color of wood turns to grey or brown when exposed to different conditions.

Color should be explored by major elements of the space, i.e. ceiling, floor and walls in order to fully consider its complications with interior spaces. However, the links between color and other elements like the furniture, decorative pieces and ornaments, textiles and such, are not covered in this research study and so can be considered as a new subject for further research (Stromer & Baumann, 1996).

Thus, for artificial light the white light considered which under white artificial light color will not have any special changes. Also, for the next limitation daylight natural light that is shining during a sunny day considered.

## **1.6 Structure of the Thesis**

This thesis has been written in five chapters. First chapter began by an introduction about basic information of color and its relationship with light, reasoned the importance of the study, defining the methodology of study and limitation of the study. As it mentioned in introduction color and light cannot be considered separately so; second chapter started with a justification of why consideration of light with color is an unavoidable fact. In the next step, for better understanding of light, human vision system and the mechanism of optical system analyzed. In addition, color defined completely during the chapter and this chapter will ended with make a smooth way for understanding effect of light on color. Third chapter of the study will be focused more on the effects of color biologically and psychologically. As well as, this chapter is a key to use the psychological effects of color in architecture via the color perception. In the fourth chapter, the university library, environment of it, architectural divisions of university library, suitable circumstances for student to



have a better study and how color can have positive impacts on users during the study specifically will be described. Fifth chapter is the last one and concludes the right colors from perspective of psychological effects of color for designing a university library.

## **Chapter 2**

### **COLOR**

#### **2.1 Color and Light**

Color and light cannot practically separate. If there is no light, there will be no such thing as color. Assuming to be in a grave dark room, there is no way of distinguishing a red sofa from a light orange vase on a mahogany coffee table. The color of objects appears in relation to light which is shed upon them. The sensation of color is fully impacted by the brain's interpretation of the signals which are sent from the eyes. If the sun shines on a garden of colorful tulips but there exist no eyes to see and no brain to interpret, there will be no color. So in fact, color is a vast interactive process rather than a mere tangible object. Technically it is no object at all. But color is more important than light from psychology of point of view (Itten, 1976).

Light is probably the major component of color. Sunlight is known as the ultimate natural light source, thus turning into a standard based on which color can be measured. However, natural daylight can be very changeable just as color itself. There are loads of everyday experiences of buying a new shirt, scarf or a lipstick to go with a night dress in the daylight inside a store with certain lighting environment, but they changed in color and shade at home during evening hours. This is all because of the change in the conditions of light. The often forgotten fact is that light

conditions on a particular day and time have dramatic impacts on how color appear and actually the color could appear to be quite different (Wurtman, 1975).



Figure 1: Color Dependent to Light and They Will Change if Light Changes; URL 1

Technology is also an area which has trouble handling metamerism. For example, in the manufacturing areas of paint, textile printing and cosmetics, the primary printing inks might appear pretty much alike, but if they are made of different pigments, they will eventually look a lot different under varying light conditions. It is possible to interchange color scales only if the various primary inks or dyes coming from different manufacturers are made of pigments that are restricted to certain tolerance ranges. To wrap up, matching the color could be quite tricky most of the times (Wurtman, 1975).

Accurate assessment of color requires a light source with an equal unchanging intensity. Although natural sunlight is a known ideal standard, it cannot be very reliable because of the variances imposed by weather condition and time of the day and the angle of sun rays. To tackle this problem in the industry, artificial light sources are developed so to meet the professional demand of equal unvarying intensity. These lights, known as color analysis lamps, are designed to emit a balanced distribution of the spectrum and are used in color development and research and development (Wurtman, Baum & Potts, 1979).

At school it is taught that the combination of all the color on the spectrum produces the white light. However, it is not a really homogeneous phenomenon. Rather than a large number of white light rays, it is actually a collection of electromagnetic vibrations. The range of all the color that human eye is capable of perceiving is within the spectrum of white light. Monochromic color is produced when electromagnetic vibrations are isolated from a single wavelength of the spectrum. Even the daylight is not always white as color ratios change with the position of the sun or weather conditions such as clouds, rain or fog and smog (Scargall, 1999).

Colored objects in the same room can also appear different in various light conditions. Walls that face the windows look brighter. It is almost impossible to keep one environment constant in terms of color since light conditions are in constant change. The best way to deal with this is to make use of the ever-shifting interactive process between color and light to widen the range of visible color. There is a famous story of a client who ordered white canvas blinds to match her sofas in her living room. Hours later around sunset, the installation company received a frantic phone call from the lady arguing that the blinds had changed color to peach pink and

that for 15 minutes every day the blinds did not match her sofas. These types of unrealistic expectations come from people because the nature and quality of color and light is still unknown to a lot of them (Wurtman, 1989).

### **2.1.1 Light**

As it mentioned above understanding how color work with light is an essential piece of knowledge to work with color effectively. A designer needs the ability to manipulate the lighting using the related technologies so to create the best possible effects with the color. One of the prime functions in this field is disclosure. Light brings objects' shape to clarity. Using light, one can make an object look flat or exaggerate its dimensions. Light can also make a subject fade in its background or make it distinctive and stand out. Illumination can be a means of adding to or subtracting from the real value of an object. Interior designers must be aware of the fact that the most expensive and luxurious furniture could look rather cheap if the color and the sheen is not put at display with the appropriate lighting (Babbitt, 2014).

It is so evident that lighting has subconscious and subliminal effects on physical and mental conditions of human. Glare and sparkle only differ in their brightness degree. However, glare makes people irritated whereas sparkle gives them heightened appetite and boosts energy. Traditionally, it has always been the belief that human responses strongly to color but the fact is it is almost impossible to separate the effects of light and color (Wurtman, Baum & Potts, 1979).

#### **2.1.1.1 Definition of Light**

Physicists have obtained a clear scientific vision of light and a further understanding of it in relation to color. There are various forms of physical energy, among which electromagnetic radiation is how energy is transmitted as a form of pulsation or wave. Wave frequency (the number of waves per second) can also be accounted as

the number of cycles per second (CPS) measured by Hertz units. Due to the high frequency of electromagnetic waves (400- 800 million million), it is more reasonable to use another unit for defining wavelength in a more appropriate and practical way (Hoag, 2003).

Since the speed of electromagnetic energy is constant, a wavelength can vary in proportion to the frequency. The higher the frequency, the shorter the wavelength. The measuring unit is the angstrom (°A) or nanometer (nm). One millimeter (about  $\frac{1}{25}$  inch) is equal to 1,000,000 nanometers or an angstrom. Cosmic rays, gamma rays, and x-rays are of very short wavelengths. Long wavelengths are used for radar, radio, and TV transmission. Light comes to describe electromagnetic energy of about 100- 5000 nm wavelength. However, part of light, ultraviolet radiations (100- 5000 nm) cannot be seen by human eye (Thorington, 1973).

#### **2.1.1.2 Light Sources**

There are two main categories.

- **Natural Daylight**

Natural daylight is the most important part of lighting plan but unfortunately it is often taken for granted or not seriously addressed probably because it does not remain stable through days and months. It keeps changing in intensity, angle, timing, color, diffusion and position. Diffusion can easily be altered by rain, fog, clouds, haze or pollution. So if planning to benefit from it, three conditions need to be considered closely:

1. Direct light from the sun mixed with light from a clear sky,
2. Light solely from clear sky, and
3. Light coming from overcast sky.

Different factors can cause changes to the color of daylight: atmospheric conditions, inter-reflections from objects present in an environment and time of the day. The typical range of color change for the daylight starts from deep red into various oranges and yellows and going into blue-white and then taking the reverse path.

Daylight is also influenced by landscapes and waterscapes, the positions of windows, curtain and shades and shutters and the color found in the environment, either the reflections from the décor or the artificial lights.

- **Artificial Light**

An electric light, seen through the windows of houses at night, might appear plain white but in fact it is colored. Artificial light is not only used to illuminate the environments but also to add drama and impact to it. In butcheries, white fluorescent lights are used in the window shops to enhance the redness in meat. The term ‘color appearance’ means the apparent color seen from a light source. The term ‘color rendering’ refers to the effect that the light has on objects it illuminates. Sodium-discharge lamps are the most efficient means of illumination but the problem is the ‘rendering color’ factor is so poor, thus making them only practical for the streets where safety is far prior to aesthetics. The visibility given by these sort of lamps is so high because they radiate the wavelengths seen best by the eye, i.e. green and yellow; not to mention that they are very economical in terms of energy consumption and expenses. In 1936, mercury vapor lamps were installed in central London; an area famous for street women. In the next few days the women were trying to find another place for their trade as the lamp totally distorted their skin tone and makeup (Hollwich, Dieckhues & Schrameyer, 1977).

Normally, white light is associated with natural daylight. But as discussed before, natural light is prone to constant changes depending on latitude, time of day and seasons. However, it is known a temperature of 5000 degrees Kelvin that makes an ideal color sample glow with a light quite the same as direct sunlight in midday June. ANSI has set 5000 K as the viewing standard for color temperature of lighting. This helps evaluate an object based on both color temperature and viewing conditions. So all companies in this industry such as printing houses or film businesses use 5000 K lamps in their booths. Viewing booths are serve the purpose of comparing a color original to a color proof or printed piece (Lewy, et al, 1982).

### **2.1.1.3 Light in Interior Spaces**

Lighting is considered to be a really flexible element in design. It can easily be altered in terms of patten, color or intensity with a click of a switch. As the eye automatically fixes on the brightest object it can spot in any given space, lighting is a tool to either attract or distract attention from a particular object. It can also be used to direct movement through a place. Recently, there has been extensive use of lighting in interior design such as creating silhouettes, interesting patterns on floors or other surfaces or bringing fantasies to life using transparency projections (Jones, 1972).

When speaking of interior spaces, how the windows are placed is the most important factor of dealing with the natural light. The source of illumination is a real challenge for interior designers or artists who are planning to put art pieces to display. It all matters that the lights fall through a skylight or there is a wall of windows on one side of the space.



It is not only necessary to determine the size and positions of windows, but also what can be viewed through them. If there is a huge building out there, it will cast shadows. If there are a lot of trees outside, the color of greenery will affect the color in the room. If the window faces a white or red wall, there will be different color problems that the designer needs to sort out. The fact is adjacent color truly affect an interior space (Shlain, 1991).

It is the designer's responsibility to determine how much or less of natural color he has and how to work with it within the environment to modify or optimize the situation. For a small room for example, it is a better idea to paint it in a deep saturated tone and use bright furniture to make the walls seem to float away rather than just painting the whole room white. Of course, the room's architecture is also a matter of consideration when working with lights and color. On the whole, there is one global rule: Good design does not fight the environment; it rather blends with it (Kuller, 1976)!

Daylight is not trustable. It keeps changing and with it, the color also change under different illumination conditions. Another thing is that human's eyes are constantly adjusting to the light and the perceptions of color in such condition are not of solid ground.

There are many changes in light composition with the change of day time and seasons. In a white room, a variety of color can be viewed form morning to evening. Morning light looks fainted. It appears pale yellow or on a cloudy day it is a flat grey. Midday brings a splash of white light so the room looks exactly like what it was intended. Late afternoon light has a flush of gold which shows more of it

towards evening. Sunset is the time for the red or deep magenta and long shadows. For certain jobs like photographers, architects, artists and designers, these details are of high importance because their job directly involves working with natural light (Mason, 1981).

The location of the whole building or house determines the way light get in. It also has to do with the timing of light. North daylight has minimum red and orange and yellow, but it is suitable for color matching. But with all its reliability and minimum and gradual changes, it still does not provide a constant spectrum.

Different latitudes are a main cause for dramatic changes in daylight. In north Europe people are mostly conditioned to muted color due to the cloud cover degree they usually have in their countries. In Mediterranean regions however, people are accustomed to strong mellow color because of abundant sunshine. In Equatorial areas it is useless to use color on the facades of buildings because the sharp sun bleaches all color away. Light is pretty mutant thus it is almost impossible to settle the color on indoor environments. The best thing to do is take the best of all the variety offered by the natural light (Soldat & Sinclaire, 2001). In designing plans for lighting in an environment, six factors need to be considered.

- **Visibility**

It is to provide enough illumination inside a space for the occupants to see clearly and be seen vividly within proper accuracy, speed and comfort.

- **Atmosphere**

It is to do with the feeling or mood which is made by the illumination within a space. It is in fact one of the most difficult concepts to deal with. The designer must take into consideration multiple things such as whether to use casual lighting or formal, or shall the lighting be cool or warm, whether it should create a sense of excitement or pacify the occupants, a cheerful lighting or one which is sober, dramatic or even.

- **Composition**

Different elements caused or affected by lighting can make it the most practical for a space. Direction, pattern, intensity, contrast, color and shape are all the elements which contribute to the appropriate composition of lighting.

- **Object Appearance**

The way objects respond to light differ. The darker or the more matte an object, the more responsive it is to light intensity and direction. Lighting is also in relationship with the surfaces. White surfaces react strongly to contrasts and changes in light intensity but darker surfaces rarely absorb excess light. Also, objects in relation with the surface they are placed on need to be taken care of because of the mirroring effect. Each object has to be considered separately and at its own importance as well as how it is coordinated with the whole space when shed light on by the lighting system. The main criteria of lighting are: structure limitations and acoustics, the air-conditioning and of course the budget.

- **Mechanical Development**

It is to do a fine choice of lighting sources from a vast range of products in the market. Of course the natural daylight is the most dominant to take in use. But then there are skylights and all other artificial lighting sources available (Neer, 1981).

These criteria are the ones against which the final plan for lighting needs to be checked before establishment. It is also a great help for the designers to study previous practical and successful plans which have been used and been successful for similar spaces so to reduce errors.

### **2.1.2 Effects of Light on Color**

Light has a vast effect on color. The lights practically distort the colors. Mercury lights affect red objects and turn their color into a sick brown shade. Incandescent light makes yellow light on a white paper very difficult to see. When speaking of artificial light sources, a matter of discussion is the energy consumption and those which are economical are also those which own the poorest color rendering capabilities. For example, the most energy-saving ones are the low-pressure sodium lamps as they only radiate those wavelengths visible to human eye. However, the level of color distortion is them is so high that there are risks of negative health effects. Sunlight or daylight is by far the best lighting condition as it brings a vast variety of colors to display. It is an important issue when dealing with color because color is not a static object. There is a constant change in color as long as there is a constant change in light which is almost always. It is a very important matter of fact about color whenever or wherever color is involved. Dramatic alternation of colors due to light is an obvious fact. Color appears quite differently in different lighting conditions such as natural or artificial light, or different lighting forms such as

incandescent, fluorescent or sodium vapor. So there are two points to be considered: the spectral features of light when shed onto a surface and the reaction of the surface to the light. Often, all objects are exposed to a combination of natural and artificial lights at some given time, making it crucial to consider the effects of both. Most of the time, colors are viewed in an environment with mixed light sources like natural light with incandescent or fluorescent lights (Winterbottom & Wilknis, 2009).

The only place where color actually exists is the brain where different wavelengths of light stimulate specific parts of it. The way the brain experiences color depends on different factors such as how intensive the light is, how it is reflected and what other colors is the object surrounded by (Winterbottom & Wilknis, 2009).

Careful color and brightness control is essential for any environment. In practice, it means: an environment's existing lights need color adjustment (usually not much preferred as colors might change) or color and lights in the environment are simultaneously specified. As a matter of fact, colors are better rendered through some special lights. This is mainly dependent on a light's spectrum when distributed in the vision region. The color of the light, say warm light or bluish glow, is also another influential factor (Hyman, 1991).

A.Kruithof (1941) found through his observations that people have more tendency towards cool color temperature in intense illumination and their preference changes towards warm color temperature when illumination turns low. Also, in his report have been mentioned that all surfaces and objects will keep their normal appearances at low intensity of warm light and at high intensity of cool light.

Recently, there has been the trend of using theatrical lighting in places other than theatres. The thing is this type of lighting can have as many applications as it does in theatrical settings. This lighting style can be used to enhance the decors or manipulate the atmosphere moods or bring the youth sparkle to a lady's complexion. Most of people have experienced colored lighting in very special or extreme context from all those laser lights in a hard rock concert to those exaggerated home lighting for Christmas eves or the black light (ultraviolet) used for making posters shine in the dark. This type of lighting is often used and meant to grab attention. However, there can be more practical and effective ways of using subtle lights. Nowadays, almost everyone can have access to the same lighting options as a theatrical lighting designer and it is all possible with the colored lamps and dichromic filters. There are different options available to reshape light and produce special effects only to think about spot and flood lights, internal reflectors and framing projectors. There are varieties of all colors for lamps from red and blue and green to amber, pink and smoky colors. Candle-tip and wild-flicker styles add more to all the above. Dimmers are also popular controllers. Filters or an adequate proportion of red and green and blue are common ways in theatrical lighting to achieve the desired colored light. More than 300 filters are now available for the public to gain their tastes of effects in their homes or offices. To use the colored lights to their best potential, it is essential to learn about their effects. Pale blue adds luxury to silver collections or an indoor swimming pool. Pale pink is quite flattering on a candle-lit dinner table. Bluish light makes a room feel cooler in the subtle heat of a summer evening whereas pinkish light gives a warm sense to the space. This is a practical way to save on energy costs (Mayer & Tamer, 1984).

A key fact to know about colored light is that it distorts all other lights in the environment. Sometimes the effect is so extreme that other objects are almost impossible to be recognized.

- **Pink**

It is by itself quite flattering and makes a feeling more of a warm-up. However, blue and green turn grey in the presence of pink.

- **Orange**

Gives more strength to red and orange, makes yellow look red. Blue and green and violet appear greyish brown in orange light.

- **Red**

It is destructive to other colors. Usually warm or pale colors are all uniformed into a red hue and dark objects appear black in the presence of red light. Even red gets distorted. Yellowish red appears bluish red and dark red seems brown.

- **Violet**

Yellow looks more like orange and orange looks more of red in the presence of violet light.

- **Green**

Intensifies itself but greys other colors. Pale green must be handle carefully because it can create ghastly complexions and enhance foliage.

- **Blue**

Makes red look maroon and yellow green. Dark blue makes all colors appear grey except for blue, green and violet. Pale blue feels cold and makes sensations of ghostly faces.

- **Yellow**

It has a tendency to turn everything to orange but orange turns to a more yellowish version of itself! Light blue looks greyish violet and dark blue seems brown. Green turns more greyish while blue-green becomes more greenish. A yellowish peach light is suitable for advertising cosmetics as it makes complexions look more flattering. (Hughes & Neer, 1981).

## **2.2 Human Vision**

Color is a dominant part of vision as a universal experience. Despite the fact that everyone sees color all around in the surrounding environments and on all visible objects, and despite the fact that there is a unification of attitude towards the color of the sky or earth or a rose or the grass, there is still a mystery in the genuine entity of color. Surely, it is defined as one of the characteristics of any object or surface, but it is important to remember that any object can appear different in color when set in different circumstances and all of this process happen in human vision (Brody, 1984).

As it is mention above, there is no color a fine working connection between the eye, light and color. Therefore, a fundamental knowledge and application of this direct link is required for environmental design. Below, there is a brief review of how the eye works.



### **2.2.1 The Anatomy of the Eye**

The most basic and important elements of human eye are as follows.

The cornea: serving as a preliminary lens which is essential for focusing light. This is the transparent cover right in front of the eye. The pupil of the eye receives the entering light through the cornea.

The iris: this is in fact a ring of muscles responsible for the amount of light being admitted through the pupil. The eye color is the result of the pigmentation of the iris.

The lens: is right the path of light transfer and modifies its curvature so that the light is accurately focused to produce a clear image on the retina.

The retina: this is the inner surface which consists of a network of receptor cells and neurons. The light is converted into neuron impulses and then transmitted to the brain. The receptor cells in the retina are categorized into 'rods' and 'cones'. When the light is dim, the rods show reaction to brightness rather than color. They contain a substance called 'rhodopsin' which is a light-sensitive photo pigment when compared to the ones existing in 'cones', so to make rods perform better in dim light where cones are of no use. The 'cones', on the other hand, are made to perform well in bright light. They are responsible for bringing more details and accuracy to color and clear vision. Cones are mainly concentrated in the center of the retina whereas rods exist abundantly on the peripheral region of it. There are about 120 million rods and 6 million cones in the eye. The area right opposite the pupil in the center of the retina is called 'the fovea' and that is where cones are located- the only receptors for the most distinct vision; a fully-detailed vision (Duke-Elder, 1961).

