Acknowledgement

I would like to express my gratitude first and above all to my respected and honoring parents, for giving me the strength and the will and the needed support to reach my dreams and go beyond my own clouds. I thank my brother and my two sisters for just being there to provide warmth support for me and to all my dear friends, the ones that kept me going through all the circumstances, and stood by me… and very special thanks to my teacher and my mentor Mr. Benfarhat Mohammed Laadaoui for giving me the needed space and the needed guidance to reach this level and explore my own abilities.

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General Introduction

0.1. Introduction

Through the times humans are the center of concern in the process of the architectural design, it always seeks to obtain the answers to the human needs and to satisfy every single sense we have. In order to conceive environments that are tailored to fit with humans desires and needs, for which we have to understand the different structural elements of the environment and the multiple parameters that can influence the nature of that environment.

First, we need to see the humans as a physical-psychological-intellectual being, that perceives, analyzes, understands and feels. In other terms we should treat this matter holistically by understanding the different areas of the human's life and the specific needs of its main function. The humans are closely connected to the space they live in and the space they walk onto, they are connected to the material and the immaterial components on their world, and by saying 'world' here we refer to the entirety of the human condition.

Viktor E.Frankl (internationally acclaimed founder of existential analysis) sees the human being as a tridimensional entity, consisting of body mind and soul. Meaning that the human beings always do react holistically, all three dimensions combined: physical, mental, and spiritual are always active participants in the relationship between humans and their environments. Different dimensions are consisted of: (Physical: Tangible and material components, biological and chemical processes that distinguishes the space. Mental: Emotions, feelings and moods, intellectual talents, instincts and habits. Spiritual: autonomous decisions and free will, material and artistic interests, ethical competences…) [1]

General Introduction

"Our bodies and minds are now closely tuned to its cycles and spectrum" [1],

"Architecture is the skillful, accurate and magnificent plays of volumes seen in light."

Le Corbusier

0.2. Resume

Light and color are crucial elements in our vision process and in our daily living experience. The totality of our world is perceived through light and distinguished and characterized by color. It's pretty obvious that we can't escape the reality that every space we go into has a different impression on us, a different emotion to trigger and a different living experience.

One must know clearly that every space is composed by physical tangible elements and other intangible ones that we can't touch but we can sense and feel. A space can differ from an other just by readjusting the intensity of light of the quantity of light or even changing the nature of the source of the light, for each one a different experience and a different impression. The same things for color tones, by using warm tones like red scientifically the blood pressure rises and the heart beats get a little bit faster just by being in a space that is dominated by the red. This is from a scientific perspective and by changing the colors in the same space the impression changes and the experience we live through that space changes too and subjectively.

Figure 1. Corbusiers church in Ronchamp. Detail of a window.

Figure 2. Colors circle source.

General Introduction

0.3. Statements

"Color is an integral element of our world, not just in the natural environment but also in the man-made architectural environment. Color always played a role in the human evolutionary process. The environment and its colors are perceived, and the brain processes and judges what it perceives on an objective and subjective basis. Psychological influence, communication, information, and effects on the psyche are aspects of our perceptual judgment processes. Hence, the goals of color design in an architectural space are not relegated to decoration alone."

By Frank H. Mahnke

Especially in the last eleven decades, empirical observations and scientific studies have proven that human-environment-reaction in the architectural environment is to a large percentage based on the sensory perception of color. These studies include the disciplines of psychology, architectural psychology, color psychology, neuropsychology, visual ergonomics, psychosomatics, and so forth. In short, it confirms that human response to color is total – it influences us psychologically and physiologically. [7]

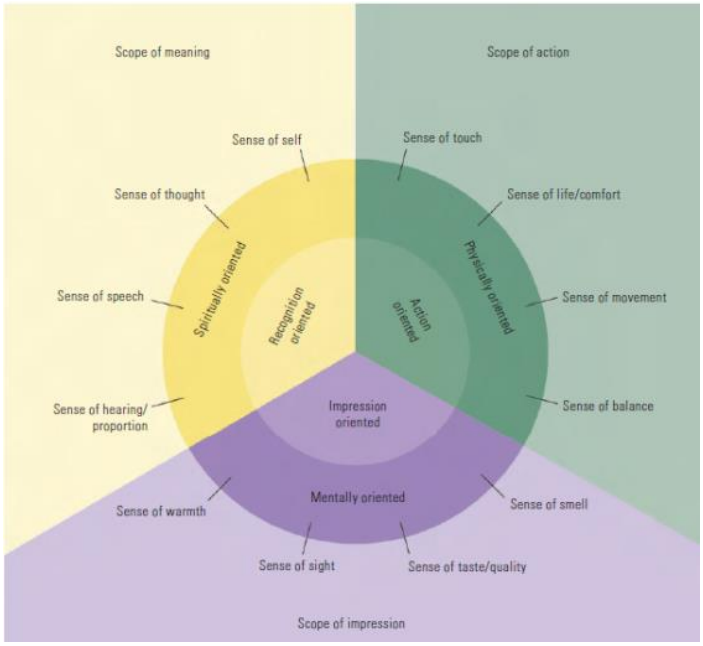


Figure 3. Spectrum of the senses.

"Light is of decisive importance in experiencing architecture. The same room can be made to give very different spacial impressions by the simple expedient of changing the size and location of its openings."

Steen Eiler Rasmussen – Architect

After taking a close look at these quote from the big Danish architect, we can understand that the light isn't just used to enlighten a space but to add an impression, changing the size, the

location and the shape of the openings will give us each time a different atmosphere around the space and a different light quality.

"Light belongs to the heart and spirit. Light attracts people, it shows the way, and when we see it in the distance, and we follow it."

Ricardo Legorreta – Architect

From this quote that belongs to Ricardo Legorreta (Legorreta is the first Mexican architect to win the Gold Medal of the American Institute of Architects, that is also known for his color using in architecture and his unique rich contrast hue palettes), we can understand that the light here is used as a guiding element, or as an element of attraction. By other means it does trigger the emotions and the spirit of the humans and affects on it by influencing its decision. [1]

Figure 4. Ricardo legorreta's house.

Sources: (legorretaarchieves.com/projects)

Figure 5. Ricardo legorreta - casa saphiro.

Sources: (legorretaarchieves.com/projects)

General Introduction

0.4. Research question

Starting from different points and from multiple researches we are trying to get closer to answer our main question about the relation between the light and color and the space or the environment we live in, and define on what levels it affects our space.

So what is the relation between light and color? And how can these factors change the impressions and the feelings that we have in that space?

0.5. Hypothesis

- Light and color are the main dominant visual components of the space, it draws the limits of the space and define its essence accordingly with its function and its nature.
- Light and color does trigger the emotions and the feelings of the occupants of the space by stimulating different chemical substances and hormones that does influence the mood and the humor the occupant.
- Different parameters about light and color: intensity, brightness, hue, contrast, dark, light...etc do play a major role in deciding the character of space.

0.6. Objectives

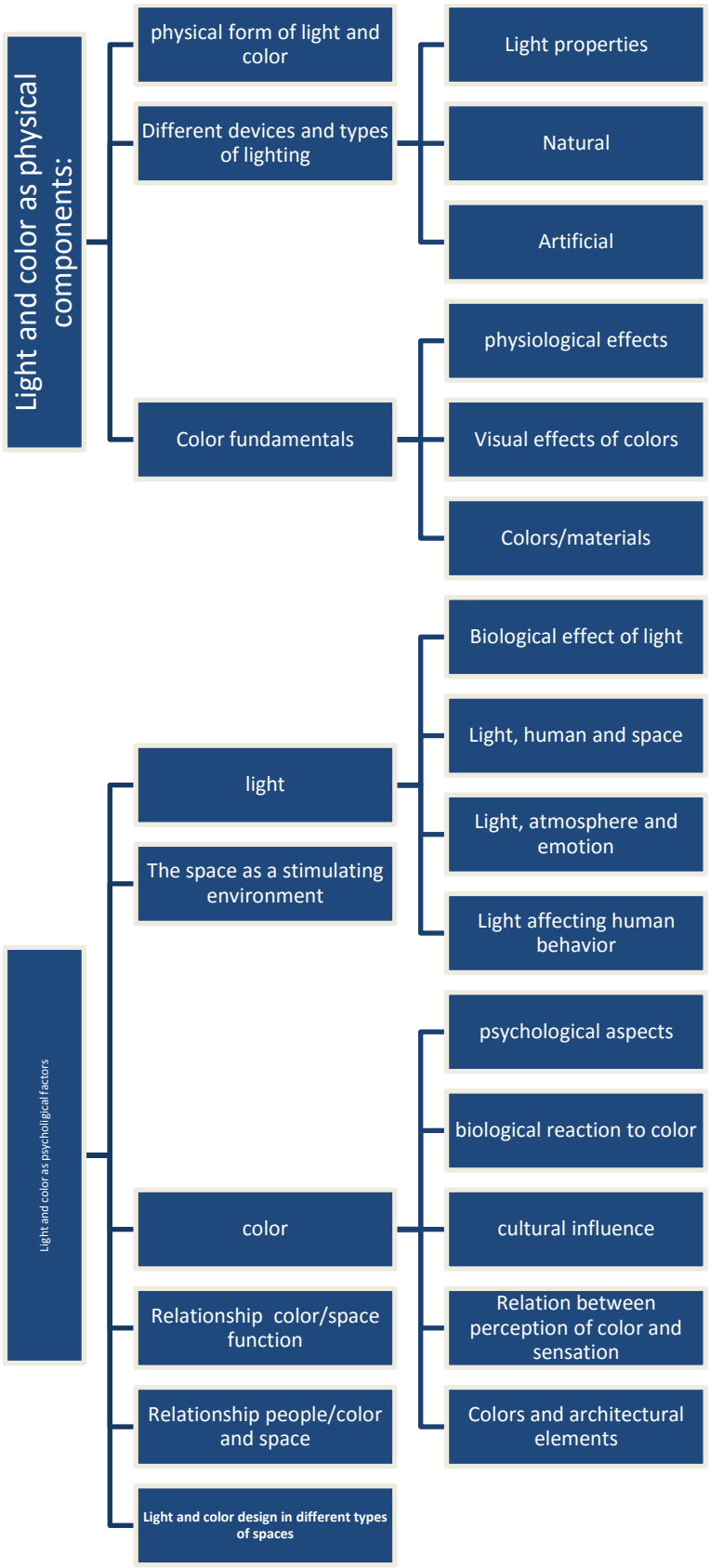
The main objectives of this work of research are:

- Define the major role of light and color in the space.
- Define the relation between light and color and the space.
- Define the influence of the different types of lights, and colors on conceiving the space and the nature of its function.
- Establish a list of different light parameters and color palettes and the emotions triggered by each type.

0.7. Methodology

There are a lot of book, journals, paper works, magazines and publications that does talk about this architectural matter in many different approaches, this research will be based on reading and analyzing these works, analyzing the results of some experiments and collecting the needed information and answering the questions that we came to ask.

General Introduction



General Introduction

0.8. Thesis structure

This work is composed from:

- General introduction
- Chapter I: Light and color as physical components
- Chapter II: Light and color as psychological components
- Chapter III: Study of examples and articles.
- Chapter IV: The design process of the project

Chapter I:

Light and color as physical components.

Light and color as physical components

1.1. Physical form of light and color

1.1.1. Light and color

Light and colors are complementary and inseparable partners in the process of vision and perception. Together with the perception of the physical form, they become part of the overall picture. As with colors and its effects on the human organism, light is also associated with many disciplines and fields, and the interrelated effects are highly complex. It touches on psychology and physiology, biology and visual ergonomics, medicine and chemistry, electrical engineering and physics; it plays a role in architecture and is synthetically linked with the perception of sound, and directly or indirectly with climate. Light occurs naturally in the form of sunlight, but there are also many different artificial light sources.