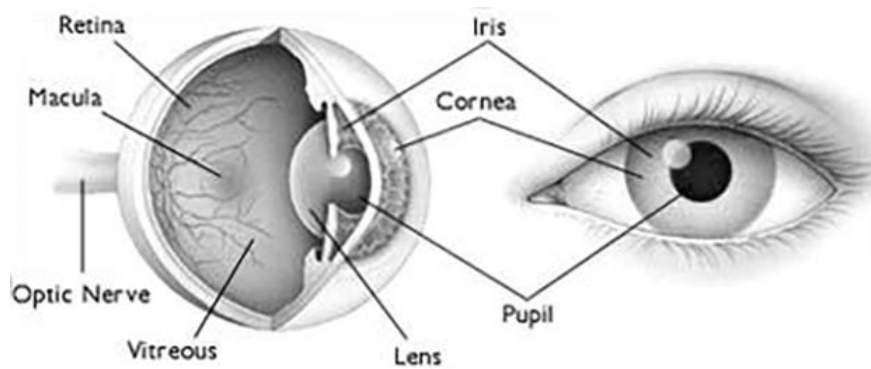


Figure 2: Structure of the Human Eye; URL 2

The muscles in the eye are categorized as internal and external. External muscles come in action when the eye finds interest in an object and their job is to keep both eyes centered on the point of interest. Internal muscles have more to do with focusing and controlling the size of the pupils (Ruskell, 1985).

The term 'accommodation' is the process of the eyes changing focus from one distance to another. This process involves change in the shape of the lens which is performed by the 'ciliary' muscle. This muscle gets aid from an elastic ring of suspensory ligaments connected to it called 'zonula', located around the lens. When the eye is resting, it is by default set to distant vision mode, thus the ciliary muscle is in relaxed state and the ligaments are tense. When the eye tries to focus on an object which is close, the ciliary muscle goes into contraction in order to release tension on the ligaments so that they can change the curvature of the lens. This focus on a nearby object is maintained through a continuous force on the ciliary muscle to stay contracted (Stephens, 1985).

'Adaptation' is another brilliant ability of the eye and is the instant reaction of it changes in illumination or brightness. There exist tiny muscles in the iris which

delicately widen or narrow the pupil size when it is exposed to sudden change of brightness of light.

“Seeing” is merely an optical perception when sensory cells in the eye’s cerebral cortex are physiologically stimulated by stimuli. However, seeing “color” goes way deeper, further and more complex because an exterior stimuli seen by the eye gets into human’s deepest inner part- his psyche (Loewenfeld, 1999).

### **2.2.2 Mechanism of Vision**

Most of visual mechanisms known to mankind knowledge are capable of distinguishing between short and long wavelengths. This gives them the advantage to select the spectral composition between direct and reflected light. Taking a species of frogs as an example, if they feel danger, they jump onto a blue paper as their primitive sense of vision detects it as deep water which means safety to them. They, by instinct, stay away from green paper as it the reflected light by vegetation. Visual pigments which are sensitive to color have gone through series of evolutions, those which have contributed to the fine skill of discrimination of visual fields. There are some backgrounds which have remained constant and stable in their color such as the blue sky, the brown earth, the green vegetation and the deep blue sea. There is usually no change in them or if there is, it is very gradual from the green color of summer to the reddish color of autumn (Hellman, 1982).

There is a fine array of sensitive cells in the eye called ‘retina’ onto which light is focused by a single lens in the eye and this is how an image is formed with precise details. Vertebrate animals own the most advanced and complicated eyes. Their eyes work just like a sophisticated camera. Light is focused by a single lens onto photosensitive network of cells. The elements of the picture are translated into

electric impulses by this network – the retina- and transmitted to the brain via nerve fibers. The light-sensitive cells in the retina are of two types: rods and cones. Rods are mainly responsible for dim light or night vision. Cones respond to a wide range of wavelengths but only in daylight. In nocturnal animals which are mostly color blind, the retina consists of only rods while some diurnal birds have exclusively cones in their retina. For all creatures which are living in different environments with various requirements of color vision; it is sun light which specifies the entirely visual pigments' photochemistry (Tietze, 1986).

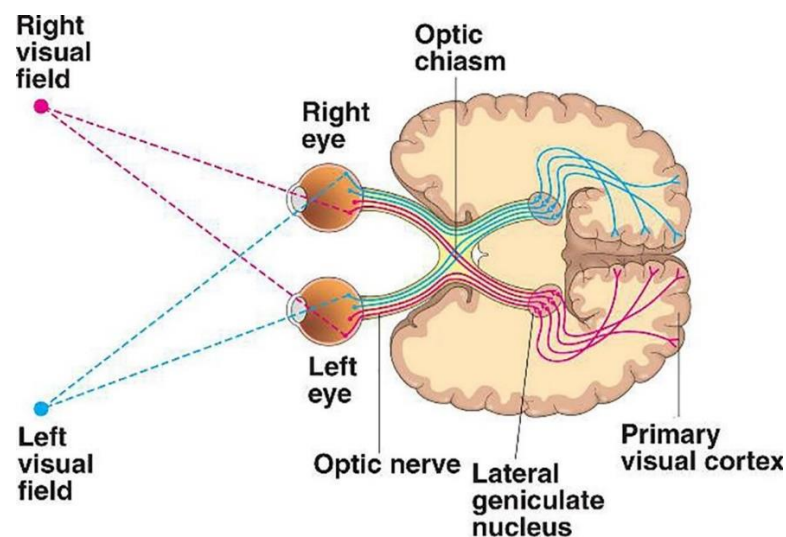


Figure 3: Diagram of the Primary Visual Pathways from the Eye to the Visual Cortex; URL 3

For all creatures which are living in different environments with various requirements of color vision; it is sun light which specifies the entirely visual pigments' photochemistry.

Human vision is a complex process of constant changes in rhodopsin molecules and electrical impulses being produced and transmitted. These electrical pulses take the message to the brain. Rods and optic nerves are indirectly connected. As for cones,

the three types of visual pigments- iodeosin's- are bleached by light and so the regenerate at a higher speed compared to rhodopsin molecules. These cone pigments react to red, green and blue spectral ranges, but they are also sensitive to yellow of 550 nanometers when 'red' and 'green' cones are equally stimulated. Generally, cones are not sensitive to blue, but rods are very sensitive to blue-green of 505 nanometers. At twilight, there is a transfer from cone to rod vision as the eye responds to the fall of illumination level. When evening time approaches, orange and red flowers appear to go dark while blue and white flowers still look bright (Lennie & D'Zmura, 1988).

When light falls on the eye, it is refracted by cornea, enters the eye through the pupil and falls onto retina. The size of pupil is adjusted in bright light or dark to control the amount of the light admitted in. Most of the light is absorbed by the pupil and that is why it appears black. Moreover, ultraviolet radiation is absorbed by the lens although the lens is transparent. Light then falls on the retina and must get past two complex yet transparent layers of nerve cells. Afterwards, it reaches the photoreceptors which absorb only 20% of the light. These receptors translate light into electrical signals and transmit them to the brain across synapses.

Photons which fall on the retina are sent through photoreceptors and are captured by visual pigments. Rhodopsin molecules get bleached by light so more channels get closed if the light is too bright since more molecules are bleached. Consequently, there is a reduction in the 'dark signal'. Human eye is accustomed to detect dark objects against a light background. So when there is light, less energy is needed to produce electrical pulses. When more channels are closed as it gets brighter, the photoreceptors use less energy compared to when it is dark (Gerard, 1957).

Humans can only see color when light and color signals reach the brain. The absorbed light is converted to electrical messages by rod and cone cells and then transmitted to bipolar and ganglion cells. Rods and cones of retina react to light stimuli as they are constantly generating electrical signals. Bipolar cells convey information about retinal image by using electrical signals to send them to ganglion cells. So, the optic nerves are involved in a continuous signal traffic (Boyton, 1979).

### **2.3 Color**

Almost every aspect of human's daily life is affected by color and surprisingly it is quite often taken for granted. Color can penetrate the human's body in form of light waves. It is eaten in forms of fruit and vegetables as well as artificial food coloring in candies and ice-cream and so on. Color is used as a tool to warn against danger as in traffic lights. It is extensively relied on when it comes to distinction between medicine and poison. It is used as a stimulating drive in advertising to persuade people in buying the products. Considering all this and the major role of color in human's life, a lot of people have a vague awareness towards color (Pytel, 2006).

There is a choice in interpreting color; it can be taken as mental or physiological impression which is formed in the viewer's mind when he looks at an object or a surface, or be described as a stimulus which is the cause of those mental impressions. It is more or less similar to the famous question of a falling tree in a forest and whether it makes a sound. To define color as a stimulus or the sensation caused by a stimulus is in fact a semantic –or maybe a philosophical- issue (Naz & Epps, 2004). However, when it comes to scientific views, the difference is negligible. It all has the basis in understanding how the human eye actually functions with color and light that in this study all of the will be dealt with.

### **2.3.1 Definition of Color**

Despite the fact that everyone sees color all around in the surrounding environments and on all visible objects, and despite the fact that there is a unification of attitude towards the color of the sky or earth or a rose or the grass, there is still a mystery in the genuine entity of color. Surely, it is defined as one of the characteristics of any object or surface, but it is important to remember that any object can appear different in color when set in different circumstances. A variety of research studies has made it clear that there exists a reliable and solid ground of knowledge of the basic physical principles of color beneath its visible effects.

There are many point of views and disciplines to approach the concept of color, such as human factors engineering, the natural sciences, technology, color theory, philosophy, psychology, medicine, and art that indicator perspectives will be mentioned.

Color does not belong to the objects, or in another way it's not a property of them, surfaces, or spaces; it is the sensation that caused by recognition of light by the eye and interprets by the brain as certain qualities. Therefore, color and light are inseparable, and for a great design, they have to be considered equally be devoted to their visual, physiological, psychological, technical aspects, and aesthetic (Garau, 1993).

From another point of view color is a mere illusion. The whole environment just appears colored to human eye. In fact, the eye gets fooled seeing all the color around as the whole world is totally colorless. The forming components of the visible world are actually achromatic (colorless) substances along with electromagnetic vibrations

(also achromatic). The only differing factor among them is their wavelengths. Thinking of various sections of electromagnetic spectrum which is measured in meters (Figure 4), one could give examples such brain waves, TV and radio signals, solar flares, color and light. Radio waves could be meters' long whereas visible light is so short to be measured in nanometer (1-millionth of a millimeter). Despite this relatively limited ability, human eye is still capable of distinguishing around ten million color variations. Going below this range, there is the body heat as a narrow band of energy. Even perceive of this spectrum is between 400 and 700 nanometers, marking deep blue at one end and deep lower comes the radio and TV signals and a tiny space of spectrum which is perceived as sound. Going above 700, there is the UV responsible for the skin turning tanned and used extensively to kill bacteria. Further up and down the range of human perception, there exist molecular and radioactive energy as long as brain wave frequencies and electrical power (Cimbalo, Beck & Sendziak, 1978).



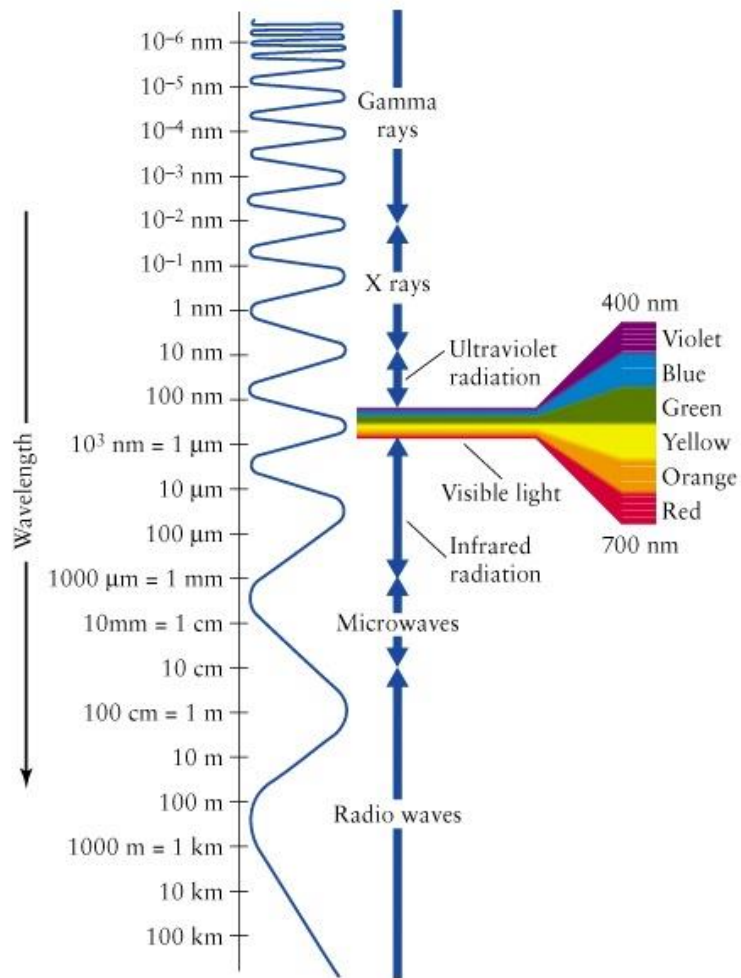


Figure 4: The Electromagnetic Spectrum; URL 4

### 2.3.2 Nature of Color

Ancient history reveals that dyes and paints all had origins in natural substances. The age of industrial growth and surge of technology opened doors to the artificial synthesis of pigments, making an unlimited range of color available for personal and commercial use.

The development of quantum theory shed light on the sensation of color. A carrot is by nature equally orange inside and out, but in fact its orange color is not inherent and associated conditions of light in certain time and place take role (Bottomley, et al, 2006).

An object is seen by the eye only because of the amount of light it reflects. According to Einstein's theory, light is composed of photons- he took this word from the Greek word 'photo' meaning light. When light is propagated, photons move in the form of waves with different length and frequency. This difference in wavelength and frequency brings out different colors. Those photons with the lowest wavelength have the highest level of energy whereas the ones with long wavelength fall short in the level of energy. When a stream of light is shed onto an object, photons behave more like tiny particles and not waves, so some of them are absorbed by the surface, some are transmitted and the rest are reflected, giving the eye the color of the object (Byrne & Gilbert, 1997).

Some objects or surfaces (in terms of textile and matter) absorb a wide range of wavelengths equally well. Black velvet, for example, absorbs almost all the light it receives (incident light). Snow, on the other hand, reflects almost all the incident light. A grey looking object absorbs some of each wavelength and reflects the rest at nearly equal ratio. In practice, the actual shade of grey depends on what proportion of each wavelength is reflected. So, based on what was just explained, black and white and grey are known to be 'neutrals' rather than colors (Lewy, et al, 1982).

Different objects have different tendencies for selective absorption. They absorb photons of certain wavelengths and reflect the others. As mentioned before in the case of carrot, it absorbs most photons of green, violet and blue wavelengths and reflects photons of red, orange and yellow wavelengths.

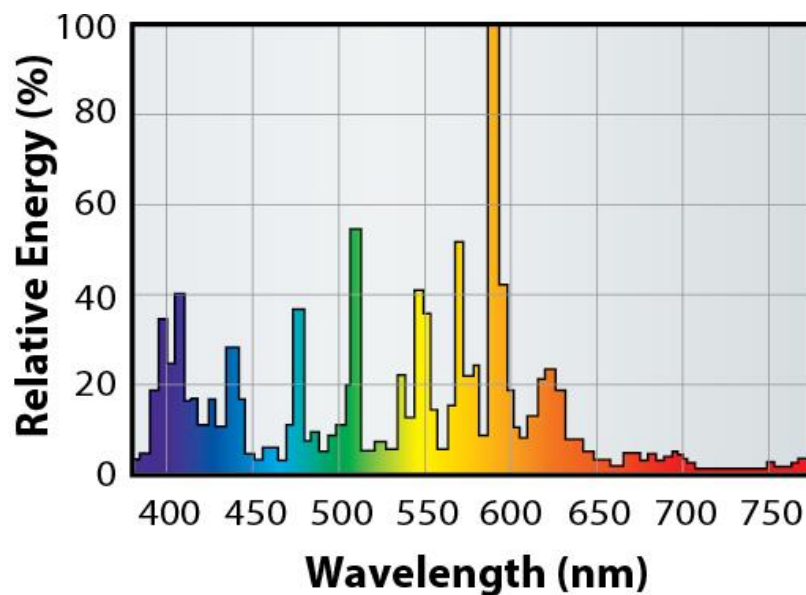


Figure 5: Spectral Distribution Chart; URL 5

Those photons which are not absorbed can be reflected in different ways. If the molecules of the object are well ordered, the reflection of the unabsorbed photons makes the object look quite a sharp image in the eye while disordered and chaotic network of molecules in an object- as in liquids and sparse gas diffusions for example- can let light get past through them in the empty intramolecular spaces and get radiated in random directions. So light gets scattered rather than reflected (Toy, 1996).

In general, high-level energy photons like violet and blue are scattered more easily than others. This is the reason for the blue color of the sky in the daylight and a blue tinge can sometimes be seen in milk due to the suspended fat particles which scatter photons of blue light.

The main reason for all this reflection and scattering is that light is radiated at the same frequency as it reached the object. ‘Fluorescence’ is the quality of objects

which are capable of radiating energy at a lower frequency than it first hit them, converting high-frequency radiation into visible light (Hope & Walch, 1990).

### **2.3.3 Color Terminology**

Understanding the right terminology is necessary for effective discussion about color, because color just like any specialized field, has its own jargon. The words color and hue are usually used interchangeably. Hue is used as an attribute to distinguish one color from another. All colors share similarity with one or a portion of two hues on the spectrum: red, orange, yellow, green, blue and violet. Taking scarlet and crimson and pink as examples, they are known to be different colors, but pretty much close in hue. Black and grey and white are called neutral because they actually lack hue. The hue is determined by wavelength. (Byrne & Gilbert, 1997). There are two other important attributes: saturation and value. The lightness or darkness seen on the surface of the color is the definition of value and the way it is measured is based on a scale of grey against which it is compared. The comparison is done by applying a set of greys to a vertical axis which starts with a perfect black as value 0 on one end and a perfect white as value 1 on the other end. There is also a horizontal axis for colors which are similar to a certain grey are given the same value as the grey one they correspond to. Saturation is another term for purity and refers to the amount of color pigments and it is also defined by how strong or vivid the hue is. As for red, the color moves from one end of pale pink to the other end of vivid vermilion when saturation is increased. Saturation can, in another word, be defined as how much of color exists in a particular shade, which means less pigments of white gives more saturation to a color. The other piece of terminology related to color is the spectrum. The spectrum is the famous color image formed when the white light is passed through a prism. This image forms simply because light is

spread out according to its wavelength'. Thus, the range from red through orange, yellow, green, blue and finally violet are known as the spectral colors. Spectral colors are completely saturated and so they do not contain purple, brown, pink or grey as contaminants. The terms tint and shade are also among the most frequently used ones in this field of study. A new shade is created when a color is mixed with black or grey. A tint comes to existence when a pure color is mixed up with white. Pastels are usually categorized as tints whereas shades are named for deeper colors. Other qualities of color to mention are: flicker, glitter and sheen. These terms mainly relate to variations in how colors appear in surface and depend on lighting conditions (Riley II, 1995).