Natural sunlight represents the entire visible spectrum of electromagnetic radiation from approximately 380 to 780 nanometers. The quality of light in a given space depends on the relationship between its area and the size of the opening permitting light to enter, the location of the light source, its location in relation to the points of the compass, the distribution of light in the space, as well as the atmospheric conditions. [6]

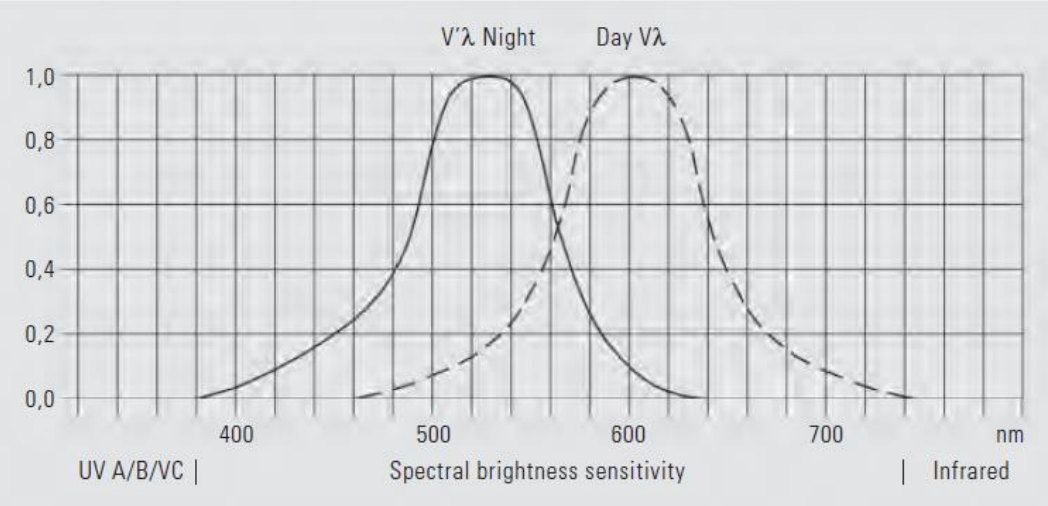


Figure 6. Spectral brightness sensitivity.

Light is the most important quality in the interaction between people and their environment. During the course of the day, the angle of light changes, which changes its quality, and ultimately the way in which it is perceived. The plastic qualities of a given space, the quality of hue and color nuances also change with the time of day. With the advent of conscious ecological

planning, sunlight is becoming increasingly important as a source of light for workplaces and for spaces with particular dimensions. At the workplace, biological sources of full-spectrum light are receiving increased attention. In wide, high, or deep spaces, systems to channel light or direct it with lenses can allow a longer use of sunlight and thus decrease the amount of artificial light needed.

Figure 7. Spectrum at the Goethehaus at Weimar.

Artificial lighting units are only good if all possible interactions are considered during planning and installation. Very often, however, planning is limited to purely technical and economic aspects, making the artificial lighting systems deficient and unsatisfactory both in terms of their design and physiologically. The reasons for this include:

- Faulty lighting is seldom consciously perceived.
- Adverse effects are usually registered very slowly and after a time lag.
- Complaints are often general and not related to the light.
- Energy-saving measures in lighting units often result in a loss of quality in color rendering properties.

1.1.2. Technical basis of lighting

Four basic terms are encountered in the evaluation of artificial light and the planning of lighting units:

- Luminous flux (measured in lumen, lm)
- Luminous intensity (measured in candela, cd)
- Illuminance (measured in lux, lx)
- Luminance (luminous density, measured in candela per square meter, cd/m^2)

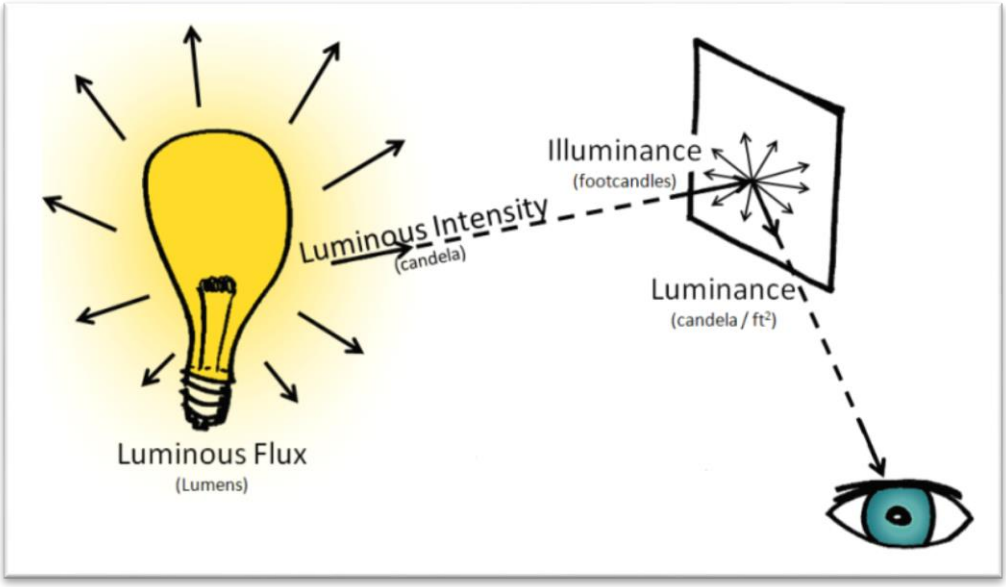


Figure 8. Lighting units.

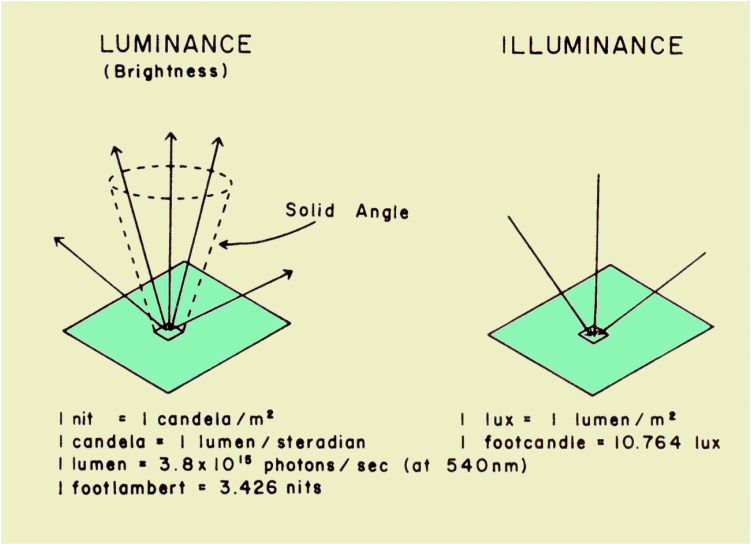


Figure 9. Luminance and Illuminance units and measurement.

Illuminance measures the luminous flux that falls on the surface of an object or a space. Illuminance is still used today as the foundation for most light planning, but it is not in fact a measurement of perceived brightness.

Luminance (luminous density) is the only measurement that describes the perceived brightness of a surface. The effect and the visual impression produced by a particular lighting unit can only be assessed by evaluating all the luminance values in a given visual field. Luminance measures the light reflected or emitted from a surface as perceived by the human eye.

This is based on the assumption of a flat, diffuse surface. The following table lists luminous efficacy of a source for various light sources (see Table1).

Tableau 1. Average luminous efficacity values for different types of light sources.

Basic light bulbs	10–15 lm/W
Halogen lamps	10–25 lm/W
Fluorescent lights Up to	105 lm/W
Compact fluorescent lights	50–75 lm/W
Metal halide lamps	60–90 lm/W
High-pressure sodium lamps	50–130 lm/W
High-pressure mercury vapor lamps	60–70 lm/W
Light-emitting diodes	15–30 lm/W

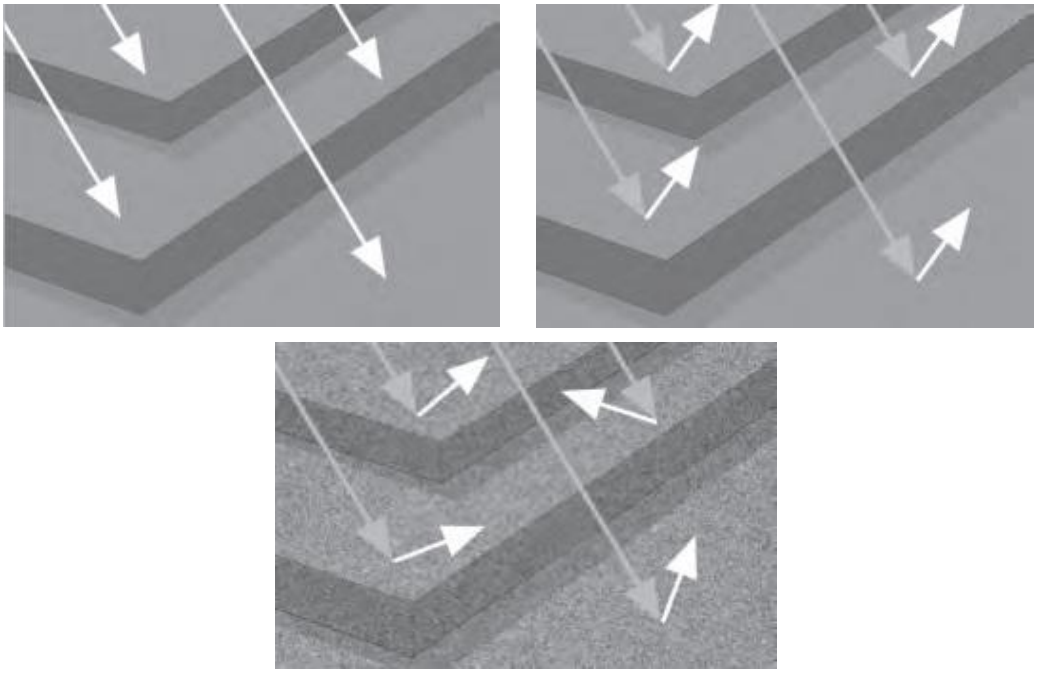


Figure 10. Illuminance, Luminance and defuse reflectance according to material properties.

1.2. Different devices and types of lighting

1.2.1. Light properties

Various aspects of the environment which affect the interior appearance of buildings have been identified in the introductory chapter, and it is the purpose here to illustrate these aspects in more detail.

1.2.1.1. Light variety

Perhaps the most obvious and certainly the most important aspect of day lighting is its capacity for change, leading to the infinite variety in appearance of the daylight interior. Change

is at the heart of day lighting, the human body has a capacity for adaptation, particularly in vision, and the need to exercise this response. [2]

Figure 11. Kaap Skil, Maritime and Beachcombers' Museum, Winner of the Daylight Award 2012.

Image Courtesy of Mecanoo Architecten source (deezen.com).

Figure 12. Gregory Halpern for Daylight Architecture news.

source: (deezen.com).

Then there are the changes associated with changes of the weather; from bright sunny days to dark and cloudy or rainy days, there is little doubt that the human spirit soars when rising in the morning on a bright day, an experience which is less likely to happen when it is dark and gloomy outside.

Closely associated with changes in the weather are those of the changes of season, from the winter snows to summer sunlight; each season will have its own character, which as human beings we accommodate to in our own way; but what is important is that the world outside, as

experienced through the window, provides necessary information of the variety of the exterior world; whilst leading to subtle changes in the appearance of the interior.

1.2.2. Light modelling

The modelling of the shape of light derives from its original physical form, whether it's round, square or otherwise, married with the way in which light plays on its surface. This is referred to as it's modelling and when this derives from daylight or sunlight, giving light from a single direction, this provides a form which perceived by the eye as having meaning, unambiguous. [2]

Figure 13. Cathedral Ronchamp, Le Corbusier, interior Window.
source: (architecturalarchieve.org.com) .

This is a different experience again from the form of an object or space resulting from a room lit by artificial light, where the overall light may be received from a multitude of light sources. The most usual daylight modelling is that derived from vertical windows at the side of a room, giving light from a single direction; this may be helped by windows from an adjacent wall which adds to the modelling; as the light will still be from the same overall direction, but adding to the total modelling.

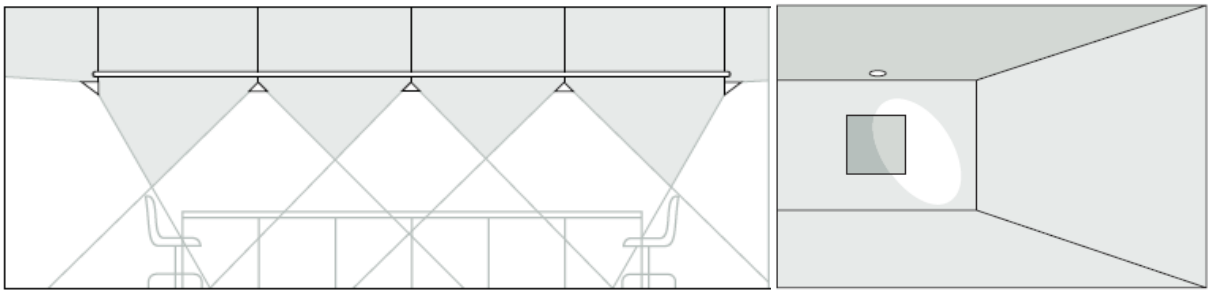


Figure 14. Artificial light distribution source: (zumtobel.com/culture).