#### **2.3.4 Color Pigments**

When it comes to 'selective absorption', pigments are the most efficient of all although any type of matter absorbs and reflects light to a specific level. Pigments Selective absorption is defined as a property and it technically means how much of a certain wavelength of light shed on a colored object is absorbed and how much is reflected in scale of photons. Carrot appears orange because it contains pigments 'carotenoid' which absorb short wavelength and reflect long one. The same pigment is also found in tomatoes, lobster, salmon and autumn leaves and is the reason to their reddish color. 'Anthocyanin' pigments are responsible for the color of beet, rhubarb, hydrangea and red wine. Hemoglobin is the pigment in the blood which carries oxygen to cells and makes the blood look red. Chlorophyll causes most plants to appear green because it absorbs all wavelengths except for 'green' photons. In the technology of dye and paint manufacturing, this principle of pigments is vastly used. Sometimes there is a form of bond between the dye/paint with the molecules of the object they are used on. Henna, for example, which is originated from Egypt as a

natural vegetable-based dye is mainly used for dyeing hair and makes a compound with the protein keratin of the hair. Henna form a bond with the molecules of hair, making a protective shield on the hair strand and also provides color. Paints and inks are actually a suspension of pigments and oil or water. When applied to a surface, the solution dries out and leaves a layer of pigments which reflect only its color and does not allow light to reach the surface beneath it (Steiner & Das Wesen, 1980).

### 2.3.5 The Munsell System

An American teacher and designer Albert Munsell, established this system that was first development in 1915 and all experts in color are using this system until now. In this system each color is defining by its chroma (saturation), value and hue (Pile, 1997).

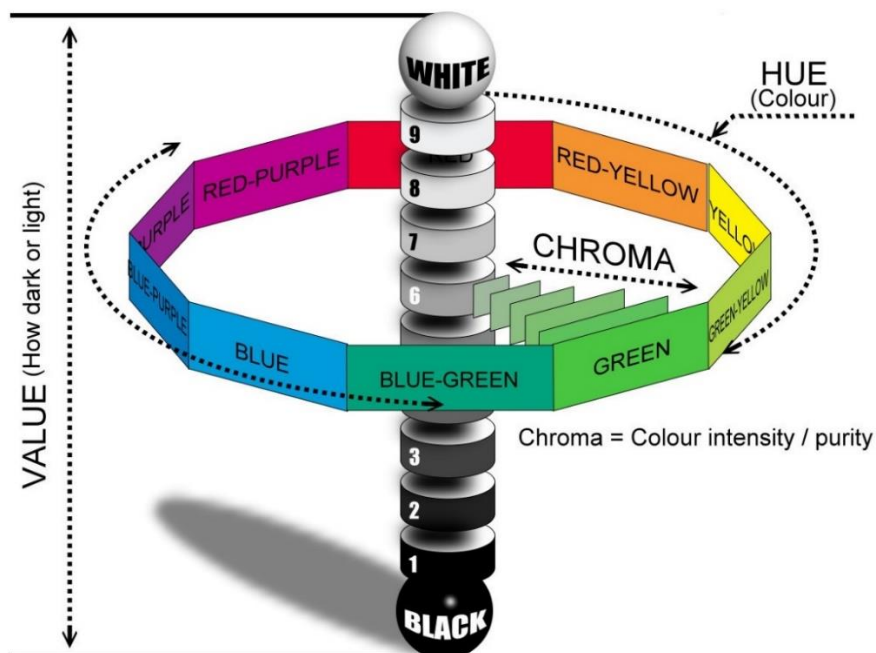


Figure 6: Munsell Color System; URL 6

### 2.3.6 The Color Wheel

Having classified the three primaries and secondaries in a circle, it can be noted that additional gradations can be generated by mixing any primary with the adjacent secondary. This produce six more colors, creating a wheel of twelve hues (Itten, 1976).

- Primary colors: yellow, red, blue
- Secondary colors: orange, violet, green
- Tertiary colors: yellow orange, red orange, red violet, blue violet, blue green, yellow green

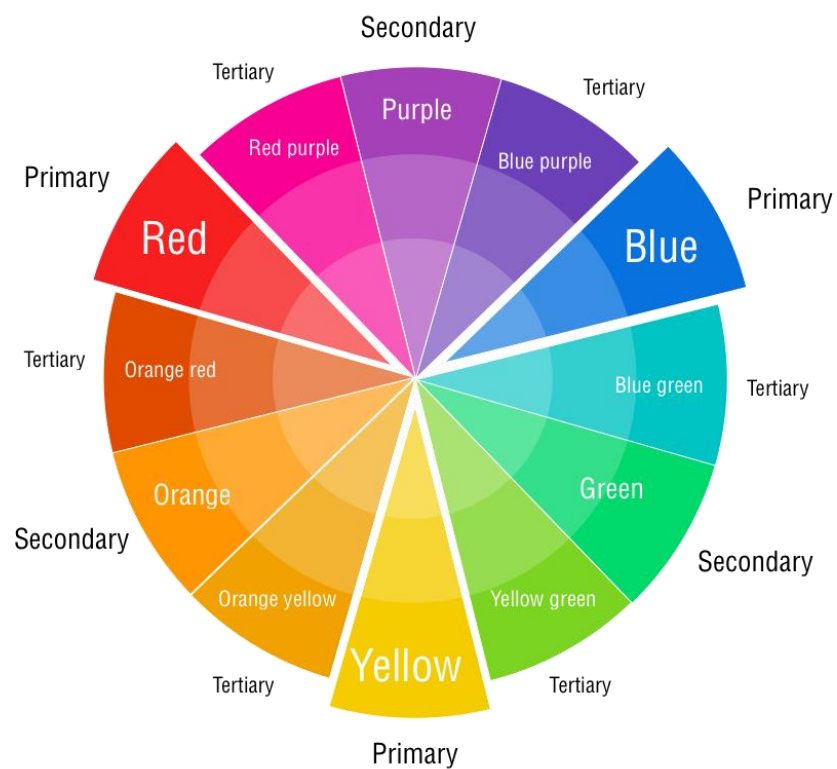


Figure 7: The Color Wheel; URL 7

### **2.3.7 Color Contrast**

When color is a main subject for investigating color contrast is a crucial factor which should consider. As it mentioned before color perception results from the action of a neural pathway that extends from the retina far into cortex. Physiological and anatomical studies have revealed many distinct stages in this pathway, including retinal, thalamic, and a series of cortical components (Engel & Furmanski, 2001). Although the color reflected from a surface or object of a particular color under a given light source will be a fixed quality, how such color appears to a viewer can vary considerably as a result of a number of effects known to color selections, it is helpful to have these effects in mind to be seen in a chart of samples do not distort judgment, and will occur in a finished space can be allowed for. Such effects are sometimes called distortions or illusions, but these effects in question is entirely and predictable (Pile, 1997).

According to this contrast has a vast effect on how color is perceived. So in this field color contrast should be considered as a crucial fact by the designers.

### **2.3.8 Color and Psychology**

Beer has provided quite enough information on human's primary psychological reaction towards color. However, there is still more to investigate the development of this primary reaction by delving deeper into psychology.

The first question to seek an answer for is: what is psychology? The science of psychology is to deal with mind, mental and emotional processes, special reference to behavior, under the condition that there is a clear understanding of behaviors such as thoughts, feelings and dreams possibly experienced by every individual. These experiences are brought out during conscious, subconscious, and unconscious processes. Conscious experience that further will be described is in fact the



awareness of what a person thinks and/or feels. Subconscious, on the other hand, refers to the mental processes which occur with minimum or without conscious perception. The unconscious is the sum of all thoughts, memories, impulses, desires, and feelings of which we are not conscious although our emotions are totally influenced by them all.

Eighty percent of human's information comes from his/her surroundings and the environment to which he/her is exposed. No need to explain that color is a huge part of every environment and obviously a key tool for interpretation and communication of human with his/her surroundings. It helps and enhances human's recognition and perception of his/her environment. It carries several effect with it through human's perception: visual, emotional, physiological, symbolic, associative and synesthetic effects (Eysenck, 1965).

#### **2.3.8.1 Color Experience**

Color perception is not seeing, it is observing, experiencing and becoming aware. There are multiple factors that work together through this process; some are interior and some are exterior, some in conscious level and some in the unconscious. It is almost impossible to classify or systematize 'color experience'. It is somehow explained in the pyramid in the following picture. Level 1 (base of pyramid) come the undeniable biological reactions. Level 2 goes into the collective unconscious. Level 3 is about the conscious and the symbols. Level 4 craves the cultural influences and mannerism. Level 5 holds the impacts of fashion and trends. The highest level, level 6, is to do with personal relationships with different colors. This is somehow influenced by all other levels (Kuller, Mikellides & Janssens, 2009).

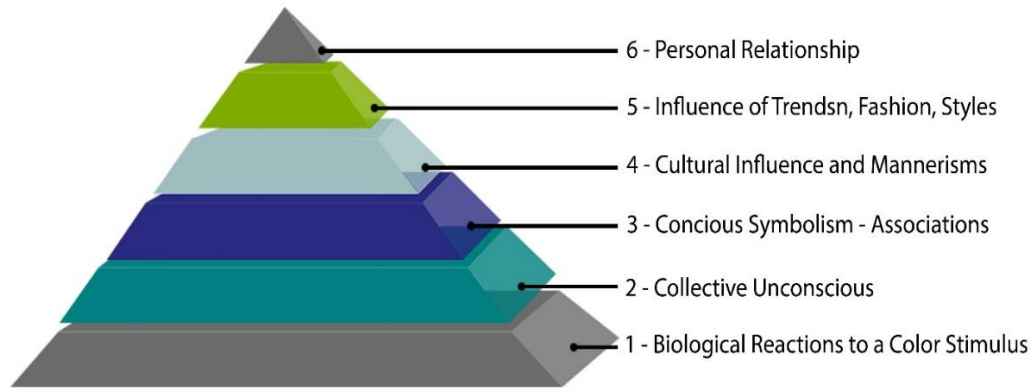


Figure 8: The Pyramid of Color Experience (made by author)

Color is also a part of the conscious, subconscious and unconscious, and an experience that is integral to human behavior because the how a person reacts to a color, a color combination or an environment is initialized as a psychological experience, later resulting in a physiological reaction. For example, imagining the picture of a ripe tomato will most probably end up with the tomato being red. However, the input that caused the red image in mind is not an external object which generates or reflects a light wave between 627-780 nanometers as a stimulus to the brain to see the color red. This reveals the fact that color is in the brain; it is within people.

### 2.3.8.2 Color and Culture

According to color psychology, colors cannot have a single specific effect on brain and emotions. Some colors were disturbing temporary and were enjoyable and lovely permanently (Stromer & Baumann, 1996).

Scientific fields, tastes, cultures and beliefs differ a lot from region to region and country to country. This is the proof that there is no definite standard whatsoever. For example, in astrology, Aries are considered red as they are impatient and hot-tempered who can be rather trailblazing leaders. Mars, the planet assigned to Aries,

is of red color and is known as the 'god of war'. This is how Aries are symbolized as red. An interesting addition to the previously mentioned is the four elements and temperaments of Pythagoras; red and yellow being assigned to the choleric (hot-tempered) people and also known to be a symbol of fire (ancient Greece Hippocrates). In Egypt, red comes with those of high energy and skill; as well as connotes the demonic, desert and blood. In China, however, red brings joy and happiness, pleasure and festivity and of course a symbol of fire as it is. In southern regions, it is to do with the expulsion of demons. Meanwhile, in Mosaic Cult, scarlet red was the color of life and blood. The Eastern or Orthodox Church used red to illustrate blazing love. As it can be observed, there is a close link among different cultures in terms of psychological associations of color and how they are used for symbolism. From the viewpoint of physiology, red is a stimulant color; it elevates blood pressure and brings excitement, especially on the sympathetic branch of the autonomic nervous system.

The above was merely an example with the color 'red'. However, it is not the only case. Same exists with other major hues. Taking all different elements of color into thought- associations, symbolisms, and the origins of color symbols in the nature and physiological effects of colors- amazing similarities will unfold in associative, physiological and psychological grounds for any single color (Mahnke, 1996).

## **2.4 Chapter Summary**

In this chapter at first the relationship of color and light and necessity of investigate color and light in a parallel way will explained. And then, explaining the human vision by anatomies human eye and how mechanism of human vision works. Also, define the light, the main sources of light and the role of light in interior spaces with

a short explanation about the main architecture factors of space that effected by light. Moreover, specific definition of color, the role of absorption in nature of color and terminology of color beside the color wheel and Munsell system of color is came in the end of color section. This chapter will finished by a description of connection between color and psychology and how color impact on unconscious aspect of human mind by observation and culture.

## Chapter 3

### THE EFFECTS OF COLOR ON HUMAN HEALTH

Color and light conditions in health care centers might have strong impacts on the patients. As a case, Methodist hospital in Indianapolis tried using the power of color to promote its patients' health and welfare and the mental/emotional state of their staff through a new construction phase. The hospital took advantage of color consulted with an especially in health care, who suggested that the hospital avoids using lavender-purple family in treatment words as these colors cause disturbance in the focus of the eye and usually give the eye a sickly yellow-green afterimage. White inculcated a sterile sense with minimized therapeutic application. Yellowish green was rejected because its reflection causes human flesh to look like a sickly pallor. The color consulted also ruled against stripes as the constantly induce tension, particularly when gone off-balance. According to his advice package, uniform colors are wrong in any patient environment whereas various colors stimulate the drive necessary in health care and recovery.

Nature imaginary, shown in recent studies to reduce patient anxiety, is displayed in backlit color photographic Ceiling Mural and wall Mural Transparencies, surrounding patients and medical equipment in a new healing interior architecture for high-stress treatment environment known as Visual Therapy (Caivano, 2006).

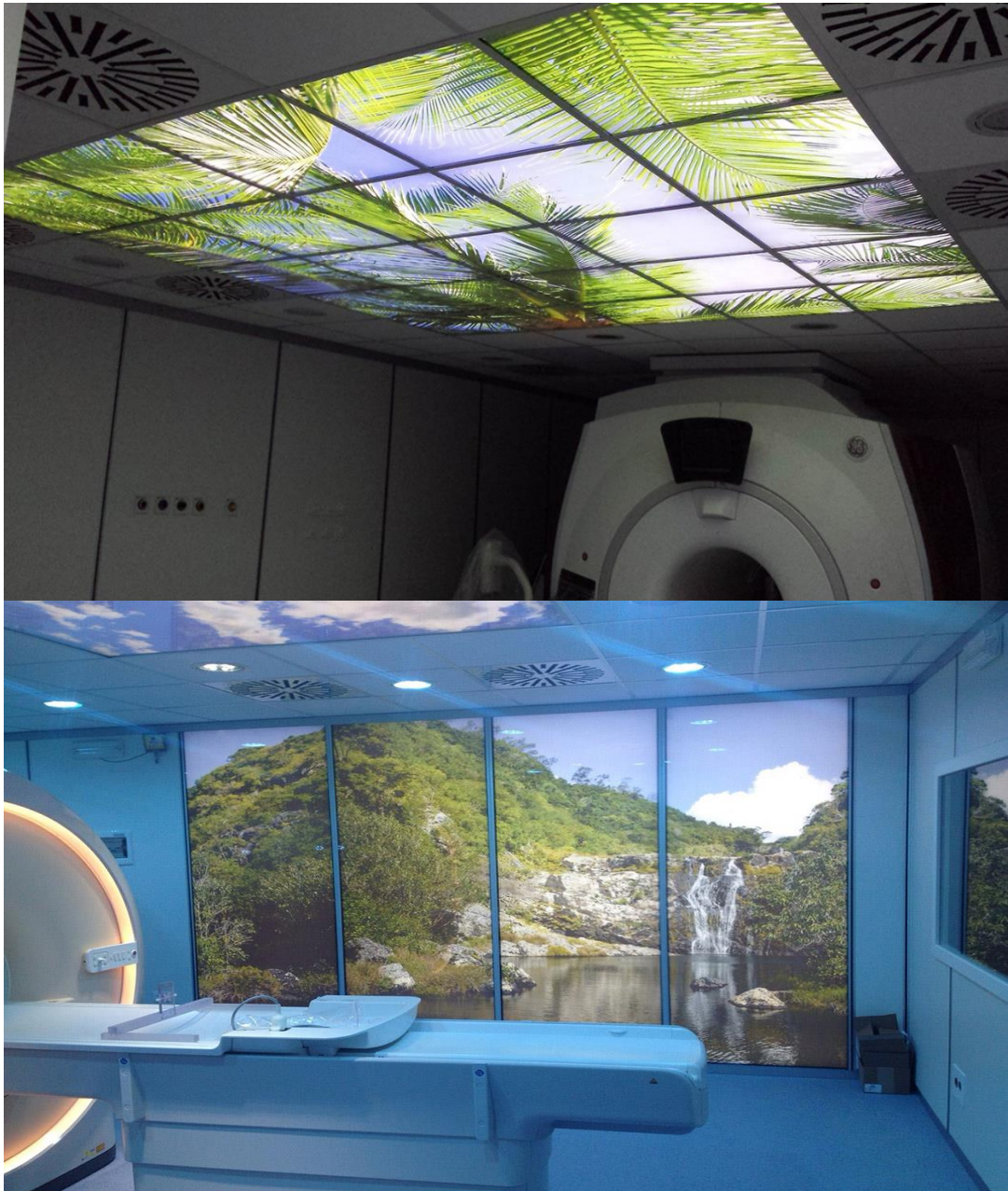


Figure 9: ITEL Company which used panels for visual therapy; URL 8

The find design was set as follows:

- Green and rose
- Blue and peach

These sets of colors were used in all patient areas such as operation theatres, CCU and ICU and recovery and treatment rooms. Sidewalls and headwalls were kept neutral so to add accent to the footwalls. However, for more specialized sections, a plum and yellow combination was used; a manipulated version of yellow-purple

complementary pair. This close attention paid by the design team for the colors of specific floors and areas, even the housekeeping staff did not have a chance to place wrong chairs in wrong rooms. The colors moved from a grey ton to the adequate degrees of lightness or darkness. Complementary colors have a soothing and stimulating effect which can leave its trace for a long time. The background color for the hospital was set to a warm neutral grey beige, because pure grey is not the right choice for health care premises as its coldness fosters depression. This neutral grey beige was used for large surface materials such as tiles, ceramics and laminates. The color is more open to various color directions for further change or replacement of paint, fabrics or carpets in the future (Mahnke, 1981).

### **3.1 Biological Effects of Color**

This world and every second of life in it is totally governed by the sun and its radiation. Color impinges every living moment of people and it even come visible in human's dream. The visible light is only a small part of the sun's radiation getting through the atmosphere and reaching the earth and evidently this is what breaks down into colors. Color is a wonderful evolution given to this planet as a gift to infuse it as life into the survival of all kinds of life.

In this section color and light are somehow used interchangeably as the focus of discussion is human health because they are inextricably connected in concept, so in the field of human biology and effects on it, color and light are assumed as one phenomenon. Color and light has direct and indirect effects on the physique and psychology of human. Light gets through the eye at different wavelengths (color) which directly impacts the hypothalamus, also known as the center of emotions in human brain. This imposes effect on the pituitary gland which controls the whole

endocrine system. It regulates the thyroid and sex glands, resulting in the regulations of hormone levels in the body and the moods they bring along (Birren, 1961).

Color and light also have the ability to find other ways than the eye to penetrate the body and significantly affects the biological system. Some common examples are the synthesis of vitamin D and the effect of ultra-violet ray on the skin turning it tanned by producing melanin pigments. Also, those people who develop skin rash due to the interaction between blood chemical synthesizers and the sunlight and ways of treating certain diseases such as herpes simplex and psoriasis using variations of color and light can be good examples refer.

Chemical reactions due to light are quite old science. Milk, beer and medicine change in taste, smell and color due to exposure to sunlight. That is why colored bottles are used in the packaging industry. Potato chips are packaged in opaque material because they can immediately turn rancid if the cooking oil gets into photo-oxidation while exposed to the fluorescent lights in the supermarkets. Some pesticides become even more toxic in exposure to light. In some supermarkets yellow light is installed in the dairy sections to keep the products fresh. Although the effects of light have been noticed for long years, the ramification of color and light for health and illness is a pretty new issue of consideration through the relatively modern science of photobiology (Hollwich, 1980).