Daylight by its nature gives meaning and aids our understanding of a shape or space by its directional flow; a meaning which is emphasized even further by the addition of direct sunlight. Interior spaces are judged to be pleasant, bright or gloomy as a result of the effects of modelling and interiors are judged by the way in which the spaces and the objects within them are seen during the day to be natural, or accord to our experience of the natural world. [11]

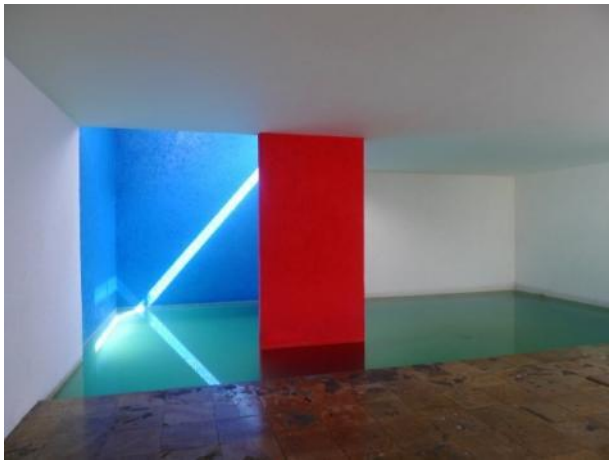


Figure 15. Casa Gilardi, Luis Barragan light reflection source: (archdaily.com).

1.2.3. Orientation

The importance of orientation in a building must be considered at the outset, when the architect is planning the location of the building on the site, the aim being to ensure the maximum availability of useful natural light and sunlight to the interior.

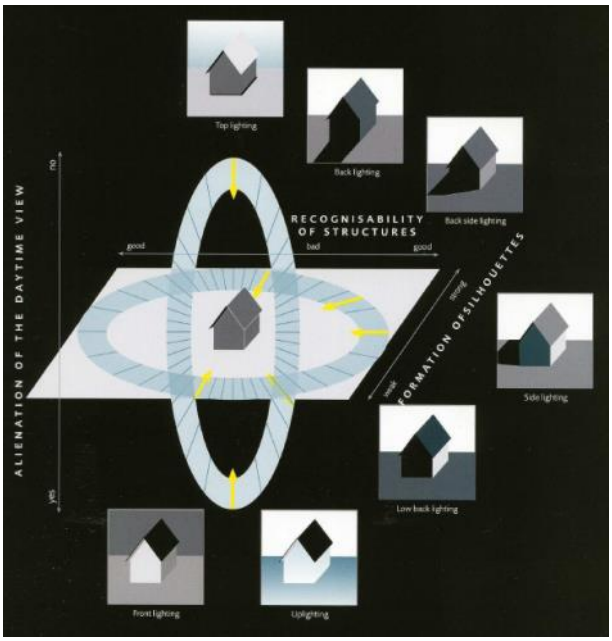


Figure 16. Solstice and sun path, orientation.

Another aspect of orientation and one where the mere presence of day lighting is reassuring, is the subconscious desire of people when inside a building to keep in touch with the outside world, whether to know the time of day or the nature of the weather.

1.2.4. Sunlight effect

The impression of sunlight is also important seen from windows which themselves admit no sunlight, but where the view of a sunlit landscape or buildings may be enjoyed. Whenever sunlight is available there is a strong desire to perceive it, and disappointment when it is unnecessarily excluded.

1.2.5. Color

While the color of daylight will vary from morning to evening, and with changes in the sky and weather patterns, it is always regarded as the reference by which color is judged . . . daylight is regarded as ‘real color.’ In early stores, voids were opened in the roof to admit daylight to sales areas below; whereas for some years this was ignored. There were several reasons for this, not least being that it was considered that means of artificial light were more suitable for display, to show off the goods ‘in a better light.’ [2]

Figure 17. Gray sky, MENOSEMAIS_JMR.

Figure 18. Blue sky, Casa de artes source: (archdaily.com).

1.2.6. Importance of view

The content of a view is clearly of importance, and it is the information it provides which will determine its success. A view out to a blank wall may be better than nothing but a view out to open countryside, or a garden will be a different order of experience. [1]

Figure 19. Visual arts center, nl-serreria.

Figure 20. 14Concourse at Abu Dhabi Airport. Artificial lights.

The quality of the exterior view will depend on the surroundings of the building, and the height at which it is experienced, but it is of importance that where a view is available it should be exploited. There will be instances in large building complexes where internal views from one part of the interior to another may be had; these will provide the visual rest centers to satisfy the physiological requirement, but unless there are views today-lit areas they will lack the amenities of change, variety and modelling which inform the natural scene outdoors.

1.2.7. Architectural devices of natural lighting

Natural lighting is always seen as the most used and the major type of lighting the space, through ages we did develop many ways to attract or let the sunlight get inside our living spaces, and he did create several techniques and strategies such as:

1.2.7.1. The window

The window is an opening in a wall or side of a building admitting light and often air to the interior. Early windows were developed before the introduction of glass, so initially windows were left open to the external atmosphere, or filled by some form of closure to minimize the heat loss at night. The more sophisticated buildings would have had thin slabs of marble, mica or oiled paper for this purpose with time the window did evolve and took many shapes, functions and materials with the industrial revolution.

1.2.7.2. Roof lights

The roof light by definition permits daylight to enter from above through a glazed opening in the roof protecting the interior from wind and weather. The early roof lights were perceived either as domes with ordinary windows in the sides allowing in the daylight, but by the nineteenth century structural techniques had developed sufficiently to allow fully glazed barrel vaults or glazed domes to be placed above areas of building remote from the side walls and the proximity of windows. Examples of nineteenth century shopping malls still exist today where these overhead lights permit daylight to reach deep into the interior of buildings.

Figure 21. Steven Hall architects, Visual arts center, interior workshop windows.

Source: (archdaily.com).

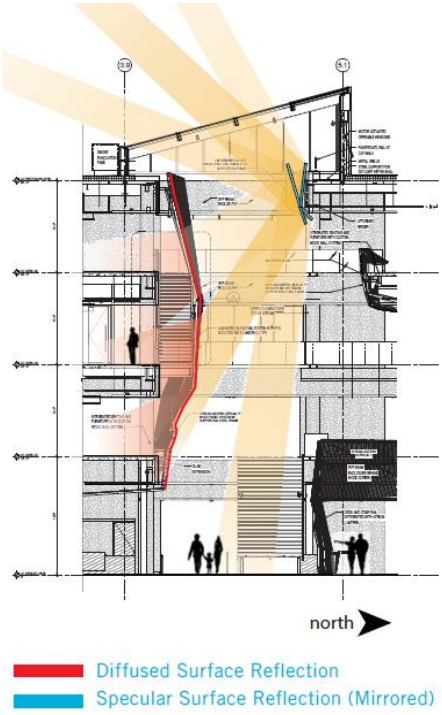


Figure 22. Reflected day lighting party.

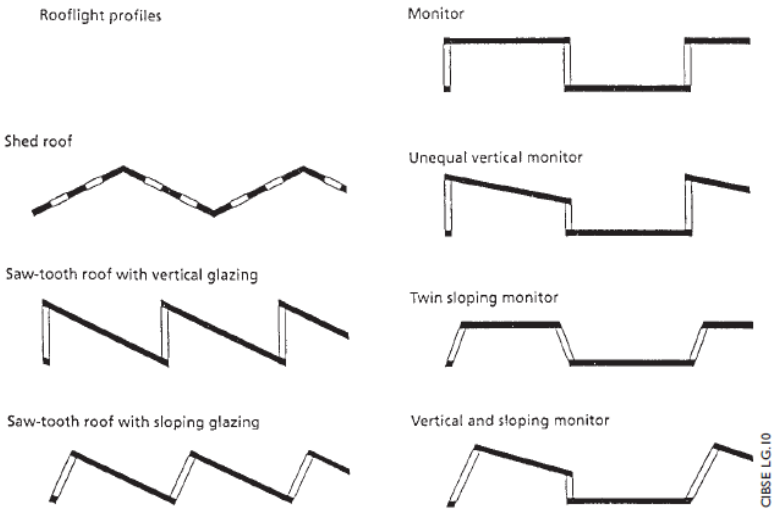
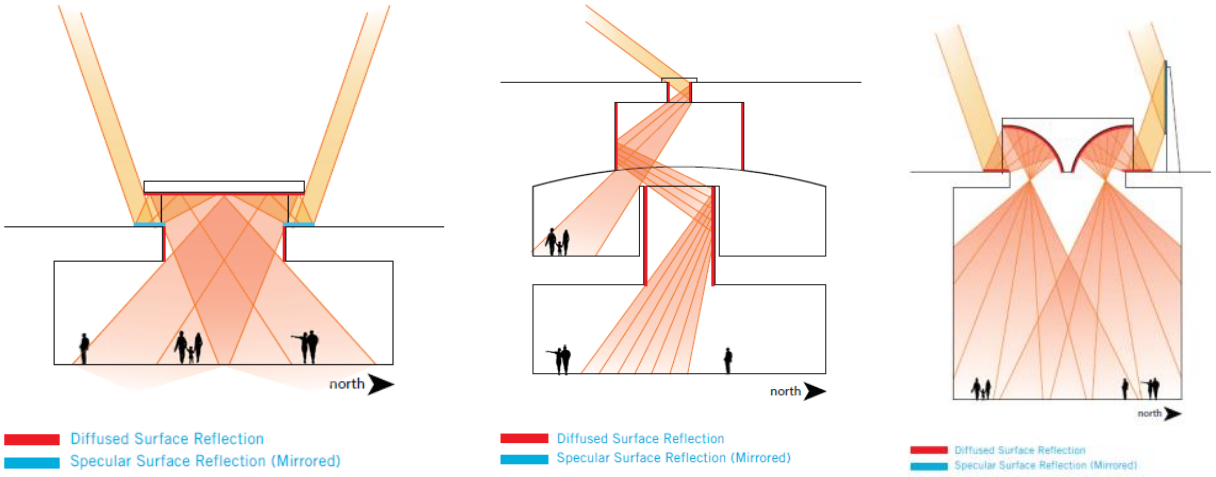


Figure 23. Different roof types. UMass Lowell University Crossing.



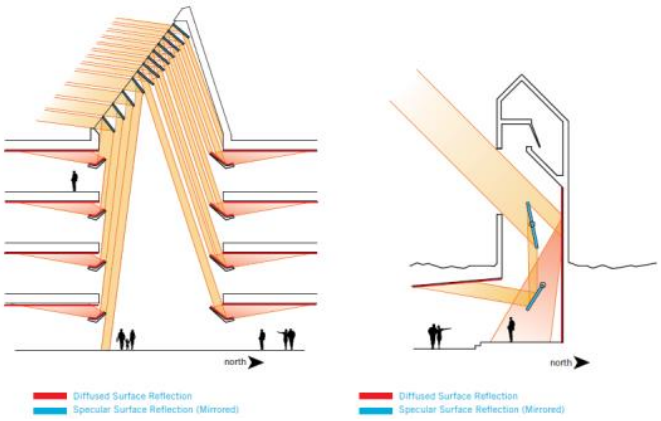


Figure 24. Schemes showing different reflective strategies of natural lighting.

1.2.7.3. Atriums

The atrium is therefore a further development of the dome or vault allowing daylight into the central areas of the great houses. The modern atrium will be covered by a glazed skylight, which, whilst slightly reducing the amount of daylight, monitors the external atmosphere keeping out the rain, whilst contributing to ventilation, and reducing the necessity for air-conditioning.

Summarizing the advantages of atrium design:

- **First**, the human advantages: by getting daylight into the center of deep plan buildings, this provides the occupants with a sense of orientation, information on the time, weather and the world outside the building.
- **Second**, the environmental advantages: there is a potential for savings of energy, assistance with the problems of ventilation, and a reduction in the need for air-conditioning. [1,2]

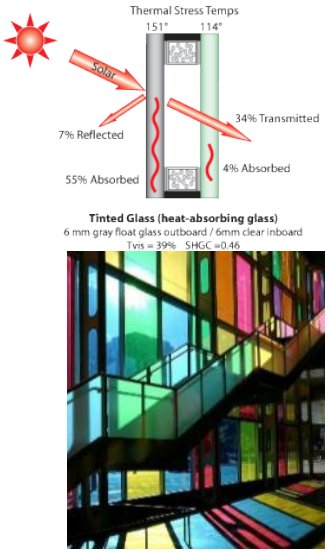
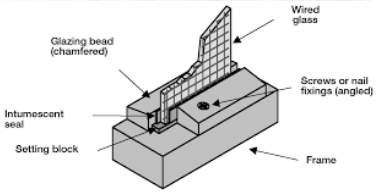
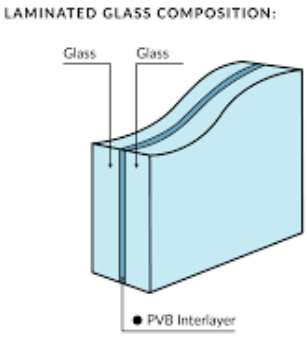
Figure 25. central atrium source: (Daylighting: Natural Light in Architecture, Derek Phillips, 2004.).