The radical medical treatment of jaundice in newborns with the use of light and color were introduced in 1950s. Neonatal jaundice is the result of incompatibilities between mother's and her baby's blood type. This produces a waste serum called 'bilirubin' which must be filtered by liver. However, the baby's liver is premature



and is not capable of filtering it to prevent consequent brain damage and eventually death. Before this light treatment, the only option was blood transfusion until a smart nurse in Britain realized that those jaundiced babies left by the windows in the sunlight, would lose the yellow color on their skins. Further research brought out the fact that the sunlight enabled babies to excrete toxic wastes in their little bodies (Chin, et al, 1997).

The preliminary assumption was that light could break down bilirubin or speeded up the production of essential enzymes that a new born baby's sluggish liver had to have to filter the toxins. However, it was later revealed that when the sunlight penetrates the baby's body, it produces a photon of visible blue light which changes the physical structure of bilirubin molecules and makes them soluble in water and easily excreted.

The antibacterial characteristics of sunlight were discovered some time in the 19th century and utilized in treatment of diseases such as tuberculosis and strep and staph infections. In addition, based on research studies exposure to ultraviolet light increases the number of white blood cells and lymphocytes which are the most important factor for immune system. Still, institutions are conducting more in-depth research on how light/color can be effective in curing cancer, AIDS and other immune system deficiencies (Wurtman, Baum & Potts, 1979).

Some empirical experiment is usually done in lectures on color. A couple of young men, preferably large athletic ones, are ask to volunteer so to prove the psychological effect on color on human brain. They are asked to clasp their hands and extend them right in front of their chests. Another person applies pressure on their arms and they

have to resist which is usually not a difficult thing for them. Then, the same is done to them but this time they are asked to look at a pink construction paper sheet covering their vision field. Amazingly, they fail to resist the pressure and their arms fall limp. Later, they experience the same thing but this time they look at blue construction paper sheet and surprisingly they regain their strength and are able to resist the pressure on their extended arms. Although this demonstration does not have a scientific basis, it does dramatically display the immediate effect on color on human's brain. Pink makes the volunteers weak and blue restores their power. However, what actually happens is a question not easy to answer. There needs to be a closer look into the effects of blue and pink (Grangaard, 1993).

An amusing experiment was conducted in Seattle, U.S.A on March 1, 1979. With focus on the provocative results by previous studies on the effects of pink, a holding cell at the U.S. naval correctional center was painted pink except for the floor which was left grey. This was done to test whether the calming effect of pink would also bring a violent new inmate to tame. The plan was to hold new comers in that cell for 15 minutes while the paper work for confinement was being done. After 156 days, the correctional center reported that no incidence of violence or erratic behavior had been witnessed. Before the experiment, security officers described the hostile behavior of inmates as "a whale of a problem" (Wurtman, Baum & Potts, 1979).

This experiment and its result also persuaded the commander of Santa Clara County Jail to paint one of the holding cells pink. A fish tank keeps around 15 inmates while the process is being run and eventually cells are assigned. Observers were amazed at the fact that the detainees were being humorous and in a relaxing mood while waiting in the pink holding cell. This part of the study quickly gained interest of the

public with the hope that pink might be a remedy to stop violence in alike places. However, the rest of the study did not come with promising results (Wurtman, 1989).

In experiments done on animals, pink light adversely impacted their behaviors and in some cases caused them to become cannibalistic. However, the effect of pink does not seem to be permanent. An inmate animal kept in a pink cell for a duration of four hours, suddenly started behaving totally berserk attempting to destroy the cell and severely injure himself. Further studies revealed that the pink effect last for a maximum of 30 minutes. In terms of humans, exposure to pink longer than thirty minutes had a counter effect causing hostile behavior and boosted strength. The significant fact is in the reality of all these effects. They actually happen. Study shows that it only takes 2.7 seconds for pink to plant its effect. How it happens is still a mystery although it is somehow assumed that it could directly act on the endocrine system, manipulating the chemical balance in the body and resulting in a temporary relaxation and weakness of muscles. Obviously, color has enchanting powers yet to be investigated and discovered (Hollwich & Dieckhues, 1989).

According to scientific research, there are other ways for light to penetrate human's body rather than only eyes. In a study conducted by the New York Association for the blind with the goal of possible benefits of neodymium light source for low-vision patients or completely blind people, calculations were done to specify how different rations of ultraviolet and infrared rays from a neodymium lamp could have batter effects compared to an ordinary lamp. A neodymium lamp emits 30% less ultraviolet and 20-28% less infrared. The sharp plunge of the amount of yellow light (570-610 nm in range) emission is clinically evaluated for low-vision people. The visual impression while looking at colored objects is a clear "true" color as if it is viewed in

full sunlight. To show the significant patient this, one should think of diabetic patient trying to read a color match strip to check on his glucose and urine test constantly (Ott, 1976).

In many different key charts such as acuity charts or contrast sensitivity chart test, there is a challenging wide range of contrast between black and white. The reduced amount of yellow light emitted by the lamp make white appear whiter and black look blacker. Different groups of patients with visual field defects (retinitis pigmentosa, optic atrophy or glaucoma) along with diabetic's ones struggling with proliferative retinopathy all responded in favor of neodymium light study (Schiegl, 1993).

Electromagnetic radiation of color in a certain limited frequency band which is registered by the eye has been established a long way back. It is quite clear now how human brain interprets it. More to this, light and color has undeniable influence on inner body chemical reactions. Electromagnetic radiation outside the narrow visible range also work in the body, as the ultraviolet ray resulting in sunburn is a vivid example. Basically, human body absorb electromagnetic energy in from of heat. Alarmingly, body cells can easily get cooked in such environment just like the food in a microwave oven. This is why there should be considerable measures of precautions to control or block the dispersion of such kind coming from television sets, computers, mobile phones and microwave ovens. However, some leakage is always inevitable. A big question being studied curiously by photo biologists is whether biochemical reactions are occurring at the same time as visioning color extended. It is doubted whether these additional biochemical reactions could in any possible way have extremely strong effects on human psychology or their behavior. Most probably the eye itself does not necessarily have a part in such reactions. After

all, just like other waves, color can also get through human's skin. An unbelievably stunning study was conducted on a group of blind students when the color of their classroom was changed from white and orange to royal blue and grey. The study returned a result of 16% reduction in the students' BP (Mayron, 1975).

### **3.2 Psychological Effects of Color**

All of the color stimuli from the external world is directly received by human's internal world: his psyche. Thus, color is not only dependent on what the external world sends, but may also originate through the human's power of imagination and his inner world.

Most people might not be fully aware of color psychology and how profoundly it can affect them. People obviously have their own tastes and preferences. However, most of these reactions to color are all subjective. This is why color is too often treated as a secondary or cosmetic role in the architectural environment. Of course, the subjective feelings are also important, as are personal taste and preference.

Generally, how color affects the psychology of human is an extensive and complex field of study and research. Color psychology as a concept can be separated into two interrelated branches having different tasks. Applied (practical) color psychology is usually put in practice professionally in architectural environments or marketing (Hyman, 1991).

The impressions that every single hue of color can leave out and how its associations are made in human's mind along with the character of every hue is a really vast matter of discussion.

- **Purple/Violet**

Purple is a mixture of red and blue which are physically and psychologically in opposition. However, violet is a pure spectral hue and it is of course a lighter shade of purple. As a mixed color purple includes an extensive differentiation in hue. In a positive sense, purple is dignified, exclusive and regal. On the other hand, it is negatively associated with being lonely, mournful or pompous. It is worn by priests to bring both feelings of strength in red and integrity in blue. Dark shades of purple have a feeling of strictness. But it is as well a symbol of dignity and wealth, mysticism and magic. Lighter shades closer to red become sweet, seductive and sensual, but certain nuances can become narcotic, morbid or unsettling (Mikellides, 1990).

- **Yellow**

This is indeed the happiest color. It is luminous and reflective. Its positive associations and impressions are: happy, cheerful, suggestive, high in spirit and life-giving like the sun. It is a color not bound to the earth so it talks of bright future, high hopes and elegant wisdom.

Yellow is used in packaging because it makes the food look active, healthy and cheerful. A look at Kodak film adverts with those beautiful sunny days on the beach and the yellow box can tell all about how yellow can be effective in advertising. Also the SHELL logo has a combination of red and yellow; red referring to the fuel for motors and yellow to new adventurous discoveries. Yellow is expansive meaning open to communication. It symbolizes 'Mercury', the messenger of the gods. A look back at old mail boxes can be a good reminders of the role of yellow in

communication. It can also go further in mental and spiritual communication. However, if it becomes too strong, it gets egocentric (Bottomley, et al, 2006).

- **Red**

This color is known to be arousing. It is also associated with excitement, enthusiasm, energy and passion. It inculcates a sense of strength and warmth. However, there are negative associations such as anger, rage, fierceness, aggression and of course it is the color of blood, hence commonly linked to combat and rebellion as it holds its aggressive masculine nature. In the Roman times, a red flag was a sign of attack, and because after every attack would soon be a river of blood, it was called the blood flag. The idea of red military uniforms was to boost strength and endurance since blood wouldn't show too much on red fabric. Red is also used as a sign of provocation and active resolution. There is a sign or glow of red in almost every revolution throughout the history. In that sense, the Russian and Chinese Communist revolutions are the best examples as well as the Jacobin 'liberty caps' during the French Revolution. The same goes with Italy's Garibaldi men. Planet Mars is seen as red; a symbol of god of war. There is a modern idiom as 'to catch someone red-handed' referring to the victim's blood still visible on the person's hand (Miller & Taube, 1997).

Red also illustrates life and living. There is an ancient connection between life and blood. Being alive means being healthy, energetic, strong and confident- all the characteristics of the color 'Red' mentioned above. In the USA, a red-blooded person is someone who is vigorous with a high spirit and a strong will.

Red is also known to be the color of 'love'. In ancient mythologies the Greek wore red robes to symbolize sacrifice and love towards their gods. In Christianity, red holds a sign to Jesus Christ's blood which was spilt in the name of love. The cardinals wear crimson robes to represent the 'godly' and 'fatherly'. However, Hebrews took red as sacrifice for sins. Red is also the color of passionate, lusty, sensual and erotic love (not platonic though). That is where the 'red-light' districts get their name from.

Red is somehow the most dominant and dynamic color of all. It is truly attention-grabbing and suppresses other hues in its presence. The lens of the eye needs adjusting to send through the red wavelengths of which the focal point is right behind the retina. But red goes further back and that is why it makes the illusion that red objects appear to be closer. All these characteristics drastically fade away when red turns into pink. The gender changes, becomes more feminine with softer and gentler effects (Jung, 1968).

- **Orange**

This color seems to be in a crisis in terms of identity for it is seen as 'second fiddle' to red. Bright orange brings a sense of excitement and stimulation of jolly emotions; pale orange is cheering. There are several positive associations for this color such as extroverted, happy, energetic, lively and sociable. A highly saturated orange gives a sense of intrusiveness and blustering. Comparing to red, orange is less primitive and mellower. Fire is naturally orange although it is symbolized by red. It also dominates any other color when it comes to the foliage of autumn. There are more eye-catching and glamorous variations of orange in the nature such as Bryce canyon and the sunsets over ocean horizons. Brown is a darkened orange. It is not set within the



spectral hue but it is definitely the last word in natural colors containing all the shades of earth and wood. It also pats the eyes when looking at chocolate or roasted coffee beans. Psychologically, brown makes affirmations of security and comfort. It is earthly and motherly and that is why it makes one feel stable and dependable. Peasants and farmers wore brown in the Middle Ages (Sharpe, 1975).

- **Green**

This color has inherited the gaiety of yellow and the dignity of blue. Its light effect is retiring and its pure hue is relaxing. Its positive associations are: tranquility, freshness, natural and quiet. Its wavelength is focused right on the retina, making it a very restful color for the eye. Negative associations could be listed as ordinary, tiresome and guilty. The most common association of this color is with the nature and its vigorous growth so this gives an essential meaning of life to green. Ancient rituals of mankind were held on green and fresh vegetation and the wait for the harvest of food, hence life. Ancient Palestinian brides wore green as a symbol of happy life and fertility. Mohammad the messenger of Islam wore a green gown to embody hope and led his believers under a green banner to the holy war. For Islam, green is still a holy color. As for Christianity, green is the color of hope, spring, resurrection and immortality. To the contradiction of all said above, green is also known as the color of sickness and death. The root goes back to the Middle Ages but it is not exactly known what the origin was. There is high chance that many people come up with the color green if they are asked what color reminds them of poison. In German, there is a bilious-looking green called the poison green (Giftgrün) similar to English. A neutral green right in the middle of the blue-yellow grid brings the sense of calm. If the slider is moved towards yellow on the grid, the green becomes lighter

and more stimulation. Moving it towards the blue end, it gets colder and more sensitive. A light bluish green is very refreshing (Cage, 1999).

- **Blue**

It is a peacemaker color which a minority may dislike. It is also relaxing and retiring. It is positively associated with calmness, comfort and security, contemplation and sobriety. Negative associations are with being cold, depressing or in certain conditions frightening. The feelings and emotions that might be spontaneously evoked by blue are: wetness, cleanliness, odorlessness, sadness, the sea, the sky, quietness, mental reflection and yearning. It is also associated with wisdom and spirituality. It holds the tranquility and truth. In ancient Rome, blue was the color of philosophers' 'academic' robes. Hope and piety is what blue means in Christianity and resembled spiritual and pacific virtue in Christian arts. For Hebrews, however, it was a sacred color. In Hinduism, Krishna is exclusively painted blue. Among the Chinese, it was a color to represent immortality and power of heaven. It is referred to as a noble color which holds dignity and poise. Blue ribbons are awarded to 'winners'. In order to inspire confidence and build trust, dark blue is used in adverts as it offers security and also high quality. On the other hand, blue is considered cold and associated with melancholy. People express their state of sadness by phrases such as "I'm blue!" or "I've got the blues!" It is also the only color that holds a position in arts by its name: Jazz and Blues or R&B (B standing for blue) in music. But in German being blue means being totally drunk. The general attitude for the coldness of blue is accurate to some extent as it also appears on the cold side of the color wheel. Light blue is a cold color, but moving to the middle shades up to deep blue, colors appear warmer. The material which is dyed blue is also effective on how

cold or warm it looks. Deep blue on a thick carpet looks really warm (Pierman, 1978).

- **Grey**

As calm and quiet as it appears, pure grey can also inculcate a sense of conservativeness, being dreary, lifeless, tedious and somehow passive. It is neutral and in a middle zone, so there is no clarity. A German term 'grauer Alltag' meaning a grey day refers to a day with no specific ups or downs; like no change in the routine or no excitement. Grey is very low in energy and has no will of its own. It does not hold any definite statement, nor is it interested in any involvement. In color design it usually picks up the characteristics of the color it sits with. Grey is a color mainly associated with modernism, monstrous man-made constructions of metal and concrete (Potter & Mikellides, 1976).

- **White**

There are a lot of beautiful things and concepts represented by this color. One can think of calm, peace, light and spirituality, holiness, cleanliness and innocence. In religions like Christianity and Judaism it stands for chastity and purity. White is also a symbol of goodness when placed in opposition to black as evil. White lie is a type of lie which is not vicious; it does not destroy a life or disrespect or betray a person. White magic is benign as opposed to black magic which is harmful and destructive. Submission and request for an end to hostility is often shown by a white flag in battles just as the white dove is the symbol of peace. Nirvana- the state of having received the total blessedness when the soul is completely dissolved in the Supreme Spirit- is also white, and so is the color of mourning in some parts of Asia and in Zoroastrian as a new life and a new beginning is set ahead rather an end to a non-

absolute existence. Apparently, black became the official mourning color by Louis XII of France despite the fact that Christianity also believes in afterlife and think that black is the wrong color for it. White is expected to be clean. Brand-X detergents are expected to whiten the whitest whites, just as white and clean freshly-fallen snow which does not have any dirt spots on. It might constantly fall to the bottom of the list of people's favorite color in psychological tests but white definitely has its spacious room to show off in interior design. As clean as it is expected to be, it brings the sense of being sterile. However, misuse of this color in hospitals and medical clinics as a means of denoting hygiene has made people think of it as unemotional, leaving this color with no psychotherapeutic effect (Fontana, 1994).

- **Black**

Black represents the power of darkness, or maybe one should say darkness is power and black is used as a representation for such power (Frieling, 1957) Black is a notion of a dark night, where nothing is known and the unknown brings fear. It is an ominous color; the color of death and grief. There are a lot of negative connotations with black in it such as black market, blackmail, black sheep and black humor. Black also identifies a mighty power that spreads fear, just like Hitler and Mussolini's black troops. A color association study showed that the combination of black and red is taken to be the ultimate expression of hatred. Punks dress up in black leather jackets and boots and their symbols of defiance such as chains and skull decorations and razor blades to express their preference of belonging to a no-future generation. Interestingly, based on various psychological tests, teenagers tend to choose black as a way of defiance in pursue of independence from rules set by parents or society.

However, it could merely be interpreted as a normal choice in the course of growing up. On the contrary, the black robes of priests and nuns is a sign of self-denial.

In the world of fashion though, black is to represent elegance, status, wealth and dignity. Examples are the black evening dresses for the Gala parties, black limousines with rich businessmen in black suits onboard. Black is also used as a color to set apart as it was worn by the aristocrats to distinct themselves from the ordinary colorful public. Black in companion with gold is the ultimate expression of class, elegance and luxury, being sophisticated and high quality. A unique characteristic of black is that beside the other colors, it makes them look more luminous. In ancient Egypt, women drew thick black lines around their eyes to look more mysterious (Fehrman & Fehrman, 2004).

Table 1: The Psychological Effect of Hues (Fehrman & Fehrman, 2004)

	Positive	Negative
Red	arousing, excitement, enthusiasm, energy and passion	anger, rage, fierceness, aggression
Orange	excitement, jolly emotions, extroverted, happy, energetic, lively and sociable	blustering, intrusiveness
Brown	security, comfort, stable, dependable	-
Yellow	happy, cheerful, suggestive, hope	egocentric
Green	relaxing, tranquility, freshness, natural	ordinary, tiresome, guilty
Blue	peacemaker, calmness, comfort, security, contemplation, sobriety	cold, depressing, (in certain conditions frightening)
Purple	dignified, exclusive and regal	being lonely, mournful or pompous.
White	calm, peace, light and spirituality, holiness, cleanliness and innocence	-
Black	class, elegance, luxury, high quality	fear, death, grief
Grey	conservativeness	dreary, lifeless, tedious and somehow passive

In accordance with all facts and discussions referred in this thesis study these effects will survey from two point of views: human health and interior spaces.

### 3.2.1 Psychological Effects of Color on Perception

When it comes to discussing color, there is an important factor to consider and that is color perception, which can be really different among people. Color perception depends on many things, from physiological factors such as a person's brain interpretation form signals sent by the eyes to a person biases in terms of psychology and culture or ever whether there is a defect is one's color vision. People relate differently to color. Most think of color as simply color- red is forever red and blue is just blue. But the fact is that color perception varies dramatically from person to person and also from species to species (Kuller, Mikellides & Janssens, 2009).

Through research gigantic loads of data have been collected, only to display a really fascinating set of information about how the humans and other species differ in perceiving color. It opened ways for the researchers to walk out into the world and stand on a different vintage point and view it from a whole new perspective in order to get a better understanding of humanity as well.

There is another classification of color according to perception (Figure 10):

- Cool Colors (calming): colors that represent cold temperatures, water, sadness, ice and decrease your body temperature, i.e. Green, Blue.
- Warm Colors (exciting): Colors that represent warmth, heat, fire and increase your body temperature, i.e. Yellow, Orange, and Red.
- Neutral Colors (good for backgrounds): Colors with no strong differences, i.e. White, Silver, Gray, Brown, Beige, Tan, Black,



Figure 10: Classification of Color According to Perception (made by author)

There is an amusing aspect of color and that is how the eye edits the signals before transmitting them to the brain. The eye is capable of coding the information which it receives. So the image is actually broken down to texture, shape, color and depth. Later, the brain reconstructs the image, but this image is not an exact replicate of the original. This means that the external world is not pretty much the same as what humans see. Essentially, the external world is of a human's creation (Rivlin & Gravelle, 1984).

Undauntedly, there are different senses to unity. In Gestalt psychology, unity refer to an organism as a whole. As it is clear, there is a link between the centers of processing sensory information.

Associations can be developed between color and “odor and taste”. Color can also affect the sense of touch as it can appear heavy or light to produce tactile impressions. It can also be associated with sound, having its own volume. There are temperature associations to color, too. All these associations are so real and in fact they have great influences on the design of environments, advertisements or any other situation where color can be used as a means of communication (Mehta, 2009).

- **Perception of Volume**

One of the main factors in forming of perception to openness is fact lightness in interior spaces. There are ways to increase apparent room size by means of light or pale colors, cool colors and small patterns. Light and pale colors recede whereas dark hues or saturated colors protrude. That is how they affect the apparent size an interior space. Also, it works the same with high and low illumination of the space. The first enlarges the space as the latter diminishes the apparent size (Mehta, 2009).



So, for designing spaces with a large area saturating the space with a cool and light colors will lead the space to be seen bigger.

- **Perception of Temperature**

In the book of “The Elements of Color” the writer speaks of experiments which demonstrate a variety of feeling that occupants had in two workrooms painted blue-green and red-orange. Those in the blue-green room felt that 59°F was already cold, but for those in the other room it did not feel cold until the temperature was reduced to 52°F. This is a popular hypothesis that color can inculcate warmth or coolness and this is a unanimous judgment passed by many people (Itten, 1976).

Clark also had an experience in a research: in a cafeteria of a factory light-blue bulbs were installed and the space was air-conditioned and the thermostat was set to 75°F. However, workers complained it was cold. Then, the area was painted orange and the same temperature was complained to be too warm and so the thermostat had to be set to 72°F. Additionally, another study in Norway turned out similar results. This time the degree difference was 4. All these studies show that one feels cooler in a blue room and warmer in an orange room. But there are other elements in this regard. Even objects react when moved from a blue room to an orange one and a temperature difference was observed. In Hans Scheurle’s study in 1971. Thus, he suggests the hypothesis that human’s body always adjusts and normalizes to a condition (sweating when feeling hot to cool the body or increasing the metabolism when feeling cold); this feeling of warmth can only be a normal reaction of any organism. However, the body should find ways to compensate for excessive heat in the surrounding environment and cooler colors can be a great deal of help in this process (Clark, 2008).

Colors also take in and preserve heat to different levels. This depends on their reflection ratio of light. Lighter colors reflect most of the light whereas darker colors absorb the light. The darker a color, the lighter it absorbs! So, as there is less heat loss indoors, a light color is likely to throw back more heat from the walls compared to a darker one. So, as a matter of fact, light colors must be applied where there is a lot of exposure to high temperatures. Hot or warm colors are red, orange, yellow-orange, pure yellow and yellow-other. Cool colors are green, blue-green, etc. other colors are to be categorized based on their hue position or on the colors that are used as accent with them in interior design (Kearney, 1966).

So, for designing spaces that are located in a cold climate with choose right colors for example warmer colors can help to the space looks like warmer and it would help to users for being more comfortable in each place.

- **Perception of Weight/Size**

Generally dark colors appear heavy and light, less saturated colors (pastel) look less dense and the lighter. Among the same intense hues, warmer hues look heavier than cooler hues. There are many environments such as factories and workshops where these perceptions can be put in good use. If the base of machinery is painted dark, it makes it look steadier. On the other hand, if heavy objects which are normally or regularly moved by humans are painted in light colors, they could appear less heavy. Cool colors can also help objects look smaller or shorter. Warm colors do the opposite. These are essential factors in color design with consideration of the big picture of the interior space. In interior spaces with really high ceilings, warmer or darker hues are used to make them look lower and it is the effect of the heaviness of

dark hues with its advancing characteristic. On the contrary, light colors make them appear higher (Payne, 1961).

- **Perception of Noise/Sound**

Gestalt psychologists such as Hienz Werner, Krakove, Allen and Schwartz realized that loud noises and strong odors bring more sensitivity to the eye for green and less sensitivity for red. This can be used in interior design with regards to the environments which have mental associations. Stimulation of senses along with brightness and/or loudness are among the active impacts of warm colors. For cool colors, it is the other way round. People might use the word “loud” for very strong and highly saturated red but never a loud blue. There is a tendency of associating high-pitched and shrill sounds with saturated and light colors (Montgomery, 1988).

Loud noises or environments can be visually compensated using these associations. In noisy places like factories, olive green could offset high-pitched sounds, but yellow or red could make the space be felt even noisier and bothersome. Same applies to muffle sounds when they become more muffled in darker color environments and so light colors can compensate for it.

There is a list of color-sound associations done by Heinrich Freiling (1980) as follows:

Table 2: The Effects of Color on Perception of Noise/Sound (Mahnke, 1996)

Color	Perception of Noise/sound
Red	loud/trumpet
Pink	soft/delicate
Orange	load/major key
Brown	dark/deep/minor key
Gold-Yellow	fanfare/major key
Yellow	shrill/major key
Yellow-Green	high-pitch/major key
Green	muffled (when dull)/shrill (saturated)
Green-Blue	soft
Blue	distant/flute to violin
Ultramarine	dark/deep/more minor key
Violet	sad/deep/minor key
Light Purple	weak/restrained
Crimson	powerful/stately

- **Perception of Time**

Apparently, there is a sign of some sort of contradiction on the issue of color effect with the perception of time. There is a famous belief that time usually gets overestimated in environment with warm colors. However, cool colors make time underestimated. A study was done by Linda Clark on this issue. Two groups of salesmen were asked to remove their watches and hold their business meeting in two separate rooms; a red room and a green room. The “red” group estimated the elapsed time two times more than the elapsed time two times more than the actual time whereas the “green” team estimated it to be shorter (Garber, Lawrence & Eva, 2003).

A British university shared its findings quite similar to the previous: only that the rooms were lightly colored and subtly colored. The audience in the lightly colored room assumed they had spent 45 minutes' less than the actual time elapse (Smets, 1982).

### **3.2.2 Psychological Effects of Color on Interior Spaces**

As clear as it is, color is one of the main aspects of successful work in interior design. The proper use of color in a space, provides a pleasant and suitable impression leading to the generation of a favorable reaction. If not taken seriously, even a well-planned and well-equipped space will look or feel depressing and disappointing due to drab and indifferent or unpleasant color terms. In interior, color is in vivid sight in every element– walls, floor and ceiling, objects such as furniture, ornaments, artworks, upholstery fabrics, curtains or other window treatments, and even in the clothing of people residing in that space. Windows are a main source of outdoor colors as well as areas of intense color, and surely sources of light. Bright areas of light can be created by sunlight or lamps. Light falls on to other surfaces and objects, reflecting the colors of the surface. Brightness can be on a roller coaster of variety from floor to ceiling and in various parts of a space as it directly depends on the windows or artificial light sources. Objects cast shadows, color appear darker or lighter on different sides of the objects. All these effects are crucial to consider when deciding on color for the interior of a space. The visualization of such complexities makes it possible to make the right decisions about color – decisions to be later translated into a satisfying project when it is all over (Schweitzer, Gilpin & Frampton, 2004).

How to locate colors are the interior space can have a great impact on how it appears. There can be a great deal of differences in the way the color and its character are

perceived psychologically and how people react. The interior space locations (top, bottom and sides) are a matter of concern. A specific hue might be the best fit for the floors of an interior space but cause a totally different reaction on the ceiling.

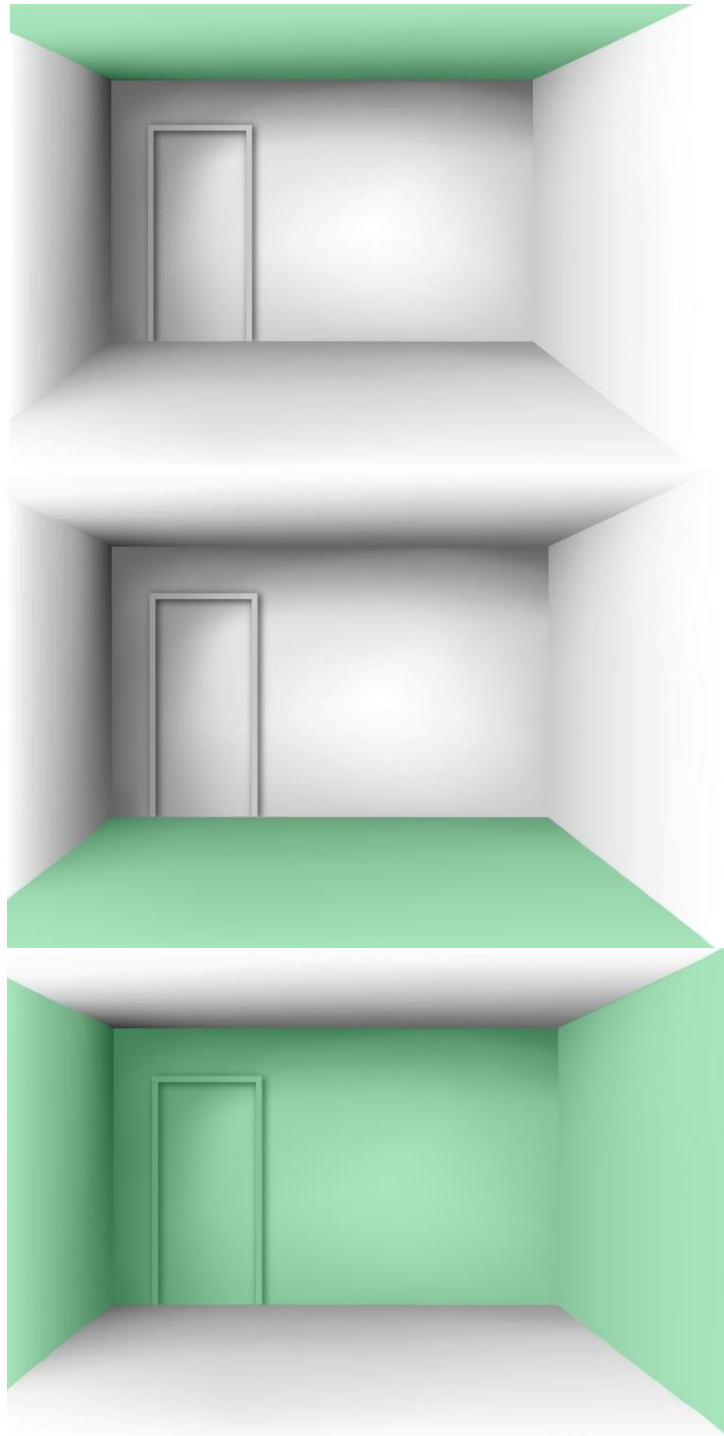


Figure 11: Three main Interior Space Elements (Ceiling, Floor, Wall) (made by author)

- **Red**

Red can appear rather heavy and intruding on the ceiling and give a sense of intruding, and for walls it looks sort of aggressive and at the same time advancing on the floors, red could mean being alert and conscious or at certain times pompous. This, pure red is rarely used on the walls as a dominate color. It is more used as an accent. The overuse of saturated red intensifies complexity due to its emphatic characteristics. Thus, variations of pure red are technically more suitable.

- **Pink**

Pink appears delicate and brings comfort on the ceiling but the floor it inculcates a sense of unfamiliarly and its delicacy is not a good feature. However, on the walls it feels intimate but too sweet if it is not greyed down. Pink needs careful handling as it is generally perceived a feminine color, it is better for more intimate feminine sphere. A typical use of it is in young girl's bedrooms but it is quite a cliché, light blue-green is a good alternative to be used for both genders only with different accents to customize it for each. The exact nuance of pink is the point of consideration. Bubble-gum pink is for sure livelier but also more cheap-looking compared to elegant rose pink.

- **Orange**

It can make attention-seeking and stimulating ceilings as well as activation and motion-oriented floors along with warm and luminous walls. Orange is not as sharp as red so it is easier to get on with. However, a too bright hue of it, it must only be used as an accent to other colors. Pastel oranges can be really practical for setting cheerful, energy-filled sociable moods. Considering its reflection on skin, it can enhance complexions, especially with its hue close to peach.

- **Brown**

Dark brown is too heavy for ceiling and it induces oppression but for the floor it appears steady and stable just like the earth underneath one's feet on the walls, it appears secure and if the brown color is for the wood, it is so assuring.

Brown differs in natural materials such as different wood, coffee, chocolate or soil. Brown as a paint is never comforting but the natural material brown looks warm and comforting. Brown paint should be avoided in certain places because it might evoke fecal associations.

- **Yellow**

Lemon yellow makes ceiling light, stimulating and luminous. It is warm for walls (especially towards orange) but it can stimulate excitement or irritation if it is highly saturated for floors, it is elevating and diverting.

Yellow enjoy high visibility so it can serve for many purposes, particularly in areas like industry. As it is brighter than white are not well-illuminate with various accent can sit in harmony with various accent colors, therefore it can enliven a spaces as it takes its surroundings into its predominant friendly and mood-boosting essence. The accents can have profound effect, though. Orange and red accents slide it towards more exiting and warmer element whereas green and/or blue-green take it to be cooler and more pacifying.

- **Green**

For ceiling green brings a feeling of being protective, but its reflection on the skin in not very favorable. For the walls however, green is cool and green can be irritating



and alive green looks muddy. Up to a certain limit of saturation, green looks soft and natural on the floor but if it goes towards blue, it looks old. Green and blue-green are sound and suitable for creating a good background in environments assigned to meditation or concentration.

- **Blue**

Blue on the ceiling celestial if it is light, but darker hues appear heavy and passive. For walls it appears cool and distant. For walls it appears cool and distant and darker shades can be used for space-darkening purposes, however encouraging. Blue for the floors inspires effortless movement, but dark blue can appear quite substantial. Usually used on doors to look as an accent to surrounding walls.

- **White**

White on ceiling is hopeful to diffuse light sources and eliminate shadows. It is empty and hold no objection towards any design. On the walls, it looks sterile, but also lacks energy, but on the floor it inclines touch-inhibiting justifications in areas of psychology.

- **Black**

Black is oppressive on ceiling and make an individual feeling like he/she is in a dungeon when it has been used on the walls. For floors, it appears quite odd or abstract (Mahnke, 1996).

In order to gain the best results for design objectives, it is essential to alter the atmosphere of the space so that it serves the functions of that space well. The choice of colors is a determining factor for the degree of mood creation. To produce a

centrifuged action, warm and illuminous colors should be used with high level of lights. This combination will direct the attention outward on the environment, which is good for cheerfulness activities which need a good level of energy.

Centripetal action comes through softer and cooler colors along with lower levels of illumination. These environments are practical for concentration as they persuade inward orientation. This is a useful formula for areas where employees are responsible for difficult visual or mental tasks (Ladau, Brent & Place, 1989).

A color's strength (chromaticity) and the perceived level of excitement of a space are closely related studies show an increase in the complexity of a space as the strength of color increase. Strong colors, regardless the hue, make a room look more exciting while weak colors have a more soothing and calming impact.

Considerable color contrast is also another factor in the excitement of the space (Birren, 1961).

Table 3: The Psychological Effect of Hues on Interior Spaces (Mahnke, 1996)

	White		Yellow	Orange	Brown
Ceiling	hopeful		light	stimulating/ attention-seeking	heavy/induces oppression
Floor	inclines touch-inhibiting justification		excitement	activation/ motion-oriented	steady/stable
Wall	sterile/lack of energy		warm	warm/luminous	secure
	Pink	Red	Green	Blue	Black
Ceiling	comfort	intruding	protective	celestial (light blue)/ heavy or passive (dark blue)	oppressive
Floor	unfamiliarity	alert	soft/natural	effortless (light blue)/ quite substantial (dark blue)	quite odd/ abstract
Wall	intimate	aggressive	cool	cool (light blue)/ space-darkening (dark blue)	make a dungeon

### 3.3 Chapter Summary

Generally color has effect on human in three different ways biologically, psychologically and sociologically, which in this chapter two of them which are essential for achieving the main aim of this study were investigated: biological and psychological. The next step was focused more on effects of main colors on human psychology. Therewith, the human perception that can be effected by color, such as, perception of time, weight, volume, time, sound and temperature were studied. Some of those perceptions can be used for improving the efficiency of library for users by psychological effects of color that in the fifth chapter will be mentioned. In addition, the psychological effects of color on three main interior building elements, wall, floor and ceiling were discussed. In the end of this chapter, how human feeling was effected by psychological effects of each color on each interior factors are illustrated.

## Chapter 4

### COLOR IN LIBRARY

#### 4.1 Definition of Library

Since ancient times, libraries have catered to the reading and socialization habits of their customers. Also, library is a place meant to inspire a sense of community (Macken, 2006). Libraries have been around for a very long time and are traditionally seen as collections of information and services. They have always played a significant role, enabling people to engage with all kinds of information and knowledge resources.

A library is a place that support learning and teaching in academic context. It can also be defined as an extension to lecture halls and classrooms because it brings more access to knowledge through its available resources and services (Curran, et al, 2006).

Some books were so rare that their free access was only open to scholars with high academic degrees. In early modern times however, access was granted to more and more people but the working hours were quite limited. In that period it was a storage-consuming method, leaving less room for the users and so keeping their number limited. (Holmberg, et al, 2009).

- **Public Library**

The mission of public libraries is serve the board and various interests of its community intersects via digital technology on different ways. The main aim of this project is providing free information for its constituents. In the modern societies which all aspects of human life dominated by the internet the public library is an essential resource. For those who the digital access is unavailable for them, the library can play a significant role for this shortage. This vital source of information is not only available for everyone such as citizens, students, small businesses, and the rest of people not only under privileged.

Public libraries could be very similar and different at the same time. Their basic structures could identical in many ways. Maintaining relevance of humanity with digital technology is their special common mission in the 21st century which included many different objectives and concerns. In the fulfillment of this concern, however, there a variety of similarities. Size is one of those differences which could be between large and small public libraries. Their amount of information and books which are existed in each library, interior design of each one (color, furniture and etc.) are others different similarities. Public libraries are located centrally. In addition, they are often located in close vicinity to other civic establishments like a fire station, the town hall, a post office and maybe a public pool. . Therefore, the library could be consider as one of the informal governance of the city or town component, and plays a significant role in everyday town life by its community meeting space. Consequently, the public libraries are belong to vast group of people with variety considerations. So, choice of color for this project is a hard task to do because each group according to its psychological requirements will need a specific

atmosphere. For instance, in the Peckham Library and Media Centre which located in London (United Kingdom) the main color which has been used in this library is white. Colors which are used on floor of this library included blue and red. White is the only color which considered for the ceiling of this library. The verity colors for using in floor, ceiling and wall of the library considered (neutral, warm and cool colors). Also, the “pods” of this library are seen such as a main interior elements like walls are light brown (wood) color which is included in neutral colors (Stephen, 2007).



Figure 12: Exterior and Interior Photos of Peckham Library (Lushington, et al, 2014)

Another instance, Médiathèque André Malraux which located in Strasbourg (France). The origin color of cement that is light grey, white and red. Also, light brown and red are colors which have been chosen for the floor of this library and the colors of ceiling are light grey and red. The neutral colors have be used in the whole space of this library. On the other hand the red in a conservative way used in floor and walls of this library. Whereas, color of bookshelves of this library have been used in a harmonic way with other colors of walls. The use of bold color, furniture and graphic design integrates the existing concrete structure with the new library program.





Figure 13: Exterior and Interior Photos of Médiathèque André Malraux (Lushington, et al, 2014)

## 4.2 University Library

Nowadays, libraries act like the heart of the universities, which contribute a lot to the intellectual lifestyle of the users and are somehow known to be the center of a campus geographically. University libraries differ in meaning from public ones since



there is less of concept of cafes and restaurants and auditoria within them. However, the integration of university libraries to the institutions which incorporate them, makes them quite distinctive in terms of spatial structure, objectives and other related orientations such as study and research. It is a facilitator for students' excellence and higher achievements. However, the term "library anxiety" has gained notion recently and as Mellon (1986) defined it, it is a feeling of discomfort or an emotional disposition that the students experience while spending time in the library (Mellon, 1986).