1.2.7.4. Glazing

There is now a large amount of alternative glazing for windows, and it is necessary for the architect, in conjunction with his services consultant, to write a detailed performance specification; this must include the orientation of the window, its thermal and acoustic characteristics, together with its capacity for solar shading.

Tableau 2. Different types of glazing.

Type of glazing	Definition	

Clear Glazing	High transmission of daylight, will at the same time and on certain building façades allow a high transmission of solar radiation. High transparency level and to visual continuity	
Tinted Glass	This is of two types: the first where the clear glass is itself modified in such a way as to produce different radiant heat transmission characteristics, therefore the thicker the glass the lower the transmission of daylight, and the greater the control of radiant heat from sunlight. The second type of glasses are those coated with microscopically thin layers of metallic oxides which reflect the heat away and out of the building. These coatings are applied to the inside layer of glass generally in association with other panes in a sealed double glazed unit as a protection, since on their own they would be vulnerable to damage.	
Diverse Glazing	**Patterned glass:** Any number of patterns can be rolled into semi-molten glass, to provide decorative or diffusing sheets for various purposes, though rarely for windows, since their capacity for light transmission will be modified. **Wired glass:** A similar process is used for the manufacture of wired glass, where a wire mesh is sandwiched within the thickness of the glass. This used generally in security situations, and sometimes as a protection to vulnerable skylights. **Laminated glasses:** Similar methods of manufacture are used for laminating sheets of plastic between sheets of glass, again used for security reasons as resistance to impact. These reduce the transmission of daylight. In museums where exhibits are exposed to daylight, it will be necessary to control the entry of UV light. This may be done by the use of laminated glasses, where UV absorbing filters can be laminated between the sheets of clear glass.	  

1.2.8. Innovative day lighting systems

Of the various methods none can be said to have achieved a universal application, but each has a specific use and is worthy of mention.

1.2.9. Mirrors

There are many ways in which the interaction of light or sunlight with a mirrored surface can be used for reflection. From the use of a large hand-held mirror to throw light into the dark recesses of a renaissance church for the delight of visitors, to the fixed mirrored louvres which may be related to vertical windows, installed to direct light upwards to a ceiling; alternatively there are those which, when related to glazed openings in a roof, can project light downwards to the interior.

Figure 26. Central United Methodist Church,Milwaukee, Wisconsin.

1.2.10. Prismatic glazing

The principle is to use methods of refraction of light, rather than reflection. Whilst this method can be applied to vertical windows, they are perhaps more successful when associated with systems of roof-light, sunlight is refracted away from the occupants to eliminate glare, whilst allowing daylight to the space below. As these have only a limited application they are expensive.

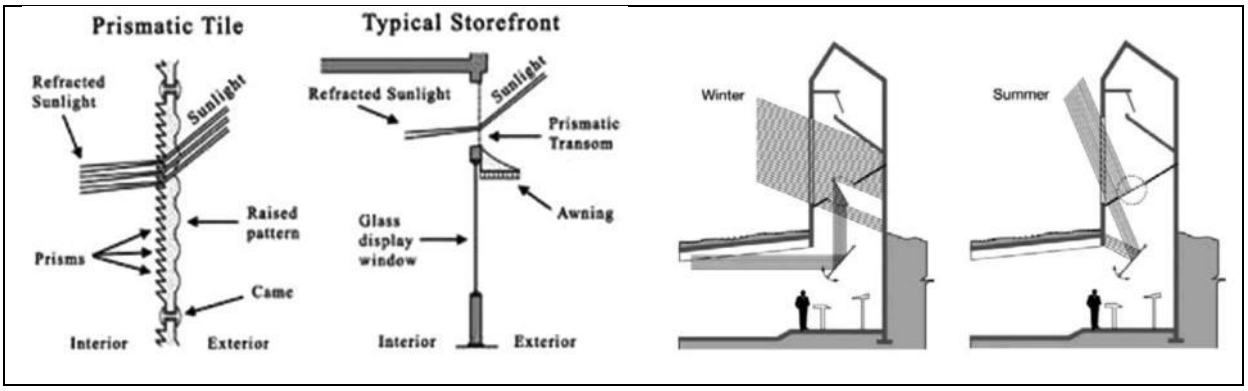


Figure 27. Prismatic glazing/simple store front example comparing.

Sources: (Daylighting: Natural Light in Architecture, Derek Phillips, 2004.)

1.2.11. Light shelves

It is possible by means of comparatively inexpensive building construction, to provide light shelves. These have already been mentioned in terms of solar shading, but they are useful also to provide a view window below the light shelf, with the light above reflected to the ceiling to redistribute daylight further into the room.

1.2.12. Light pipes

Of all the methods of innovative day-lighting, the light pipe has had the most universal application. It is basically a method of roof-lighting, which by means of association with reflective tubes, directs the light to a lower level. Whilst it can be employed to direct light through several floors, this has the disadvantage of locating the pipes through the upper floors, taking up useful floor space.

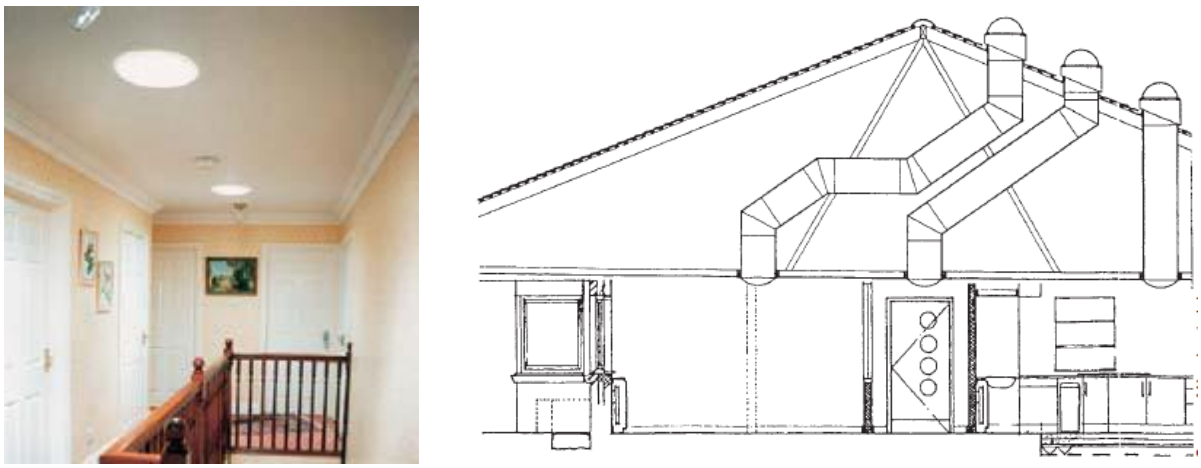


Figure 28. Section illustration the passage of light pipes.

Sources: (Daylighting: Natural Light in Architecture, Derek Phillips, 2004.)

1.2.13. Artificial lighting

CHAPTER-I- Light and color as physical components

Artificial lighting was found out long ago in the human history, and the artificial light sources are the ones that provide light without the sun or the use of solar light. The story began when the flame, the source of light, was separated from fire, the source of warmth - burning branches were removed from the fire and used for a specific purpose. It soon became obvious that it was an advantage to select pieces of wood that combust and emit light particularly well, and the branch was replaced by especially resinous pine wood. The next step involved not only relying on a natural feature of the wood, but, in the case of burning torches, to apply flammable material to produce more light artificially.

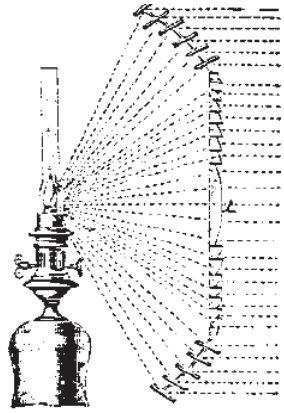


Figure 29. A section and picture beacon with Fresnel lenses and Argand lamp.

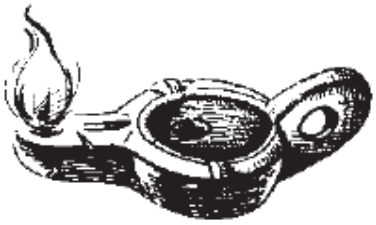


Figure 30. Illustration of a Greek oil lamp.

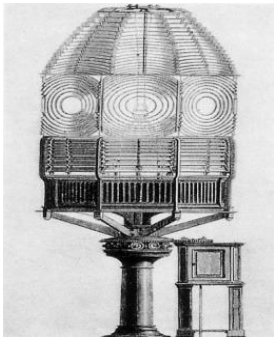


Figure 31. Photograph of typical light-pipe installation.

Incandescent gas light was doomed to go the way of most lighting discoveries that were fated to be overtaken by new light sources just as they are nearing perfection. This also applies to the candle, which only received an optimized wick in 1824 to prevent it from smoking too much. Similarly, the Argand lamp was piped at the post by the development of gas lighting, and for lighting using incandescent mantles, which in turn had to compete with the newly developed forms of electric light.

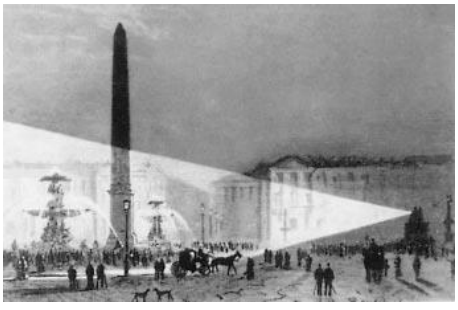


Figure 32. Arc lighting at the Place de la Concorde.

CHAPTER-I- Light and color as physical components

After just a little while the lighting industry did a quick revolution in the inventions and the development of artificial lighting to electrical sources the electrical lamps started to appear and take lead of the field of the architecture.

Figure 33. Theatre foyer lit by Moore lamps.

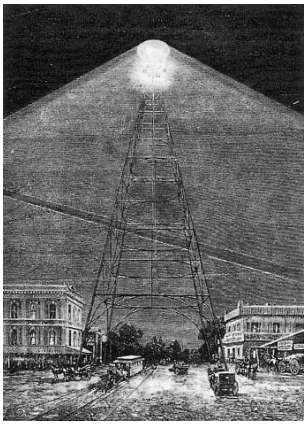


Figure 34. American light tower (San José 1885).

Buildings created up to the beginning of the Second World War were therefore characterized by what is, in part, highly differentiated exterior lighting. All this, however, made little difference to the trend towards quantitative, unimaginative interior lighting, involving in the main standard louvered fittings.

*In order to develop more far-reaching architectural **lighting concepts**, man had to become the third factor alongside architecture and light. **Perceptual psychology** provided the key. In contrast to **physiological** research, it was not simply a question of the quantitative limiting values for the **perception of abstract "visual tasks"**. Man as a perceiving being was the focus of the research, the question of how reality perceived is reconstructed in the process of seeing. These investigations soon led to evidence that perception was not purely a process of reproducing images, not a photographing of our environment. Innumerable optical phenomena proved **that perception involves a complex interpretation of surrounding** stimuli, **that eye and brain** constructed rather than reproduced an image of the world around us."*

Handbook of Lighting Design, Harald Hofmann

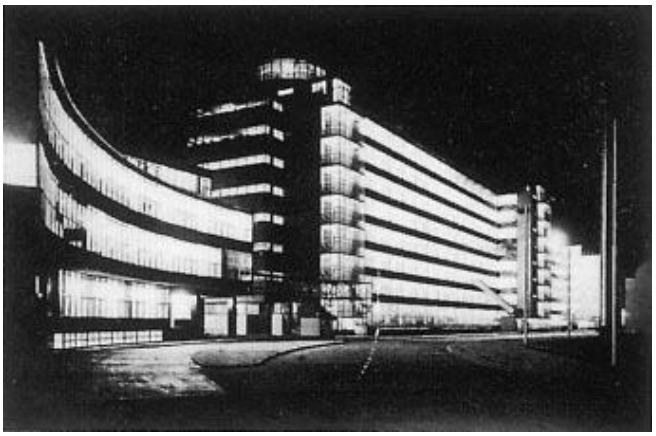


Figure 35. Brinkmann, L. C. van der Vlugt and Mart Stam: Van Nelle tobacco factory, Rotterdam 1926–1930.