To keep up with the rapid and constant change in knowledge environments, the effectiveness of university libraries depends on the printed and digital collection are composed and calibrated, as well as how much access they provide to scientific databases and extensive subscriptions to electronic publications. To assure how much of the institution's mission statement is accomplished and guarantee user service centricity, librarians take benefit from advanced monitoring tools to collect data on information seeking and users' studying behaviors, the level of satisfaction and retention of students and faculty, and the relation between library use and the success of learners alongside scholarly competitiveness. In order to establish convenient plans for strategic goals, user relations are crucial to library administrators. This gives them the opportunity for future developments in their collections, spatial configuration and service programs (Holmberg, et al, 2009).

Aesthetics and functionality are traditional considerable parts of any architectural program, but the end aim designing a library is to create structures for responding customer's requirements, which, in the case of academic libraries, means student' study utilize needs and creating a place with welcoming atmosphere that facilitate

learning and socialization (Mathews, 2009). From a psychological point of view, studying is not an easy task but it is a challenging task, particularly when preparing for a seminar, presentation, paper or most important one exam. It is not easy to sit at a desk for hours and hours, reading, practicing, memorizing and exercising, and parallel facing with the level of pressure, stress, anxiety. There are deadlines to meet and lecturer to satisfy and marks to gain. Anything added to such a situation, can deteriorate the psyche of the students. In addition, a psychologist of environment, helped generalize the meanings of privacy, crowding, personal space, and territoriality, which are outstanding concepts in theory of human organizational behavior (Jones & Thorpe, 2014).

An interior scheme is not only about the color which should use for wall and carpet the floor it is more. It is playing an important role in transmitting key messages about the psychological quality of the library for its users. Also, it is too important that how the space of university library is seemed for the students in the first impression.

Color is an emotional thing; everyone has a favorite color and they won't be shy to express their idea. Interior scheme can play as role of marketing tool to catch their attentions at the first glance, also make them to spend their time with euphoria in the library by appropriating the convenient atmosphere for them. As a result, by making the students time worthwhile in the library they will be satisfied (Lushington, Rudolf & Wong, 2014).

University library constitutes an essential component in any academic environment as it engages in activities which revolve around the provision of certain defined services and ensuring that these services are maximally utilized. Thus, various

university libraries struggle to anticipate the information needs of their users and to provide necessary services and resources to meet those needs. It is observed that teaching, learning, and research activities in universities cannot be properly achieved without effective libraries that would acquire and disseminate information materials (Ntui, 2009). As obvious as it is, libraries do not only provide a space for studying, but also for various engagements. Thus, a part of the design shall also focus on areas where other activities, apart from studying, can be conducted. Certainly so, the characteristics of different spaces in a library differ depending on what type of activities are to be performed in each space.

Buckland, in stressing the importance of library usage, emphasized that libraries are mainly designed to act as information services which are expected to have various effects (inspirational, recreational, educational, and utilitarian) on the user (Buckland, 2007). Academic libraries play a significant role in student performance because it has been shown that students who access library resources and services outperformed students who do not (Cox & Jantti, 2012). This is one of the reasons why librarians are seriously concerned about the underutilization of these services especially in the academic environment. Consequently, librarians are enjoined to create awareness for the relevance of library services by aggressively marketing them. The importance of clear statements of what happens within the premises of academic libraries is not to be ignored. Signs and boards must be used efficiently to foster complete understanding of how useful and effective each space can be and how each area can work to the best of the users' needs and requests. Most of the time libraries are underestimated, solely because there is not enough solid evidence of how capable the place can be for many various reasons it is constructed. This needs

to get bold in the interior design, with proper use of text and color to be acknowledged by the users.

### **4.3 Environment of University Library**

Madhusudhan (2008) emphasized that the services the library offers must be designed known to as many users as possible so that they think of library when they need some information (Madhusudhan, 2008). Similarly, Nooshinfard and Ziaei (2011) observed that libraries and information centers have begun to see marketing of information products and services as essential in promoting library patronage (Nooshinfard & Ziaei, 2011). According to physical program of spaces, interior space of library included six parts are vital element for designing an university library: storage- toilets- entrance- offices- computer rooms- reading rooms (Balanli, 2003) (Lushington, Rudolf & Wong 2014).

Toilets and storage have not psychological effects on users during the study time. But entrance, offices, computer room and reading room have a direct impact on users and consequently on efficiency of library. So, from this point of view investigate these spaces is an essential fact:

- Entrance is a crowded space that all students are coming inside the library through this architectural element. So, it should motivate everyone while they are coming inside the library and make them energetic.
- Office is a place which in some cases students facing the staff for consulting or questioning. Also, to borrow or extend or give back the books that they took before should standing in front of the librarian counter for a short time. Also, according to improve efficiency of library this short conversation should be

enjoyable for both sides; so, this space should create an appropriate atmosphere to make a smooth way for this short conversation.

- Computer room is a place that silence should be inside it to the extent. Furthermore, students should possess the maximum creativity and awareness with the lowest rate of anxiety, stress and other harmful feeling.
- Study room is a similar with the computer room but this space should be silent more than computer room.

Some of the strategies which could improve library patronage include provision of current awareness services (CAS) and conducive library environment. Current awareness services are methods by which libraries alert their users on newly published materials. This awareness is one of the key psychological factors to promote efficient studying habits in libraries. These days, staying updated and having access to recently released knowledge and information is the winning card in academic contexts, hence a service that can make a library a most-often-visited site for the seekers of upgraded knowledge and fresh information. Library environment can be defined by those factors which are interior or exterior to the library and can greatly or partially influence its usage. Such factors include seating capacity and arrangement, lighting and ventilation, cooling system, noise level, opening hours, building interior (furniture, color and etc) and exterior design, and staff attitude and the personality of people in charge which can all be intertwined with the psychological factors of such place. As mentioned before, among all the factors involved, color and its use is a really important factor in interior design, so it is totally and directly relevant to the efficiency of library (Madhusudhan, 2008).

A conducive environment of a library is that in which noise is controlled and other factors such as lighting, library space, furniture, and good ventilation should be adequately provided to enhance learning and motivation to study (Oyedum, 2012). Unattractive library environment may hamper library usage. Thus, the environment of a library must be designed in a way that can soothe any of the said conditions in a good practical way, if not eliminating, but sure reducing such negative things (Adekanye, 2004).

Clee and Maguire (1993), in a study of the importance of library environment in influencing library usage, stressed that although individual factors in the library environment (guiding, lighting, noise level, heating, seating, interior factors such as furniture and color, etc.) do affect a user's perception and use of the library negatively, combination of these factors have the greatest negative impact. A library should be a pleasant, quiet, and a comfortable place to come. Thus, attractive surroundings and pleasant staff will help to promote library usage (Sherman, 1981). These might sound funny or not really serious in academic terms, but in fact they can be way more effective than presumed. Feelings can be very irritated at certain times, especially exam periods, so every little thing can have a positive or negative add-up to the user's emotional status. (Clee, & Magurie, 1993). With regard to all matters which mentioned color is playing main role as a one of main factors which directly affects users psychologically.

Library anxiety is an uncomfortable and weary feeling experienced in a library. Its different effects- psychological, behavioral, cognitive and emotional- can have harmful impacts on students and their well-being along academic performance. One study shows results of Neuroticism to be the reason of increased library anxiety.

However, as the level of education elevates, this feeling is gradually reduced (Cleveland, 2004).

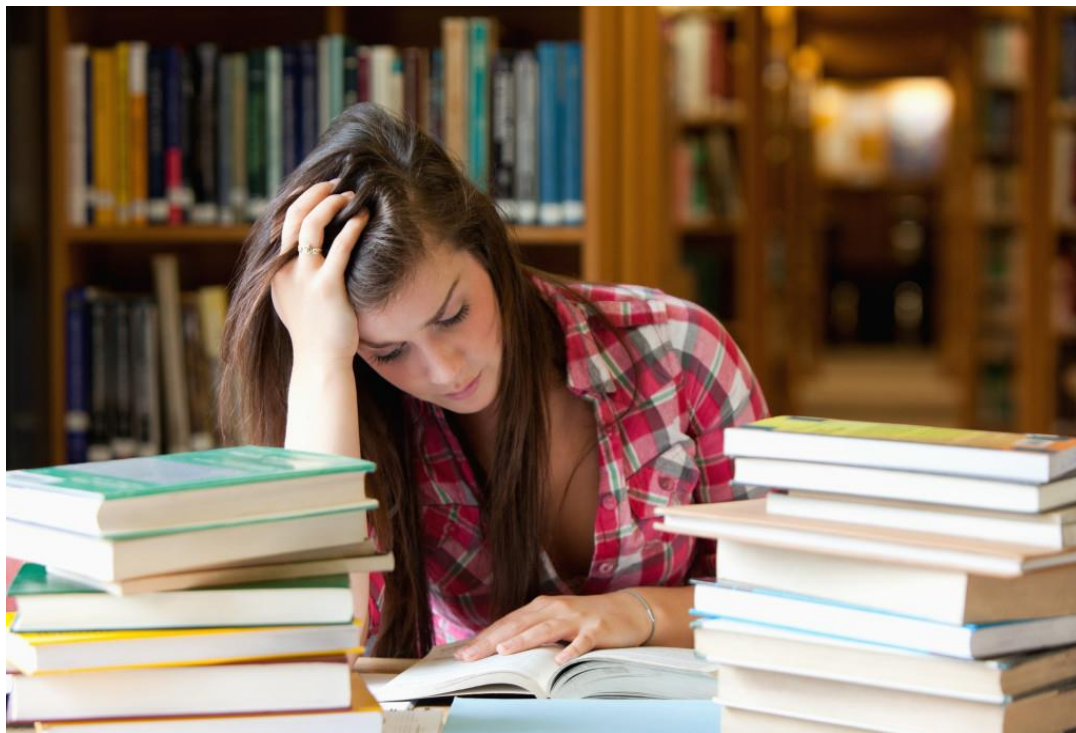


Figure 14: Library Anxiety; URL 9

It is also defined as an emotional disposition with the above mentioned ramifications. This feeling comes to surface as forms of negative emotions such as tension, feeling helpless, self-defeating thought, fear, uncertainty and mental disorganization (Onwuegbuzie, Jiao & Bostick, 2004). It acts like a mental barrier, or in another word, information barrier (Świgoń, 2010). According to (Mellon, 1986), this is happening among the majority of students and is a common phenomenon. Librarians have witnessed high levels of such feeling, but only over the few recent decades have systematic studies focused on it as an important issue and its consequences. It has destructive effects on the ability of students to perform their tasks and research purposes well (Onwuegbuzie, Jiao & Bostick, 2004). Bostick (1992) actually took important steps in research regarding library anxiety. Library anxiety classified into

five aspects as “barrier with staff”, “affective barriers”, “comfort with the library”, “Knowledge of the library” and “mechanical barriers”. Students’ perception of barriers they experienced with the staff was a reason for higher level of anxiety among them. The reason was that the staff were generally busy performing their administrative tasks and did not dedicate more time to helping students. Other reason could be listed as inadequate library programs, librarians not able to response well to questions and not trying to train and increase their information and technophobia (Patrick, 2004). Being at ease and feeling comfortable is connected with how safe one feels in the library and that the environments is welcoming and non-scary. Library knowledge concern how familiar the students are with the library (Jiao & Onwuegbuzie, 1998). These mental and emotional levels of stress and anxiety which came from different causes can be dramatically reduced by the psychological effects of interior color. For example, choosing cool and neutral color for interior walls can increase the level of comfort of users; so, the level of students’ anxiety will decreased. Also, this process can be done by psychological effects color on ceiling and floor. Thus, color has a great potential for playing an important role to resolve this issue.

#### **4.4 Psychological Effect of Color in University Library**

According to all mentioned above, there are many factors to make a library space convenient and efficient for studying. Some of these factors are of physical nature whereas some of them might actually be rooted in the psyche of the users. Among all, there are a many factors which can be modified by color, meaning that according to the convenient psychological atmosphere which are needed for each place the better choice of color could in fact elevate or reduce the psychological effects of such influential factors. In this part, the aim is to focus on three of them and discuss how



appropriate colors can help control the effects of them so to increase the efficiency of the space. For this step, three psychological negative factors considered which color can reduce them by its psychological effects directly.

**Time:** It is obvious that users do not tend to spend a very short time in the library, and if they do, it will be for ordinary everyday chores such as acquiring information, returning or borrowing a book. Thus, the focus here is actually on those groups of users who spend hours within the various areas of the library and performing different academic tasks. Spending long hours in a closed area could be tiring and boring, adding to the fact that studying or preparing for the exam can also wear the students out easily after a few hours. Scientifically, human's brain can have its highest efficiency of learning a topic through the first 25 minutes of confronting it. This is why class sessions are usually schedules for 45 to 50 minutes and then a break. The same applies when students are preparing lessons for exams. So, as a matter of fact, it is a tiring and boring situation which can result in lower efficiency. Also, taking another point of view, it is the staff who spend the longest hours in the libraries, in such a quiet monotonous space surrounded by shelves and books and quiet people. The efficiency of a library depends partially on how welcoming, cheerful, helpful and patient the staff are; and these people are spending hours and hours in the library, some working night shifts when libraries go on a 24-7 schedule in specific academic periods. So the staff can also experience drowsiness and tiredness (Chusid, 1991).

As mentioned before, color can have considerable effect on perception of time. Based on the scientific facts referred to in the previous chapter, warm colors give a sense of time being stretched compared to cool colors, i.e. users spending an hour in

an area painted with warm colors felt a longer time passed compared to those spending the same length of time in another area painted with cool colors. The conclusion is warm colors can push the people towards the boredom threshold more quickly than cool colors. This could be a key issue in choosing colors for the areas of the libraries which are solely for reading and studying. Considering the assumption that people who go into those reading room need full concentration because they are probably doing something very important or delicate or they have little time to prepare. With regard to this users' requirement cool colors or neutral colors can be good choice for this issue.

Noise: This is an external being that cannot be ignored when it comes to libraries. It is one of the main elements of disturbance and intrusion when talking about individual's peace of mind and calm. In libraries, it can be really annoying since one of the most important features of a good library is the quiet place provided so that one can fully concentrate. Therefore, it is an issue which needs considerable attention. However, absolute elimination of noise is far beyond possible. The acoustic technologies can cost a fortune if a whole structure was to be constructed using such technology. Meanwhile, even if it is a possibility, the noise make inside the area are inevitable. It might be reachable to minimize the intrusion of external noises into the space, but noises produced inside are not to be fully silenced, no matter how many signs and notes of "KEEP SILENT PLEASE" are installed. A pen might fall on to a table, a phone might suddenly start ringing as the owner forgot to activate the silent mode, people sneezing, a chair making the squeaky noise, a book falling off a shelf and so on. This types of noises are not deafening, but they are sharp, unexpected, short but loud and sudden. That is why they are really irritating. Obviously, they are out of control (Scargall, 1999).

According to the previous chapter, cool and neutral colors can have an impact on how noises are perceived. They help reduce the psychological shock of a sharp sudden noise whereas warm colors intensify it. Therefore, a conclusion can be made that cool colors can help the users absorb the shock of such noises more quickly and comfortably, making them a better choice for studying areas.


Calmness: this matter completely discussed in a part of library anxiety. Concisely, when a student is preparing for a very important exam. He or she is tight with time and stressed out. This is a big situation to deal with. The levels of stress and anxiety which came from different causes can be dramatically reduced by the psychological effects of interior color. For example, choosing cool and neutral color for interior walls can increase the level of comfort of users; so, the level of students' anxiety will decreased. Also, this process can be done by psychological effects color on ceiling and floor. Thus, color has a great potential for playing an important role to resolve this issue.

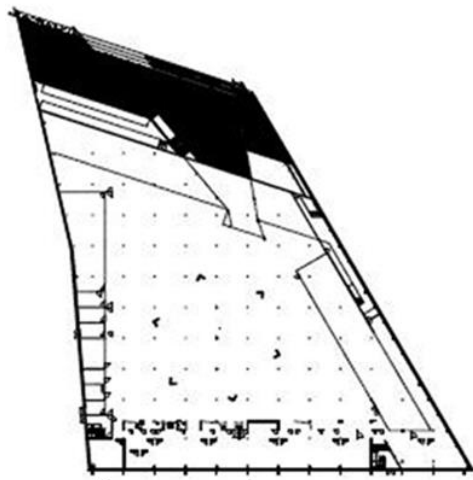
## 4.5 University Library examples

### 4.5.1 Central Library

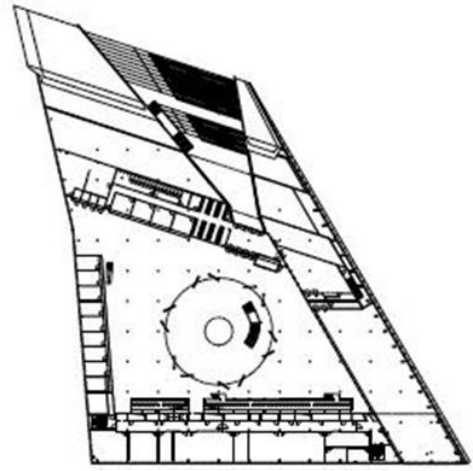
Technische Universiteit Delft (Delft, the Netherlands)

Table 4: Specifications of Central Library (Lushington, et al, 2014)

Architect	Mecanoo
Client	ING Vastgoed, Den Haag
Completion	1998
Floor area	15.000 m <sup>2</sup>
Number of volumes	980.000
Seating capacity	1.000
<p>The Central Library at Technische Universiteit Delft (Delft Technical University) is the national library of technology and the center of technical and scientific information in the Netherlands. With its extensive physical collection and electronic information services, it serves both the university population and the commercial and industrial sectors. Designed by the Dutch firm Mecanoo, this library is noted for its iconic form – an expansive green roof pierced by a conic structure. Completed in 1998, this library represents a tour de force in sustainable practice that was much ahead of its time.</p>	
	

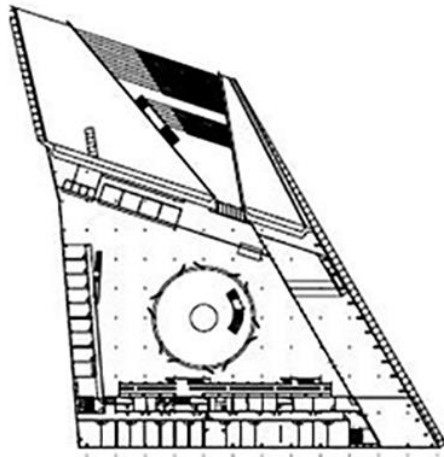


Basement plan

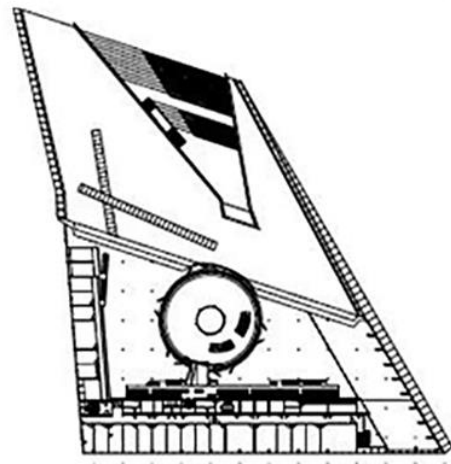


Ground floor

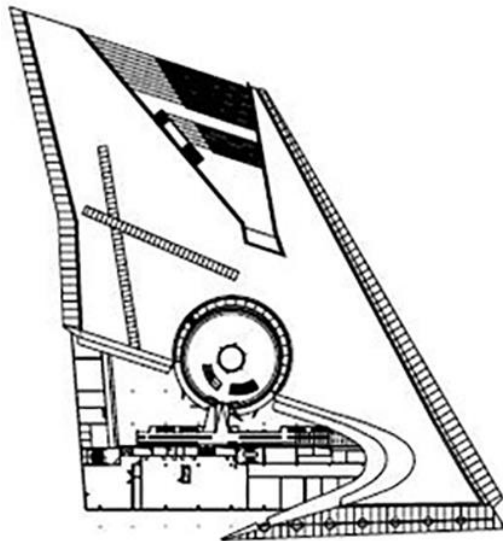
0 5 10 20 m



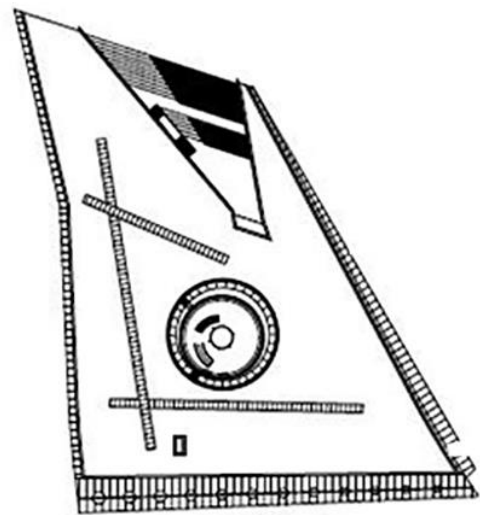
First floor



Second floor



Third floor



Roof plan



Section

Figure 15: Plans and Section of Central Library (Lushington, et al, 2014)