So after reading this, we can see the evolution of the artificial lighting was the consequence of many factors not only economic or functional, it evolved to more philosophical concepts or even technical matter. The artificial lighting techniques are different strategies of light distribution and different configurations on the installation depending on the function of the space. We site different types and configurations of exhibitions spaces:

Figure 36. Artificial light effect.

Source: (tumblr.com)

1.2.14. Room lighting

Lighting for exhibition rooms in museums is made up of diffuse and directional light. The relative amounts and resulting mix of the two types of light determines the harshness of the shadows cast by picture frames and the three dimensional impact of sculptures and spatial objects. The diffuse and directional light mix also defines the overall impression made by the room.

1.2.14.1. Diffuse lighting

Diffuse lighting illuminates room zones or objects from a surface that radiates light in all directions. At the site of illumination, i.e. in the room zone or at the object illuminated, the direction from which the light comes cannot be clearly determined: the light flowing into the room and over the objects is not directional. Where it comes from very many directions, i.e. where the radiant surface is large, the lighting produces little or no shadowing. [7]

1.2.14.2. Directional lighting

Directional lighting is generated mostly by punctual light sources – i.e. lamps that are small in relation to the lighting distance – or spots of similar design. The light falls directly onto the object illuminated, striking it, or parts of it, at an angle defined by the geometry of the lighting arrangement. Where the surface of the object is uneven, clearly defined shadows occur. These enhance the visual impact of three-dimensional surfaces but can also be a source of visual interference if they are too dominant or too large. [7]

Figure 37. Diffuse lighting in exhibition.

Figure 38. Directional lights on objects.

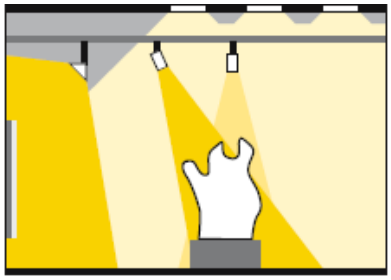


Figure 39. Supplementary directional lighting for objects in the room.

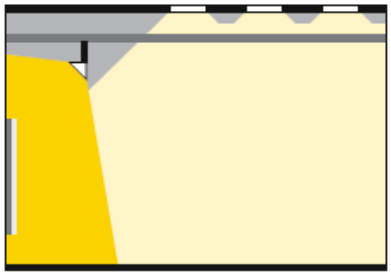


Figure 40. Directional lighting for the wall, diffuse lighting for the room.

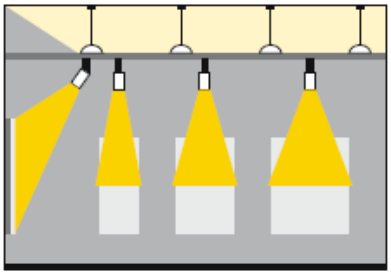


Figure 41. Indirect and direct components produce diffuse and directional lighting respectively.

The most important lighting systems used in exhibition rooms are:

- Luminous ceilings with opal glass enclosure (diffuse light) or satinised and textured glass (diffuse/ directional).
- Indirect luminaires (diffuse).
- Cove luminaires (diffuse).
- Wall washers (directional or diffuse/directional).
- Spot lamps.

1.2.15. Luminous ceilings

The idea of luminous ceilings stems from a desire to imitate daylight. Luminous ceilings deliver light which is particularly suitable for painting galleries predominantly diffuse with an opal enclosure, partly directional with enclosures of sanitized/textured glass. The heat that is generated in any luminous ceiling needs to be dissipated or extracted.

Luminous ceilings imitating natural daylight need to deliver a high level of luminance: 500 to 1,000 cd/m^2, ranging up to 2,000 cd/m^2 for very high-ceilinged rooms. Luminous ceilings are especially suitable for interiors with 6 meter ceilings or higher. [2]

1.2.16. Indirect luminaires

An impact similar to that of a luminous ceiling is achieved with indirect light bounced off the ceiling and upper wall surfaces into the room. This diffuse, uniform light is predominantly used in rooms where no daylight enters. It is produced by suspended luminaires radiating light upwards.

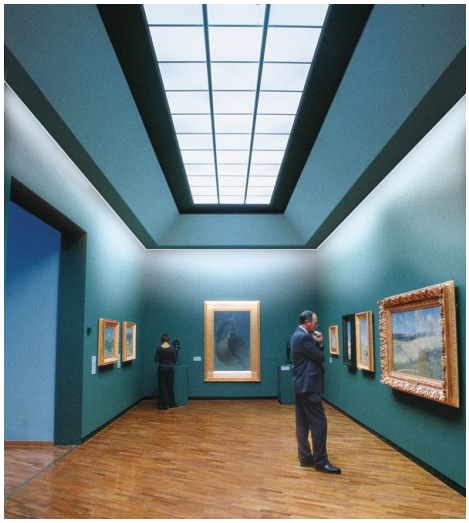


Figure 42. Luminous ceilings in an art gallery..

Figure 43. The similar impact of the indirect luminaire to the ceiling lighting.

1.2.17. Wall-washers

Wall washers are used as individual luminaires or in continuous rows. Installed flush with the ceiling (or with kick reflector protruding from the ceiling) or mounted close to the ceiling, they should illuminate the walls as uniformly as possible. This task is performed by reflectors with asymmetrical optics.

1.2.18. Spot lamps

Reflectors in reflector lamps (used in luminaires with no reflector) or spots direct most of the light emitted by punctual light sources in a defined beam direction. Spots and down lights with spot characteristics can be fully or partially integrated into a ceiling (or wall) as recessed ceiling spots.

1.2.19. Flexible lighting

The general – diffuse – lighting takes little account of the positioning of exhibits. The flexibility of the system depends on the directional lighting. Particularly suitable solutions here are furnished by power track systems, in which swivel able, rotatable spots can be snap-mounted at any point.

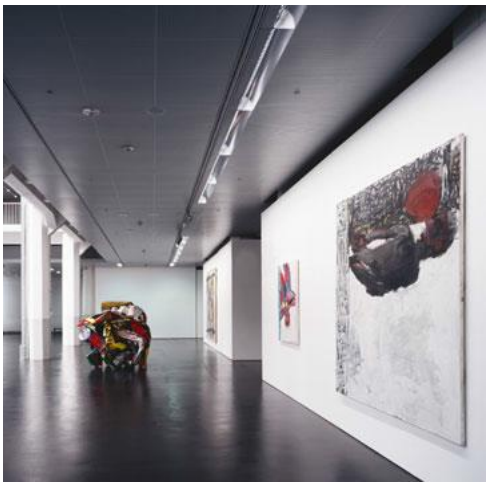


Figure 44. Wallwashers distribute their light asymmetrically.

(source: Archdaily.com)

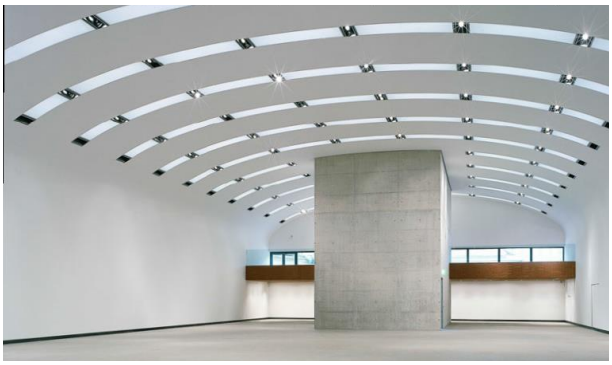


Figure 45. The light of the gimbal mounted spots is focusable.

1.2.20. Realigning luminaires

The luminaires of a flexible lighting system need to be realigned for each new revolving exhibition – if necessary by experimenting and repositioning exhibits. This invariable calls for the use of ladders and steps. For inaccessible locations, remote control spots are the right answer.

1.2.21. Mobile spots

Where mobile partitions are used for presentations, mobile spots fastened to the partitions by clamps or screw mountings are an alternative to spotlights on power track. So that power cables to spots do not present a tripping hazard, rooms for revolving exhibitions should be provided with power points in the floor.

1.2.22. What kind of light has what impact?

Basically speaking, the impact of any change on these relatively small exhibits is the same for large scale pictures and objects. The only difference is that they need more light: higher power lamps or greater numbers of spots need to be used for illuminating large objects. A very large object, such as a car or a plane, can also be illuminated from several points. This makes for striking visual impact from various viewing angles.

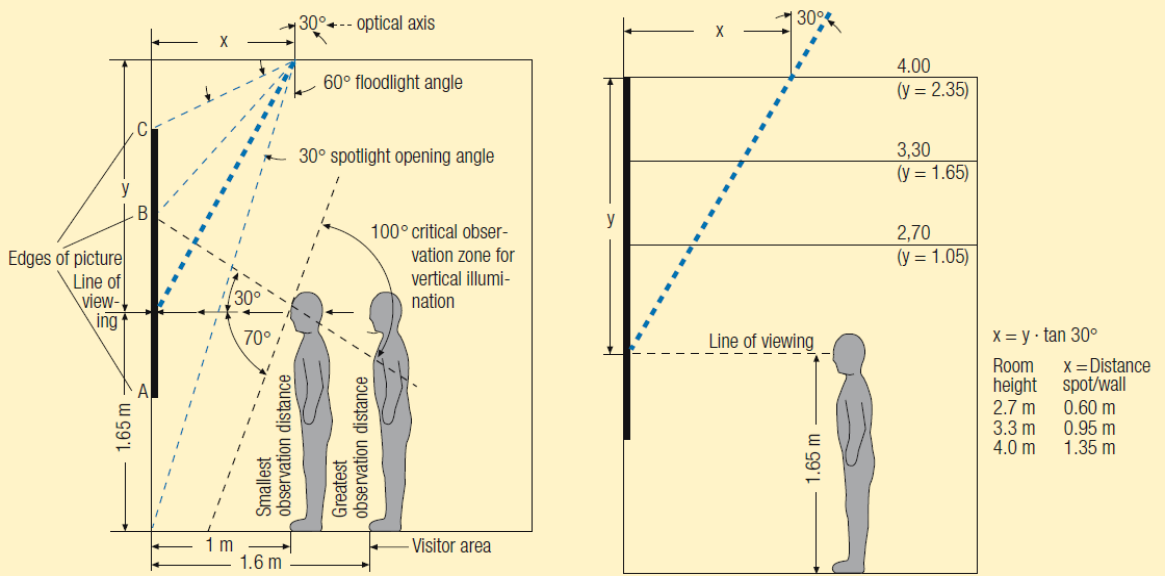


Figure 46. positioning of light according to the height

(source: Daylighting Natural Light in Architecture)

1.2.23. Color fundamentals

Every color can be defined by the following criteria:

Hue is the quality or characteristic by which one color is distinguished from another. The elementary hues that we differentiate are based on the spectral hues red, orange, yellow, green, blue, and violet. All colors are judged to be similar to one hue or a proportion of two of the spectral hues. Thus crimson, vermillion, and pink are close in hue, although they are different colors. Physically, hue is determined in wavelength. White, gray, and black are[7]

perceived as being colorless, not reddish, yellowish, greenish or bluish. They are therefore termed achromatic.

Saturation is the second attribute by which a color is distinguished. Also referred to as strength, intensity or chroma, it designates the purity of a given color, the quality that distinguishes it from a grayed-down color (less chromatic or intense). Two colors may be the same in hue (for instance two greens), and one lighter or darker than the other, yet still appear different in color strength.

Lightness, or its synonymic value, is the third dimension in the description of color, differentiating dark colors from light ones. The lightness of a pigment is the measure of how much light is reflected from its surface. Sometimes brightness is used as a synonym for lightness – which may be confusing.

Brightness means the intensity of a light source or a luminous sensation when describing light and it means highly saturated when describing color.

Nuance describes the intensity of a hue that is its brightness, darkness, or proportion in color mixtures.