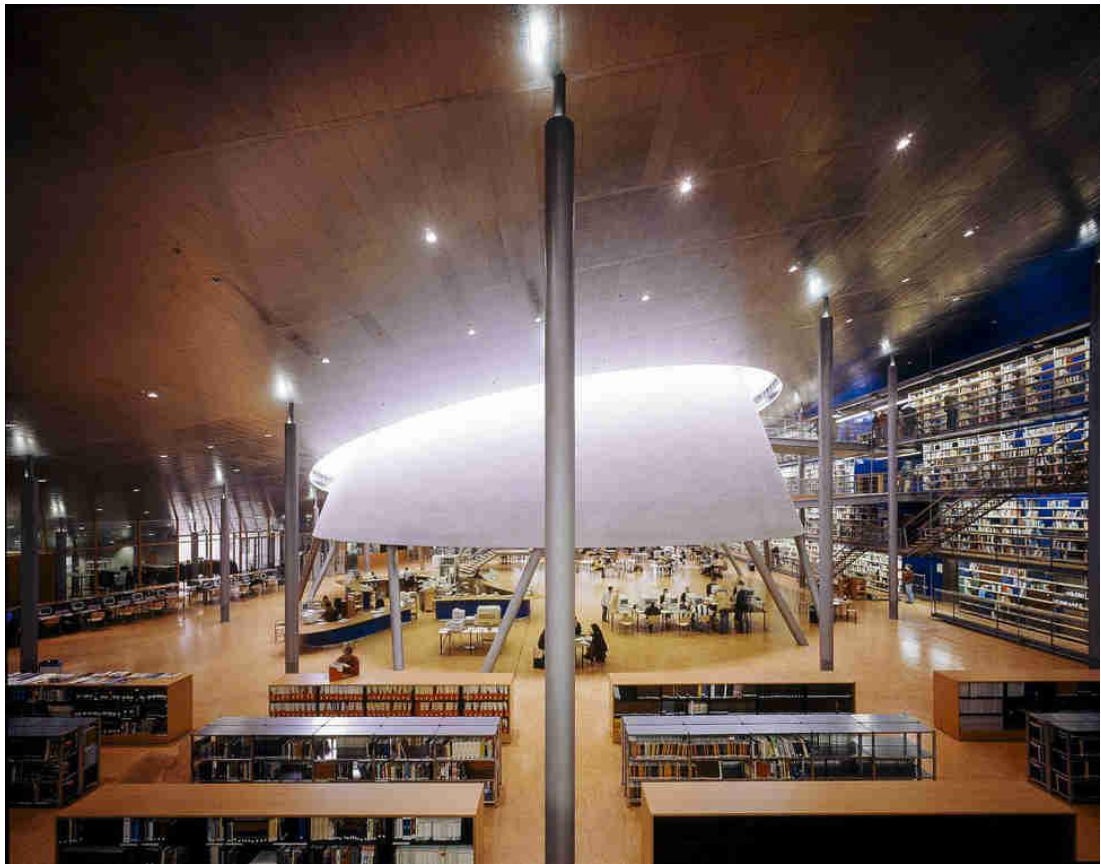






Figure 16: Interior Photos of Central Library (Lushington, et al, 2014)

Walls: the walls of this library are light brown and white which both of them are neutral colors. Floor: light brown and light blue are the colors which have been chosen for the floor of this library which the first one is a neutral and second one is a cool color. Ceiling: also light brown is a selected color for ceiling of this library. Analyses: neutral colors are considered for using in this library by its designer (light brown and white) which these two passive colors have no special effects.

## 4.5.2 Philological Library

Freie Universität (Berlin, Germany)

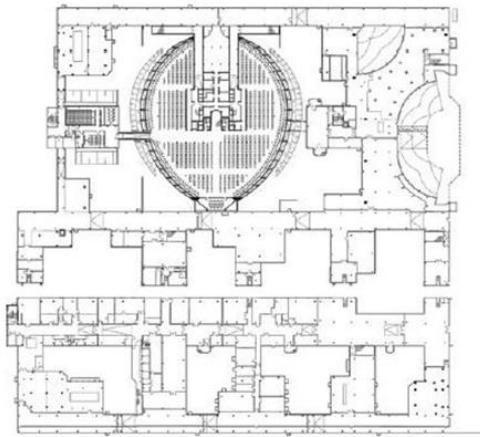
Table 5: Specifications of Philological Library (Lushington, et al, 2014)

Architect	Foster + Partners
Client	Senatsverwaltung für Stadtentwicklung
Completion	2005
Floor area	6.290 m <sup>2</sup>
Number of volumes	800,000
Seating capacity	650

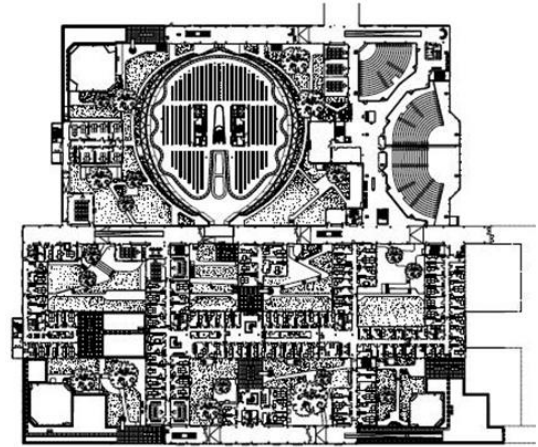
The Freie Universität or Free University, whose name references its placement in then West Berlin, was founded in 1948 as an alternative to the Humboldt Universität in the Russian sector of the postwar city. Originally housed in various villas in the suburb of Dahlem, in 1973, the campus complex was completed as a group of buildings designed from a 1963 prize-winning competition entry by the partnership of Candilis, Josic, Woods. The design is a manifesto of Team X's ideological departure from CIAM and reflected their humanistic ideology that "in everyday usage ... the inextricable complexity of urban life is expressed."



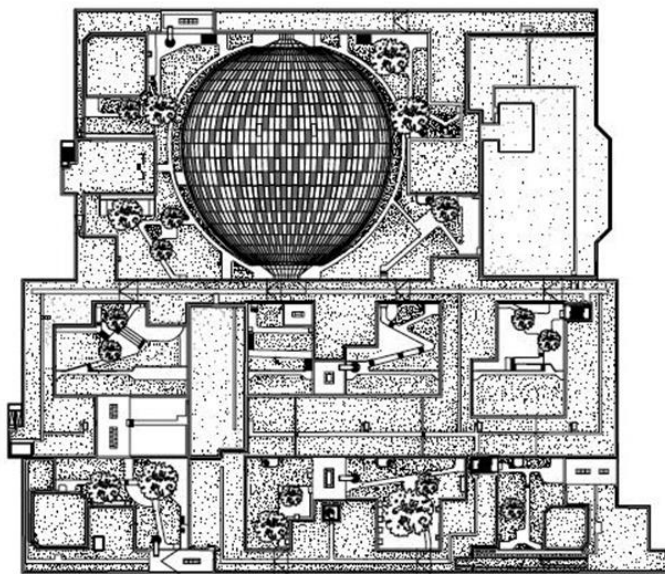




Ground floor



Second floor



Roof plan



Section

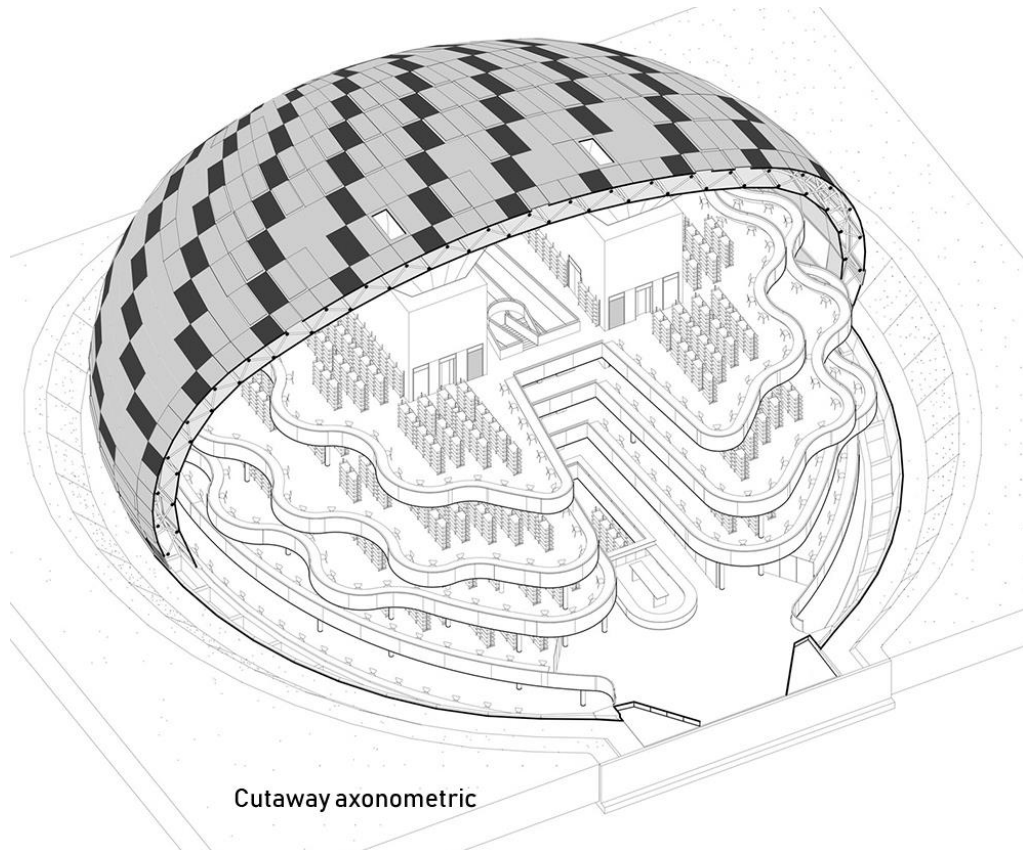


Figure17: Plans, Section and Cutaway Axonometric of Philological Library (Lushington, et al, 2014)









Figure 18: Interior Photos of Philological Library (Lushington, et al, 2014)


Walls: white for walls and light grey for the bookshelves which are seen like walls in some parts of this library have been used. Floor: floor of this library totally is grey as a neutral color which has no special effect. Ceiling: as it is obvious in the photos white is dominant color of this interior element. Analyses: the whole library's space is colored by neutral colors (white and grey). There is an interesting subject in this library, as it mentioned in table three the yellow can be a good choice for a wall and floor and also ceiling of entrance; in this library yellow used for ceiling and walls of the entrance to make a feeling of great enthusiasm and eagerness for everyone who is passing the entrance.



### 4.5.3 Law Library

Universität Zürich (Zurich, Switzerland)

Table 6: Specifications of Law Library (Lushington, et al, 2014)

Architect	Santiago Calatrava
Client	Universität Zürich
Completion	2004
Floor area	4,800 m <sup>2</sup>
Number of volumes	170,000 books, 700 journals
Seating capacity	500
<p>The Bibliothek des Rechtswissenschaftlichen Instituts, designed by Santiago Calatrava for the Faculty of Law at the University of Zurich, is formed by a series of seemingly floating, hollow elliptical plates inscribed into the rectilinear courtyard of a historic building. Formerly accommodating the Alte Kantonsschule (secondary school), the complex, designed in 1909 by the cantonal chief architect Herman Friez, featuring Neo-Baroque and Art Nouveau style elements, was adapted for the use by the Law Faculty. When seen from the street, the intervention is restricted to the new glass dome and the appearance of the historic building was preserved.</p>	
	

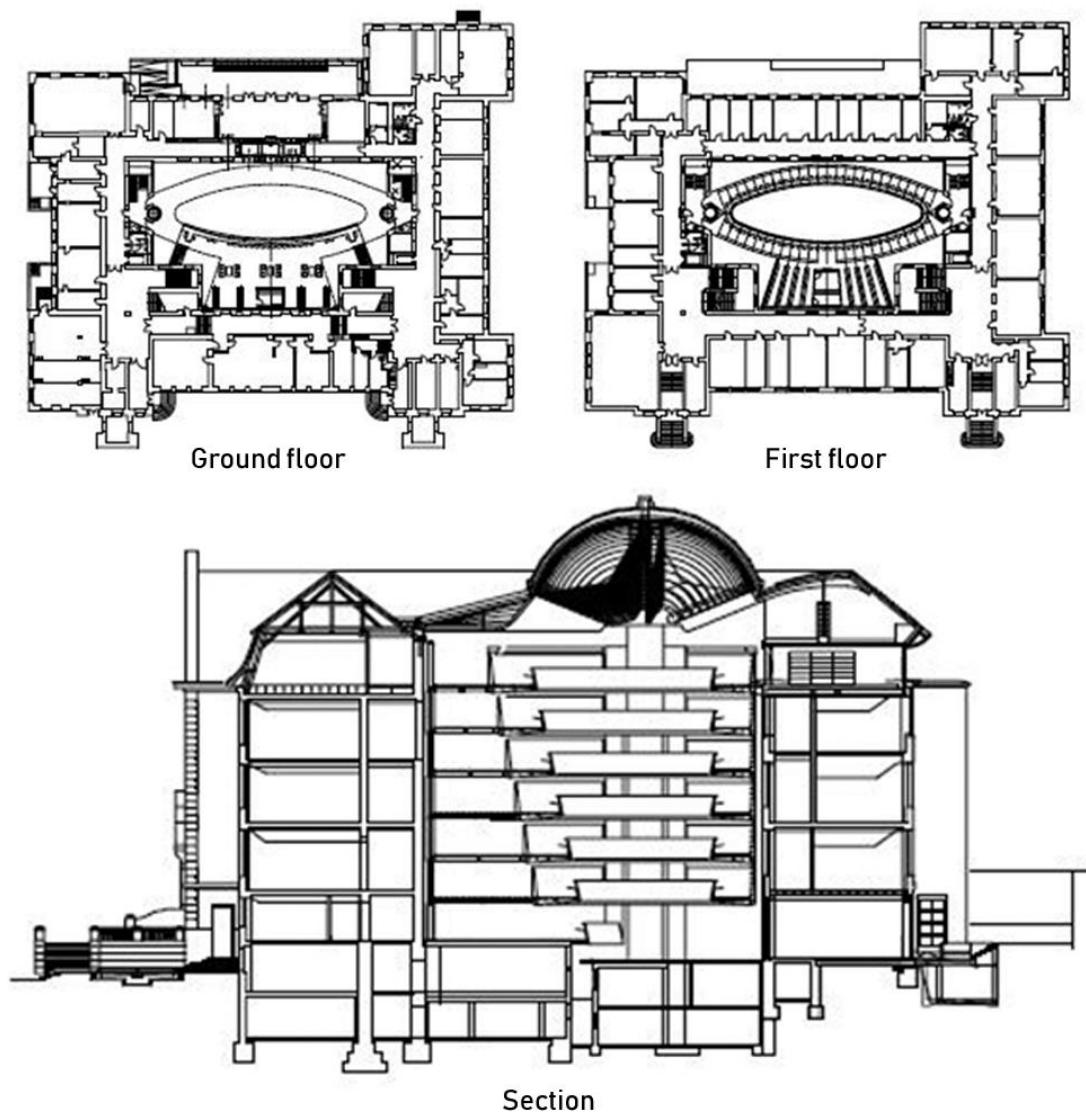
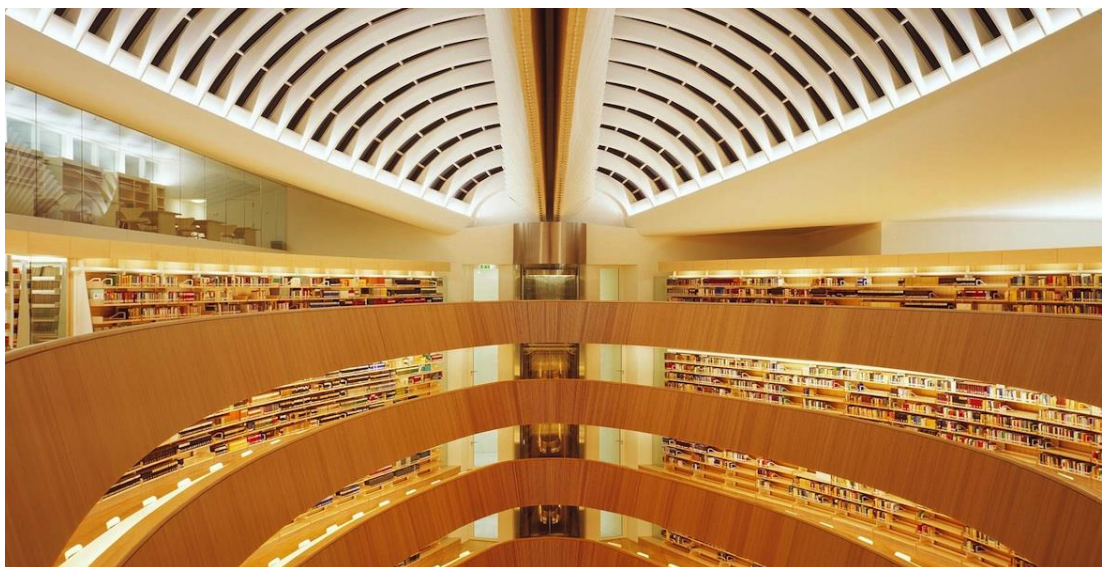


Figure 19: Plans and Section of Law Library (Lushington, et al, 2014)





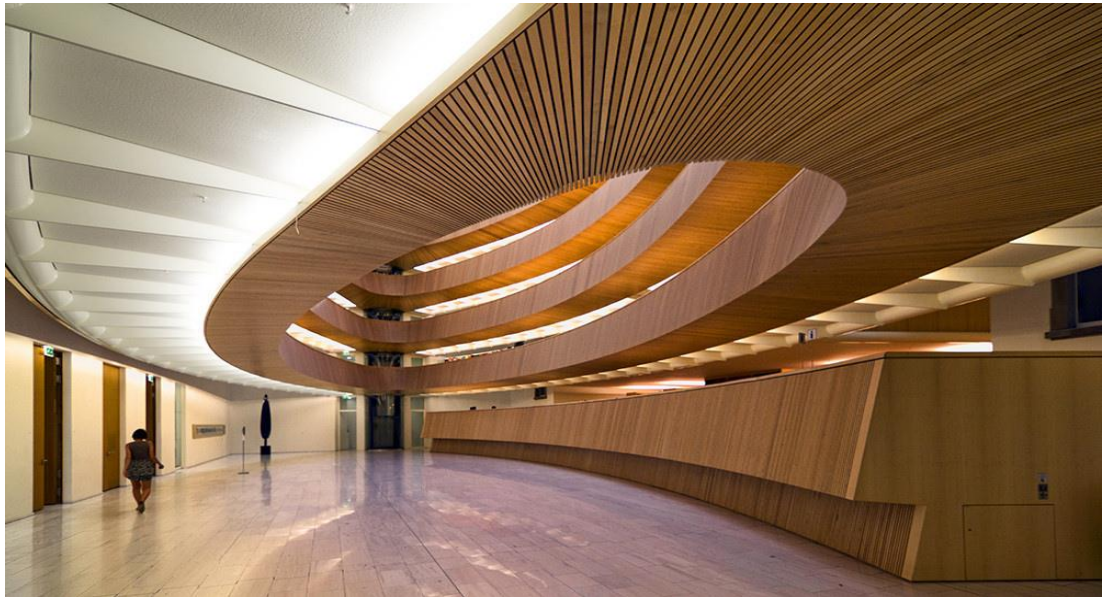



Figure 20: Interior Photos of Law Library (Lushington, et al, 2014)

Walls: white and light brown are two colors which are used in walls of this library. Floor: the color which used for entrance of this library is light grey and for the rest part of this library is light brown which both of them are neutral colors. Ceiling: white is dominant color which utilized for ceiling of this library, but wood used in some parts of this library's ceiling. Analyses: neutral colors light brown and white are seen in the whole space of the library.