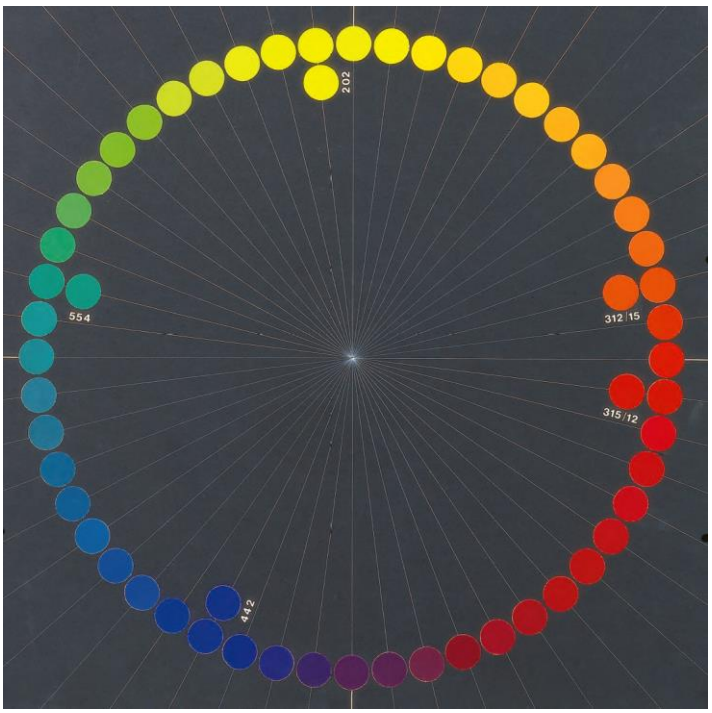


Figure 47. Color circle with 52 sections, Gerhard Meerwein.

1.3. Physiological effects

Whether red, green, yellow, or violet – every color transmits specific, quantifiable physical waves that our eye records as a color stimulus. These stimuli are directed along the energetic visual pathway to the interbrain and the pituitary gland, which regulates certain functions of the rest of the body's hormone glands. Hormonal distribution works in collaboration with the nervous system and regulates the organs.

Human reaction to color in space depends on many factors:

- Hue and nuance,
- Amount and location of the color in space,
- Paint color and spatial function,
- The effect of color over time in the space.

1.4. Visual effects of colors

Knowledge of color contrasts contributes decisively to predicting color effect appropriately and to implementing a design objective. When combining colors, it is often effective to use several different contrasts, which arise when there are clear differences between two or more colors. Contrast effects exist between objective color properties, a well as between subjective color effects.

We distinguish the following color contrasts:

- Light-dark contrast,
- Chromatic-achromatic contrast,
- Chromatic contrast,
- Complementary contrast,
- Intensity contrast,
- Quantity contrast,
- Flicker contrast,
- Cold-warm contrast.

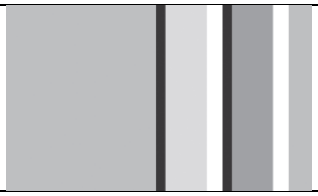
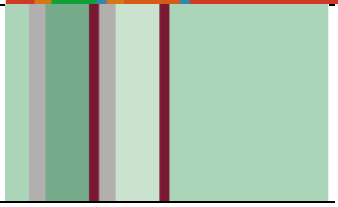
And physiological contrast phenomena such as:

- Simultaneous contrast,
- Successive contrast.

Figure 48. Optical pattern Memphis Design, Vitra Museum, Weil.

Figure 49. Specific color Cambridge University, Mass., MIT Stata Center, library Architecture: Frank O. Gehry. (Source: Archdaily.com).

Tableau 3. Different type of contrast.

Light-Dark Contrast	Light-dark contrast appears in the difference between colors in relation to their degree of lightness.	
Chromatic-Achromatic Contrast	A chromatic-achromatic contrast results when chromatic and achromatic colors come together	
Chromatic Contrast	Chromatic contrast results from combining chromatic colors. It is most clearly apparent when three or more pure-hued, highly saturated colors come together.	
Complementary Contrast	Complementary contrast can be seen where there is a relationship between two colors that are as different as possible. Each color has only one complement. Intensity Contrast This describes the contrasting of colors with different saturation. Its effect is strongest when small amounts of pure color are placed as an accent between large areas of extended, muted colors.	
Quantity Contrast	Quantity contrast refers to the proportional relationship of colors and their interaction. Very different effects can be created if the proportions of colors in a combination are modified	
Flicker Contrast	If intense colors with the same degree of brightness or darkness are applied to a wall, a “flicker” contrast will often occur.	
Cold-Warm Contrast	If we take the color wheel as a reference, some colors are considered cool or warm in the subjective psychological response to them.	

1.4.1. Color/Materials

In addition to the use of light and of architectural forms, materials and colors are the key visual parameters for perceiving and experiencing space. While for centuries Asian cultures have cultivated a highly refined awareness of materials along with an advanced understanding of construction, there has been a lively debate since the early 19th century in Europe on the role of materials and colors in architecture and interior design. [8]

Thus, a material and a color have to be placed together before they can create a specific effect. For an exact terminological description:

> « *It is recommended that readers consult László Moholy-Nagy. In his Bauhaus book "**The New Vision, from Material to Architecture**" published in 1930 (1928 in German), he differentiated between structure, texture, and processing methods.* »

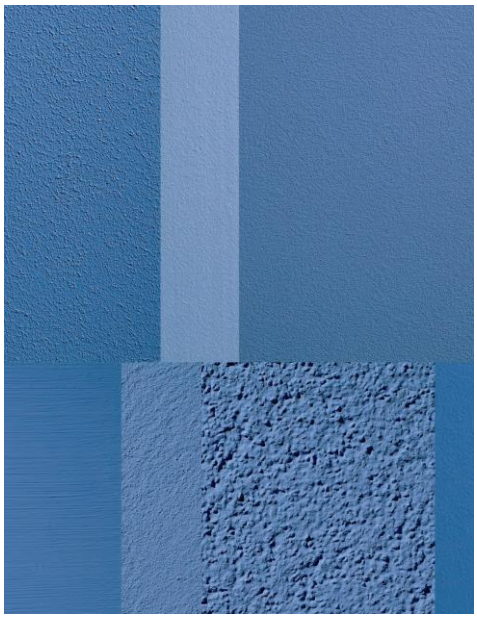
He elaborates:

Structure	Is the immutable composition of a material, for example, the crystalline structure of metal, the cellular structure of wood, and the fibrous structure of paper?
Texture	Is the organic surface area of any structure, as well as processed surfaces. This group includes the cross-sectional view and grain of wood, the granulate texture of granite, the stratification of marble, the woven texture of fabric, plaiting or yarn, and the fibrous texture of particle board?
Processing methods	Are the perceptible expression of material processing. Highly diverse materials often have graduated processing steps that influence color, for example?

Tableau 4. Different methods to use materials and change their texture, form and use.

Stone	Wood	Metal
Quarry	Saw	Cast
Sharpen	Rough plane	Draw
Fire	Plane	Press
Chisel	Sand	Forge
Granulate	Brush	Hammer
Rough-sand	Rough or fine sand	Bend
Plaster	Fill pores	Grind
Fine-sand	Finish	Polish
Polish	Polish	

It is also possible to alter the natural color of materials. During the Renaissance, natural stone was dyed.



By working with colored surfaces and natural materials, as well as color applications and material surfaces, designers have a large variety of possibilities to create exciting spaces. In the interest of each specific ***spatial function*** and atmosphere, however, it is recommended that they take a disciplined approach to the full range of possible effects. Often the individual value of a surface can best be enhanced by toning down its surroundings. ***Diverse textures and processing methods often detract from individual elements and can be visually overpowering***.

1.4.2. Conclusion

We saw in this chapter the physical and the tangible properties of light and color, as we can conclude that light and color as physical matters require also physical and interdisciplinary studies to understand the way it function and the way it affects our physical space.

The light can be provided and giver to space by two main way:

- Natural lighting
- Artificial lighting

To each of these its own properties and functions, depending on the nature of the space and type of the activity we're going to practice.

Light is essential in the living space and it affects differently on the space and on the human depending on many factors like:

- The source (artificial/natural)
- The intensity and the distribution
- The quantity and the form of light (modeled light, shaped light, sculpted light)
- The color, as we all know light can take many colors and degrees of warmth.

And the color also is a crucial element, because it affects directly the brain and the emotions of the human. So from this we can understand that different types and different nuances of colors affect differently depending on the:

- Hue and nuance
- Amount and location of the color in space
- Paint color and spatial function
- The effect of color over time in the space

Chapter II:

Light and color as psychological components.

Light and color as psychological factors

2.1. Light

However, lighting design is not an easy subject for several reasons. The difficulties of the subject have led the author to employ specific research methods that would address those problems effectively. Of course each methodology employed in all research is fundamentally affiliated to an underlying philosophical base and this is why the study begins by explaining a departure from the quantitative methods that are traditionally found in light and lighting research, an inclination towards qualitative methods and a belief in the multiple realities offered by different people, which in turn are influenced by parameters outside them. [12]

2.1.1. Biological effects of light

A great proportion of our lives takes place indoors, in artificially designed spaces and under artificial light. In contrast to natural light, artificial light remains constant, not changing throughout the day or with the seasons. Furthermore, artificial light is constitutionally different from natural light. Although there are lamps with a high output that guarantee good vision, the quality of color rendering across the full spectrum is significantly limited.

Daylight is the most balanced type of white light because sunlight reflects each hue in the spectrum equally. This light, however, does not have a consistent color of its own. The color temperature of daylight will vary according to how it is reflected and refracted in the earth's atmosphere. Daylight thus changes over the course of the day, as well as according to geographical location and season. [3]

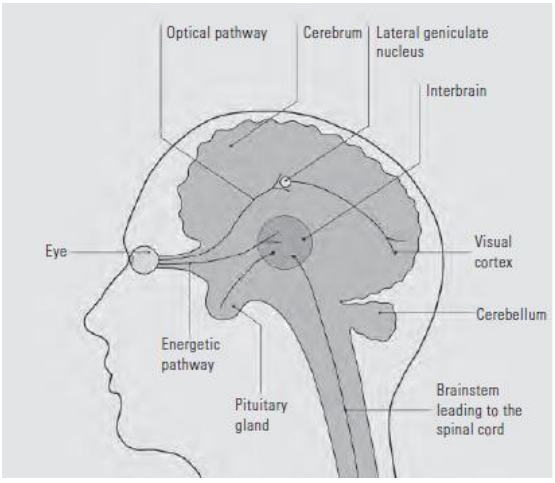


Figure 50. Optical and energetic visual pathway according to Hollwich.

Source: (Grundlagen der Farbgestaltung in Architektur, Innenarchitektur, Design und Planung)

CHAPTER-II- Light and color as psychological factors

Visible light, ultraviolet (just beyond the visible spectrum) and infrared light are crucial for human health. They affect the human organism through contact with the skin and via the light entering the eye. The eye's perception of light is not just limited to the function of vision. Light is carried to the brain via two tracts: the optic portion of the visual pathway travels to the visual cortex and enables vision. It also activates the cognitive system and psychological reactions, as well as the energetic portion of the visual pathway that stimulates the pineal gland (epiphysis) and the pituitary gland (hypophysis). These glands regulate the production and secretion of hormones and thus control the body's chemistry.

2.1.2. Light, human and space

Light is fundamental for space and essential for human well-being and it is the success of any building. Light quality affects human behavior, health, comfort and mood.

> *"Space and light and order. Those are the things that men need just as much as they need bread or a place to sleep"*
>
> -Le Corbusier, August27, 1965

Light, space and human they effect and work with each other. Space needs light to illuminate; light needs space to receive it, light within the space change human experience. They are close relation like people need bread or place to sleep. [2]

Figure 51. LAAB studio gallery Photo by Otto Ng LAAB.

(Source: medium.com/studiotmd)

2.1.3. Light, atmosphere and emotion

Natural light was employed to arouse feelings of mysticism and to give the blessedness of a place. Commonly identified with spiritual forces and beings due to its awing powers over life on earth, light could manifest a divine presence for believers.

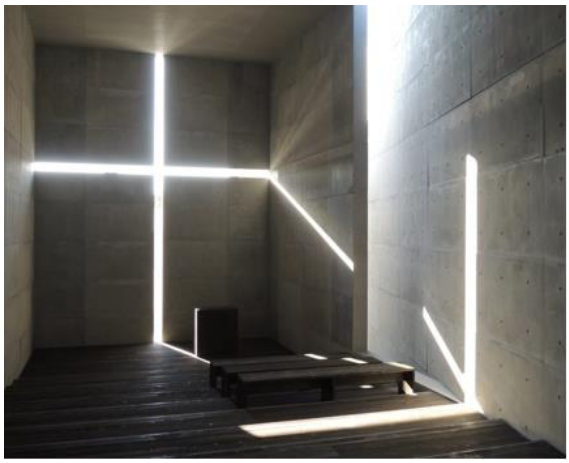


Figure 52. Church of light by Tadao Ando.

Source: (archdaily)

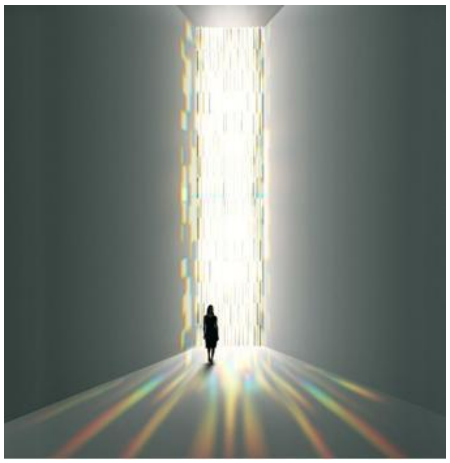


Figure 53. Rainbow Church by Tokujin Yoshiok.

Source: (archdaily)

The best example to using natural light create spirit should be church. Most of church design have a dark corridor, when people enter it, light from outside go through the roof enter the space attract your eyes to look up, you will feel that light is holy and warm; they believe that god is watching over them. It is the use of visual effects that has played the role of psychological change.

Natural light is the only light; because it has mood and it provides a common agreement for man and it is the only light that makes architecture. Architects had started to question whether light exists in its own right, visible in itself and not only for making other things visible.

Some people believe that spiritual and mystical light, apart from having a materialistic aspect due to its non-physical characteristics, is considered a kind of bond between God and man in a spiritual. [5]

Vitalizing light provides mystical atmosphere. It played an active role; it lent the various, consciously selected materials every conceivable facet, modulation, and nuance of color and there by produced the atmospheric moods of light.

2.1.4. Light affecting human behavior

Light creates a feeling of emotions. The origin of light is natural light, which is also known as daylight. There must always be space for natural light; even when people design artificial light, they will want it to look like natural light.

Figure 54. Redbrick health office interior windows .

source: (archdaily.com)

Light controls people's behavior and emotions. It can make people even happier. When people design light for space they need to put in position of people working in that space. Even lighting seems very functional. For example when people in the park, the streetlight and underground artificial light make people feel uncomfortable. But if it were natural light, people would feel comfortable. Users will create a new space from the feeling, which combines the comfort provided by natural light, and the users own feelings and emotions. [1]

Figure 55. Light interior stairs quiet effect.

Source: deezen.com

Some of architectures would regard light design as a matter of common sense and experience. Understanding and use of light goes to the heart of the architecture plan. Vision is most important sense through which we experience architecture, and light is the medium that reveals space, form, texture and color to our eyes. More than that, light can be employed through design

to evoke an emotional response to increased sensibilities. Light is related to the visual experience of form and space. Architecture and light are close relation.

2.2. Color

Perceiving colors means experiencing them and becoming more aware of them, and is always accompanied by associated meanings. Diverse conscious and subconscious factors play a role. Every objective color stimulus that we record from the outer **world corresponds with a subjective reaction from our inner world**. **The human experience and response to color are as diverse as people themselves**. For this reason, it is not possible to generalize color experience, color effect, or the human response to color.

2.2.1. Biological effects of color

The central nervous system, which consists of the brain and spinal cord, **is responsible for human behavior as a whole**. Every impulse or stimulus that reaches the higher centers of the central nervous system, passes through the "formatio reticularis" located in the brain stem, a type of control station for all incoming stimulation. The stimulating quality of color can be grasped in an activation of the reticular system. Consequently, color stimulus is always associated with other sources of stimulation as well. The formatio reticularis influences the standby state of the entire nervous system, and thus also contributes to controlling attention and awareness. Stimulation of the formatio reticularis by external and internal factors determines the degree of arousal. **It can lead to a simple increase in attention or to visible behaviors**. [12]

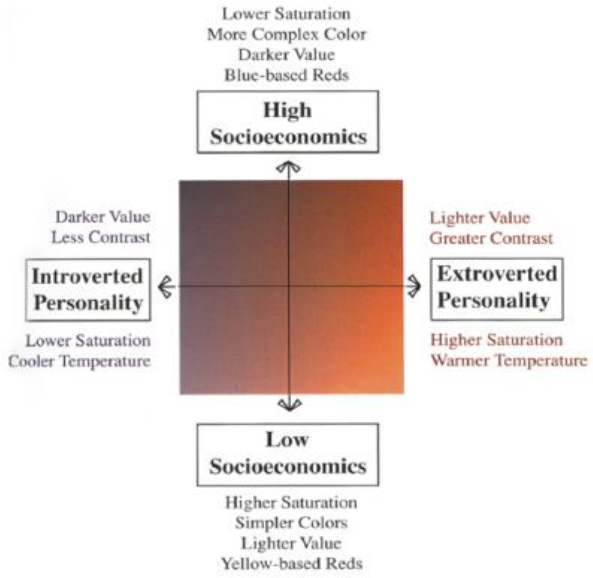


Figure 56. Likely color preferences.

(Source: Panama Werbeagentur, Stuttgart Zooey Braun, Stuttgart)

Biological reactions to color are solely physical in nature. Instead of the obvious optical reaction to color, it is in fact a reaction to the energy of the light waves. Tests show that even if a person is blindfolded his or her pulse will noticeably increase when exposed to the color red and decrease when exposed to blue.

2.2.2. Psychological aspects

Psychology is the science of people's conscious and unconscious mental processes and behavior, including their **thoughts, feelings, and dreams, and with everything that people experience**. Color is a significant element of psychology, because its effect is based on conscious and unconscious processes. **Color is also an experience that influences behavior**. While the physicist regards color as wavelengths of electromagnetic radiation, the psychologist is concerned with color as a sensory stimulus, and with its effect on people. Color psychology examines the existence and the qualities of color experience, and its effect on people. Aspects of color psychology are:

- People's experience of color.
- The emotional effect of color.
- The synesthetic effect of color.
- The symbolism of color and its associative effects.

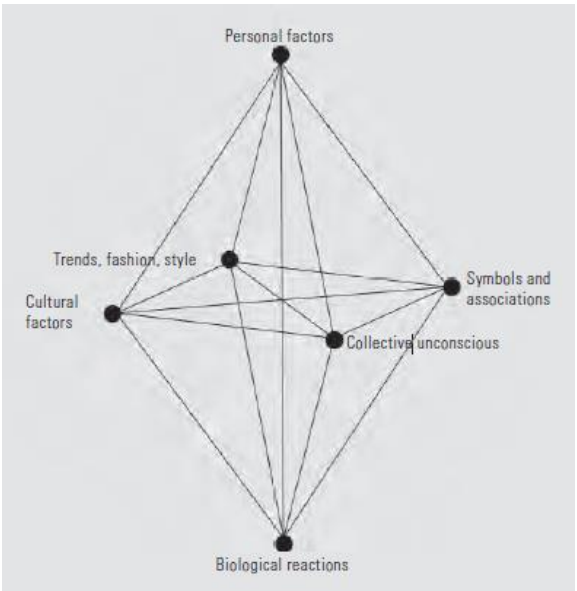


Figure 57. Factors color scheme.

Source: Daylighting: Natural Light in Architecture, Derek Phillips, 2004.

CHAPTER-II- Light and color as psychological factors

"The impression of a color and the message it conveys is of utmost importance in creating the psychological mood or ambiance that supports the function of a space.

2.2.3. Cultural influence

There are also cultural influences on our experience of color. For example, in the English language, if a person is said to be green he/ she feels sick; in German, on the other hand, if a person is said to be green he / she is hopeful. And else that the culture does influence the understanding and the appreciation of the colors depending on its local significance like blue is known to signify the sky or water, the brown for earth or the red for blood.

Almost every year there are new color trends, especially in fashion. Even though color trends are short-lived they still influence our associations. However, it is not useful for the architect to follow these color trends since they hardly ever consider psychology or visual ergonomics. [8]

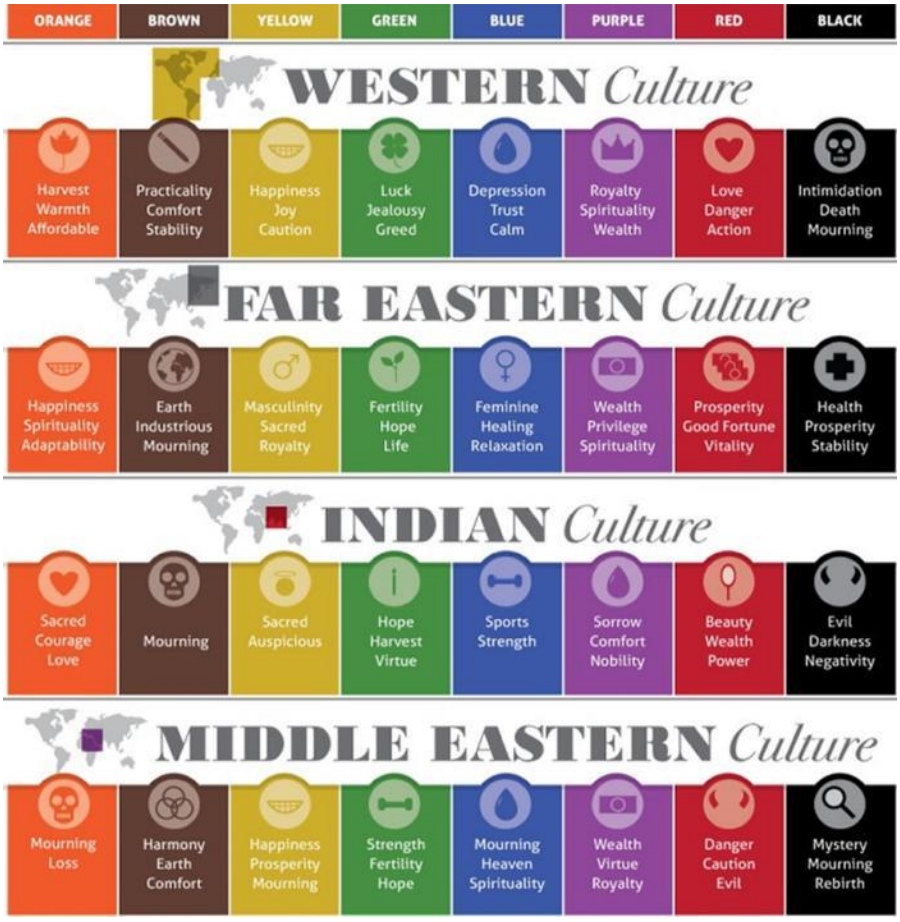


Figure 58. Colors by culture.

source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke, 2007

Relation between perception of color and sensation:

Tableau 5. the colors and their impressions and messages

	Impressions	Messages
	Soft, embracing, sunny	Gentleness, brightness, coziness
	Cheerful, radiant, exciting	Communication, openness, activity
	Muddy, moist, earthy	Tiredness, perishability
	Soft, warming, fruity	Excitement, comfort
	Loud, obtrusive, superficial, heated	Restlessness, excessive demands, speed
	Stabilizing, natural, resonant	Security, tradition, rootedness
	Aromatic, fruity, appetizing	Desire, excitement
	Provocative, fiery, lively	Passion, dynamics, joie de vivre, aggression
	Stabilizing, natural, resonant	Security, tradition, rootedness
	Girlish, gentle, fragrant	Playfulness, rapture, romanticism
	Dominant, strong, active, warm	Grandeur, vitality, prestige, festiveness
	Exclusive, resonant, celebratory	Esteem, quality, respect
	Sweet, perfumed, cheap	Ephemerality, assertiveness
	Dignified, sublime, pompous, narcotic	Ritual, power, splendor
	Majestic, solemn, ceremonious	Dignity, elegance, distinction
	Flowery, elderly	Artificiality, temporality
	Exclusive/valuable, heavy, solemn, deepening	Mysticism, contemplation, extravagance
	Dignified, noble, pompous	Ritual, power, splendor
	Relaxing, quiet, reserved	Calm, balance
	Calm, deep, concentrated, relaxing	Gathering, calm, sumptuousness
	Deep, distancing, untouchable	Ambivalence, instability, tradition, noble
	Cool, airy, light	Distance, expansion, opening

	Distant, cold, calming, reserved	Security, concentration, seriousness, aloofness
	Bottomless, receding, heavy	Seriousness, depth, security, noble
	Watery, icy, celestial	Openness, lightness, freshness
	Refreshing, cool, hygienic	Reservation, aloofness, cleanliness
	Dark, heavy, deepening	Aloofness, elegance, seriousness
	Fresh, light, swelling	Opening, revival, cooling
	Balancing, natural, calming	Balance, simplicity, security, liveliness
	Concealing, natural	Tradition, stability
	Spring-like, carefree	Lightness, playfulness
	Loud, obtrusive, superficial, unserious	Fast-moving, youth, joy of life
	Mossy, autumnal	Naturalness, tradition
	Refreshing, cheerful	Lightness, revival
	Stimulating, shining, revitalizing	Exaltedness, carelessness, alertness
	Swampy, old-fashioned, poisonous	Traditionalism, conservatism
	Open, vast, light, neutral, sterile	Purity, freedom, emptiness, indecisiveness
	Settled, fine, still, reserved	Unassertiveness, elegance, reserve, caution
	Heavy, hard, dominating, noble	Immovability, distinction, steadfastness, burden
	Valuable, ceremonious, radiant, warm	Luxury, pomp, prestige, power
	Noble, cool, distinguished, technical	Distance, elegance, clarity, status

However, since we cannot affect the individual's personal history and experience and his relations to colors, the designers is forced to design toward the common experience of color that affect the vast majority of individuals and people the same way.