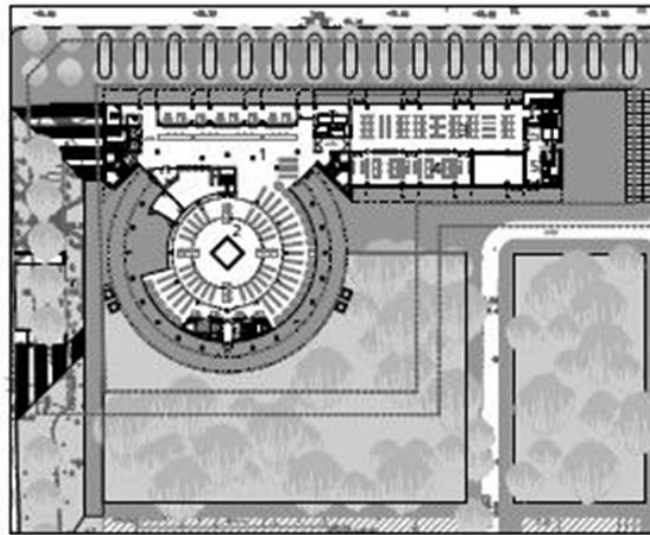
#### 4.5.4 Kai Feng Humanities and Social Sciences Library

Tsinghua University (Beijing, China)

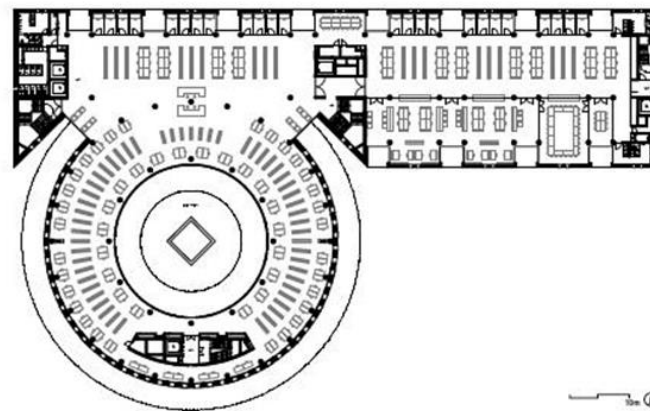
Table 7: Specifications of Kai Feng Humanities and Social Sciences Library (Lushington, et al, 2014)

Architect	Mario Botta (local architects: Ecadi, Shanghai)
Client	Shanghai Real Estate (Group) Co. Ltd., Shanghai Shentong Underground Railway Assets Mgmt. Co.
Completion	2011
Floor area	20,000 m <sup>2</sup>
Number of volumes	1.5 million
Seating capacity	1,000
<p>The Kai Feng Humanities and Social Sciences Library of Tsinghua University opened in 2011 on the 100th anniversary of the founding of the institution. Sited on the former imperial gardens of the Qing Dynasty in northern Beijing, Tsinghua is one of the leading universities in China. Renowned for research in sciences and engineering, it has earned the nickname, "MIT of China". Since the last decades of the 20th century the university has further developed a multi-disciplinary structure with the incorporation of 14 schools including the School of Humanities and Social Sciences.</p> 	

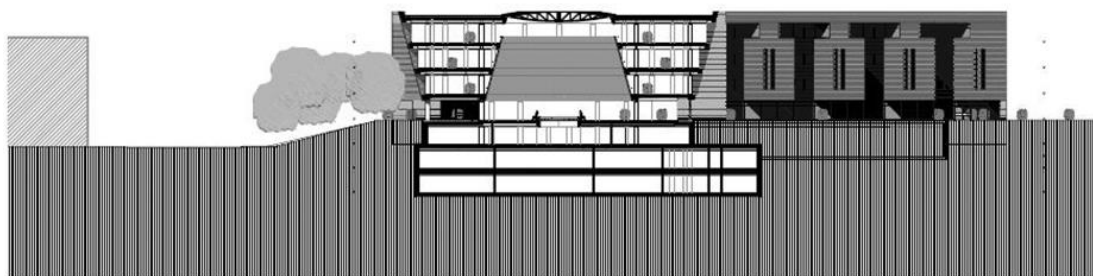




Ground floor



First floor



Section

Figure 21: Plans and Section of Kai Feng Humanities and Social Sciences Library (Lushington, et al, 2014)



Figure 22: Interior Photos of Kai Feng Humanities and Social Sciences Library (Lushington, et al, 2014)

Walls: in this library the main color is white, also some parts of this library wooded panels used as a walls for dividing spaces. Floor: all floor of this library covered by light grey granite. Ceiling: the most part of this library's ceiling which used by students is such as computer and reading room is glass, but, white is the selected color for other parts of this library. Analyses: Colors which are used in this Chinese university library totally are neutral colors such as white, light grey and wooden color.

#### 4.5.5 CINiBA (Centrum Informacji Naukowej i Biblioteka Akademicka)

##### Library

Uniwersytet Śląski (Katowice, Poland)

Table 8: Specifications of CINiBA Library (Lushington, et al, 2014)

Architect	HS99t
Client	Consortium of the University of Silesia and University of Economics
Completion	2012
Floor area	13.260 m <sup>2</sup> (GFA)
Number of volumes	340.000 (open collection): 460.000 (closed collection)
Seating capacity	460 (levels 3-1)

The Scientific Information Center and Academy Library, known by its Polish acronym CINiBA, was a joint project of the University of Silesia (Uniwersytet Śląski) and the University of Economics. It opened in 2012 and is located on the University of Silesia campus in Katowice, Poland. Founded in 1928 as part of the Institute of Education the campus is housed primarily in the former Teachers' Training College. In search of its own iconic presence, the university issued an international competition in 2002 for a new scientific research library, won by the redevelopment that reflects the prestige of the university in this city at the heart of the Upper Silesian industrial region. Koszalin architectural firm HS99. The 13,260 m<sup>2</sup> facility fulfills an objective to stimulate campus redevelopment that reflects the prestige of the university in this city at the heart of the Upper Silesian industrial region.



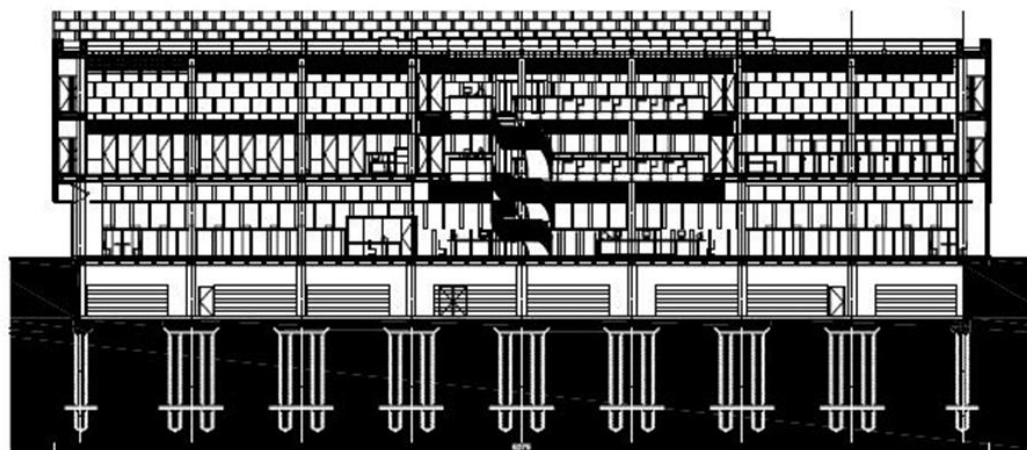
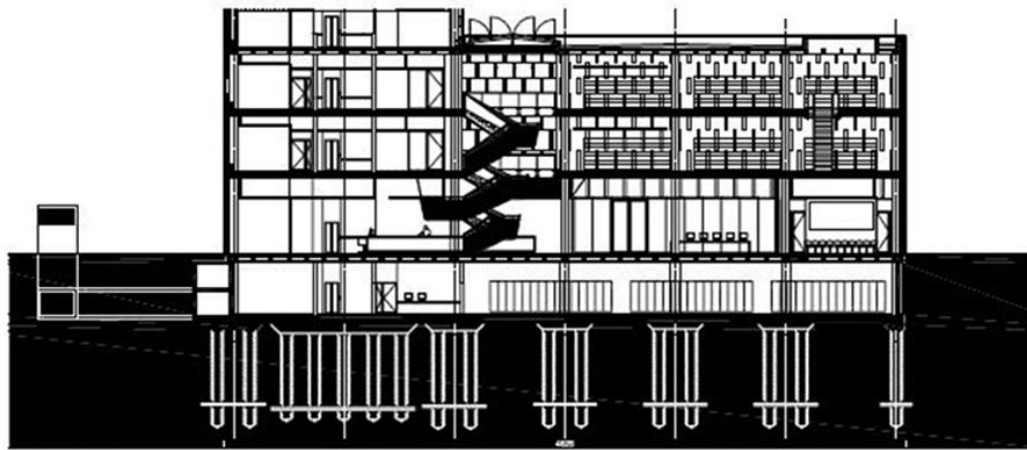
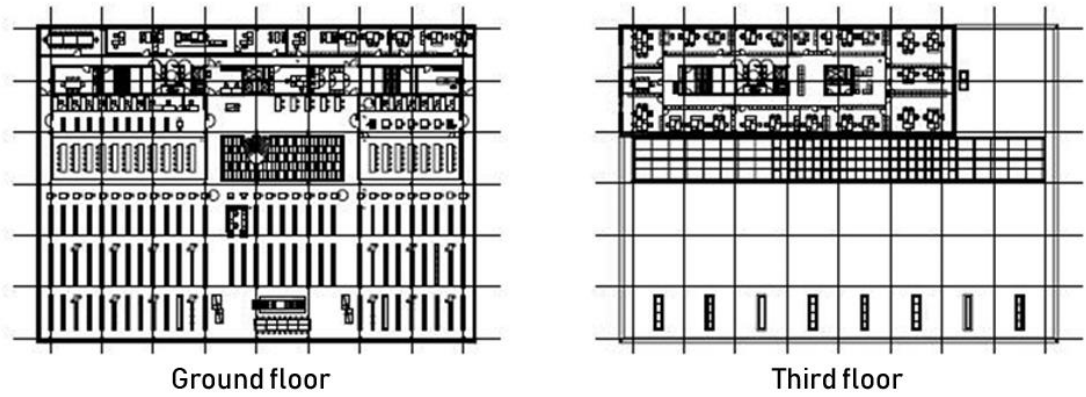


Figure 23: Plans and Sections of CINiBA Library (Lushington, et al, 2014)





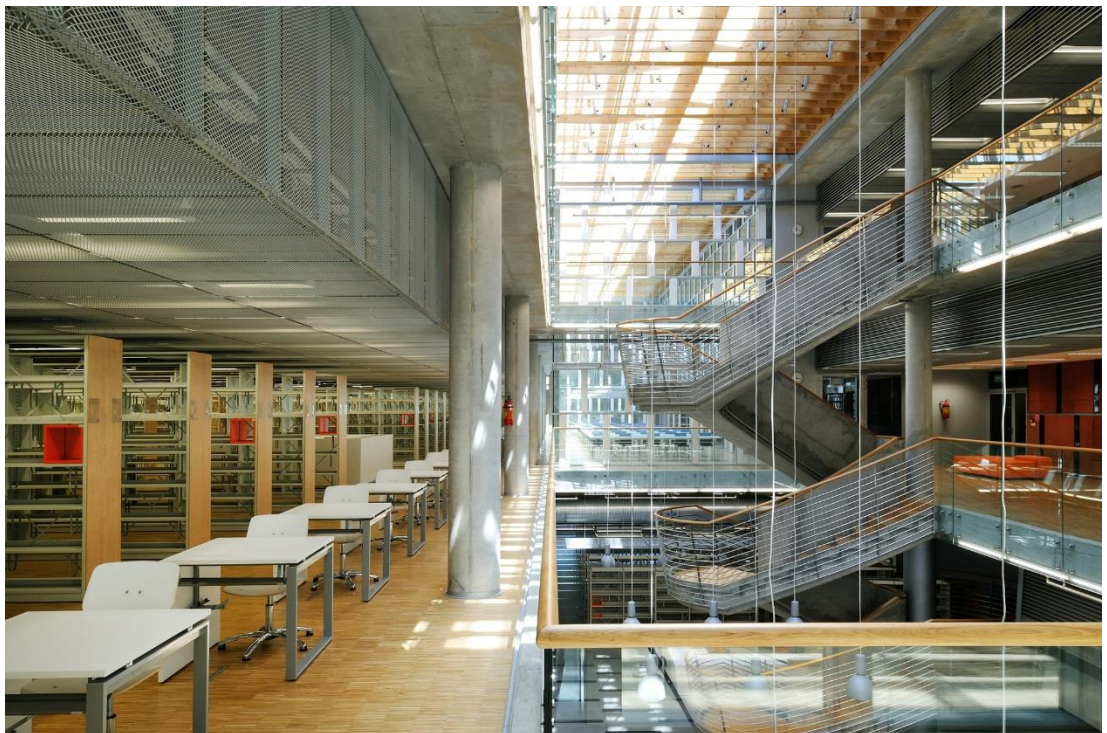


Figure 24: Interior Photos of CINiBA Library (Lushington, et al, 2014)

Walls: the majority of this library's walls seen in the color brown and light brown and white, also in some other walls of this library the color of light grey of cement to be seen (light grey). Floor: the color which is used in reading and computer spaces is light brown, whereas for entrance which located in the first floor the white color have be utilized. Ceiling: in ceiling of this library white color used, whereas some other



parts of ceiling of this library made by grey metal and glass. Analyses: the dominant colors which that seen in whole space of this library are neutral (brown, light brown and white).

## **4.6 Chapter Summary**

Chapter four is about the university library by starting a brief definition about public and university library and the importance of university library. Also, efficiency of library should be considered more important because of its specific function. In a smooth way it can be said, efficiency of campus library has a direct influence on average successfulness of a university students. For this reason, the majority of users who is going to campus library don't mean to spend their leisure time by study but, they are coming maybe for preparing themselves for something serious in a limited time like exam, presentation and etc. Thus, users may dealing with many malicious feelings like anxiety, losing awareness, stress and etc for many reasons such as not enough time, huge amount of contents should be read and more reasons. Naturally, for this task the environment of library is an important consideration. Also, campus library made many architectural spaces that in this chapter should investigate. Thus, for achieving the main goal of this study the convenient mental environment of campus library is a matter of fact that should be noted particularly. Among them library anxiety will described particularly that is more important than other negative human feelings. According to psychological effects of color, three positive effects on users in a campus library investigated. Finally, interior colors of five successful projects of university libraries have been chosen to survey.



## **Chapter 5**

### **CONCLUSION**

As color is mainly applied based on personal preferences and perceptions towards different emotions that they might evoke in every individual uniquely, it should be taken more seriously concerning areas of interior design, especially in public environments. Take apartments for example, a block of flats is constructed to house multiple individuals or families based on its capacity, thus incorporating every single tenant's attitude on color and their perception is absolutely far-fetched, hence the architect's preference or the investors' ideas speak first. With public places, and in this study academic libraries, the functionality of the space and the effectiveness and efficiency on the tasks performed inside this place, is of highly important matter. The psychology of people working in such areas can easily be stimulated by the colors which surround them. Therefore, many issues of real concern can easily be handled and many problems quickly eliminated if colors are chosen wisely. The level of energy in people, their satisfaction, their tendency to spend more time inside the space, the urge to go back to the space again and again, etc. simply lie in the interior design set up with true spirits of well-chosen color.

Color used in the interior elements of library's space such as ceiling, wall and floor, if not chosen according to psychological requirements of users in library can just bring fuel to this emotional fire. The library space must ignite such a soothing and calm feeling that actually helps the students deal with their difficult moments more

easily, reduce their anxiety, give them some peaceful moments so they can get their mind together and find ways and solutions for efficient use of their remaining time while having self-control and peace. A huge part of this can be done with color and how they are used. As previously mentioned in the literature review, many experiences have been done on places with certain functionalities such as hospitals, clinics and prisons. Surely, the same can apply to libraries. If blue or some cool colors are colors known and proved to reduce anxiety and stress, they can be the right color to be used wisely within library space to reduce students' nervousness.

Because design depends so much on hue or tones of color to create effects, simple rules are hard to articulate. Earth tones are generally seen as warming, while blues and greens are viewed as soothing. Wood as a neutral color which use in bookshelves, desks, chairs or other library furniture as natural materials provide another connection with nature and the "real world" outside the library. Stark black color scheme, which is making an oppressive space should be avoided.

Beside the cool color famous for their soothing effects, brown and white and their derived tones can also be a good choice for main interior elements (floor, wall and ceiling) as they are in the group of neutrals. Brown brings out the sense of comfort and white inculcates calm and peace, hence both contributing to the minimization of stress and haste and improving the psychological status of the users. Brown can be seen in the library via the library furniture (chair, desk, bookshelf and table) which made by wood.

The neutral cool color influence our mood in the best way so the use of neutral color can be very useful. The use of appropriate color can affect people's behavior, mood

and totally increase the efficiency of users in academic libraries. Also, according to table three yellow and orange are also good choice for utilizing in walls, floor or ceiling of university library's entrance.

With regard to library examples, it is obvious for the university libraries cool and neutral colors are the dominant choose of designers. On the other hand, for the public libraries among the cool and neutral colors red color as a warm color with the high level of attention seeking has be chosen.

The table four is a final result of this study which made by combination of table one which is generally about the psychological effects of color, and table three which is about psychological effects of color specifically on three main interior factors (wall, ceiling and floor) and how the cool and warm colors effects human psychology.

Table 9: Appropriate Choice of Colors for Interior Design of Library

	Wall	Floor	Ceiling
Reading room	white- light blue- brown- light brown- light grey	brown- light brown- light blue- light grey	White- light grey
Computer room	white- light blue- brown- light brown- light grey	brown- light brown- light blue- light grey	White- light grey
Office	white- light blue- pink- brown- light brown- light grey	brown- light brown- light blue- light grey	White- light grey
Entrance and security	white- brown- light brown- yellow- light grey- orange	brown- light grey- light blue- yellow- orange	white- light grey- yellow- orange

There is hint that after this conclusion should mention: According to table one all of color also can have some negative effects; so, the overuse of each color should avoided. For example, combination of these colors can be used in a smooth way for

wall, ceiling and floor of each space. Also, grey is tedious, lifeless and dreary color but when the purity of this color decreased and stay close to white the outcome is light grey which counted as a neutral colors that has no special effects.

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