2.2.4. Colors and architectural elements

The effect of the colors depends on many exterior factors such as the position and context, since colors are almost never seen in isolation which means we can never understand or get a color by its own, our perception of and reaction to a hue will change if it is on the interior or in the exterior of the building. Whether it is located on a ceiling or a wall or on the floor, and what are the current lighting conditions and parameters. The attributes of the different hues should not be handled as end results to the designer, but used more as a starting point. [8]

The colors way of perception changes from element to another, and from a context to another in this we will understand the association of perception to the color of space elements:

Color	Effect	Association	Character	Ceiling	Walls	Floor
RED	exciting, stimulating	Positive: passionate, fervid, active, strong, warm Negative: intense, aggressive, raging, fierce, bloody	Red is the most dominant and dynamic color. The eye actually has to adjust focus, since the natural focal point of red lies behind the retina. Consequently red appears closer than it is.	intruding, disturbing, heavy	aggressive, advancing	conscious, alert

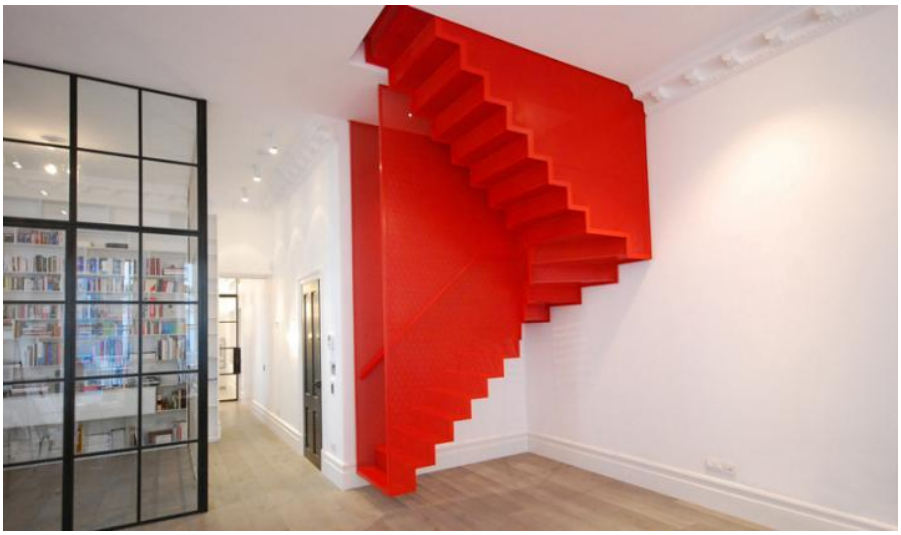


Figure 59 Bespoke red hot perforated steel suspended staircase

(Source:Pinterest.com)

Color	Effect	Association	Character	Ceiling	Walls	Floor

Orange	exciting, stimulating Cheering	Positive: jovial, lively, energetic, extroverted Negative: intrusive, blustering	Orange is less masculine than red. It has very few negative associations. However, it may appear cheap or without vigor if low in saturation.	stimulating, attention-seeking	warm, luminous	activating, motion-oriented

Figure 60. the why factory by MVRDV.

Color	Effect	Association	Character	Ceiling	Walls	Floor
Yellow	Cheering	Positive: sunny, cheerful, radiant, vital Negative: egocentric, glaring	When pure, yellow is the happiest of all colors. In radiates warmth, cheerfulness, and inspiration and signifies enlightenment, and communication.	light (towards lemon), luminous, stimulating	warm (towards orange), exciting to irritating (highly saturated)	elevating, diverting

Figure 61. Saint-Etienne office building

Color	Effect	Association	Character	Ceiling	Walls	Floor

Green	retiring, relaxing	Positive: tranquil, refreshing, quiet, natural Negative: common, tiresome, guilty	Contrary to red, when looking at green the eye focuses exactly on the retina, which makes green the most restful color to the eye. Green can symbolize nature but also mold and sickness.	protective, reflection on the skin can be unattractive	cool, secure, calm, reliable, passive, irritating if glaring (electric green)	natural (if not too saturated), soft, relaxing, cold (if towards blue)

Figure 62. lime green bathroom wall

(Source: Pinterest.com)

Color	Effect	Association	Character	Ceiling	Walls	Floor
Blue	retiring, relaxing	Positive: calm, sober, secure, comfortable, noble Negative: frightening, depressing, melancholy, cold	Blue appears to be transparent, wet, cool, and relaxing. Opposite to red, blue will decrease a person's blood pressure and pulse rate.	celestial, cool, receding (if light), heavy and oppressive (if dark)	cool and distant (if light), encouraging and space deepening (if dark)	inspiring feeling of effortless movement (if light), substantial (if dark)

Figure 63. Blue painted wall installation STG Studio

Color	Effect	Association	Character	Ceiling	Walls	Floor

Purple	subduing	Positive: dignified, exclusive Negative: lonely, mournful, pompous, conceited	Purple is a mixture of red and blue (the two colors that are psychologically most opposed). Purple can appear delicate and rich, or unsettling and degenerate.	disconcerting, subduing	heavy, overpowering	fleeting, magical

Figure 64. Architectural render to a kindergarten in Montpellier.

Source: archdaily.com

Color	Effect	Association	Character	Ceiling	Walls	Floor
Pink	lively (bubble-gum pink), calming (light pink)	Positive: lively, calming, intimate Negative: too sweet, weak	Pink must be handled carefully. It is generally considered feminine, but depends much on the nuance used (bubble-gum pink, or old rose)	delicate, comforting	aggression-inhibiting, intimate, too sweet if not grayed down	too delicate, not used very often

Figure 65. Normann Copenhagen Showroom at Østerbrogade.

Source: pinterest.com

Color	Effect	Association	Character	Ceiling	Walls	Floor
Brown	subduing	Positive: warm, secure, stable Negative: oppressive, heavy	There is a great difference between wood and brown paint. In certain institutions brown should be avoided since it evokes fecal associations. Wood and stone on the other hand appear very comfortable, and warm.	oppressive and heavy (if dark)	secure and assuring if wood, much less so if paint	steady, stable

Figure 66. Private House Kensington by David Chipperfield Architects.

(source: Waldorf Playschool, Mainz Dieter Leistner/artur)

Color	Effect	Association	Character	Ceiling	Walls	Floor
White	Pure, cleaning,	Positive: clean, crisp, bright Negative: empty, sterile	There are a lot of psychological and physiological justifications for not using white as a dominant color.	empty, no design objections-helps diffuse light sources and reduce shadows	neutral to empty, sterile, without energy	touch-inhibiting (not to be walked upon)

Figure 67. Casa del Acantilado by Fran Silvestre Arquitectos.

Source: archdaily.com

Color	Effect	Association	Character	Ceiling	Walls	Floor
Gray	neutral to calming	Positive: neutral Negative: boring	Gray fails to have much psychotherapeutic application. Thus, the current fashion of using it with various accent walls defies all logic.	shadowy	neutral to boring	neutral

Figure 68. Tadao ando Armani's teatro

Color	Effect	Association	Character	Ceiling	Walls	Floor
Black	ominous	Positive: deep, abstract Negative: dungeon like, night, grief, death	Black is associated with oppressive power, darkness, and the unknown. In architecture it is often used to make something appear as receding.	hollow to oppressive	ominous, dungeon like	odd, abstract

Figure 69. Ridge Road Residence by Studio Four.

Source: pinterest.com

This table below shows us many colors and the impressions they engender when it is used in architecture:

Tableau 6. Colors and their effects on architectural elements.

	Floor	wall	Ceiling
	Sandy, light	Warming, expanding	Light, closing
	Not resonant, motorically arousing	Arousing to irritating	Shining
	Resonant, earthy, sure-footed	Oppressive, restrictive	Burdensome
	Powdery, light, soft	Warming, stimulating	Light, closing
	Arousing to irritating, provocative, garish	Shining, warming to heated, aggressive	Exciting, irritating
	Supportive, secure, familiar	Stifling, restrictive	Enclosing, oppressive to burdensome
	Foreign, delicate, charming	Delicately scented, flowery	Oppressive, warm
	Festive, majestic	Dominant	Obscuring, burdensome
	Noble, enhancing, valuable	Decisive	Bombastic, interventional
	Bottomless, charming	Fragrant, flowery	Delicate, scented
	Valuable, majestic	Mystical, artificial	Mysterious
	Luxurious	Magical, mysterious	Reserved
	Floating, icy	Cool, retreating, calming	Sky-like, cool to airy
	Retreating, watery	Cold, foreign, distanced	Heavy, cramped
	Deepening, bottomless	Claustrophobic, distanced	Cooling, burdensome, powerful
	Floating	Expanding	Neutral, closing
	Natural, safe	Circumscribing	Closing, oppressive
	Sure-footed, solid	Decisive	Oppressive
	Bottomless, foreign, empty	Neutral, free	Open, wide, light
	Sure-footed, neutral, solid	Claustrophobic, massive	Covering, oppressive
	Deepening, abstract	Restrictive	Oppressive, burdensome

These are some color nuances and there effects:

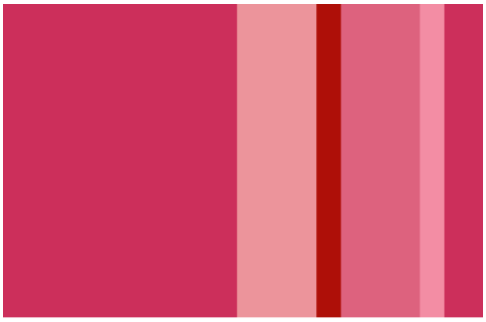


Figure 70. Cool red nuances.

Figure 71. Warm blue nuances.

(source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke,2007)

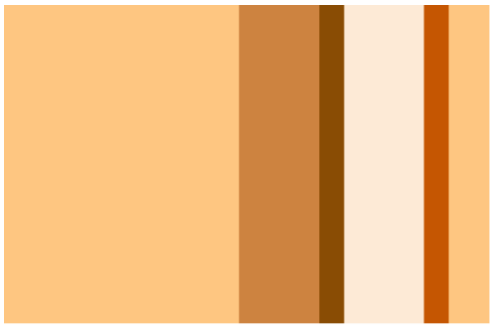


Figure 72. Warm.

Figure 73. Cool.

(source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke,2007)

Figure 74. Light.

Figure 75. Heavy.

(source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke,2007)

2.3. The space as a stimulating environment

CHAPTER-II- Light and color as psychological factors

Space, both material and immaterial, is a fundamental basis for human existence, development, and evolution; **space comprises the outer shell within which life takes place in** all its variation. People are directly and inseparably connected to the space that surrounds them. “Lived space,” a term coined by philosopher and educator O. F. Bollnow, refers to the close connection between people and the spatial environment. The human life cycle, from its beginning in the womb through to death, unfolds in a wide variety of spatial environments and is subject to specific conditions, is in relation to them, and in exchange with them – that is, as part of a mutual relationship between people and their social and material-spatial surroundings.

The characteristics of space are among the conditions of life that affect the course of human development, the quality of life, and the human condition in the different phases and spheres of life. The creative statement, **symbolic effect, and impression made by an architectural space determine how people feel within it**, to what extent the space appeals to them, and how they identify with it. It also **affects how they appropriate it**, behave toward and within it, and how they act individually and socially**. Space is always an immaterial and intellectual space as well. It encompasses the atmospheric, experience-related dimension** and the social and communicative dimension of interpersonal encounters and relationships. A variety of scientific disciplines have focused on the significance of space with regard to its effect on people. [9]

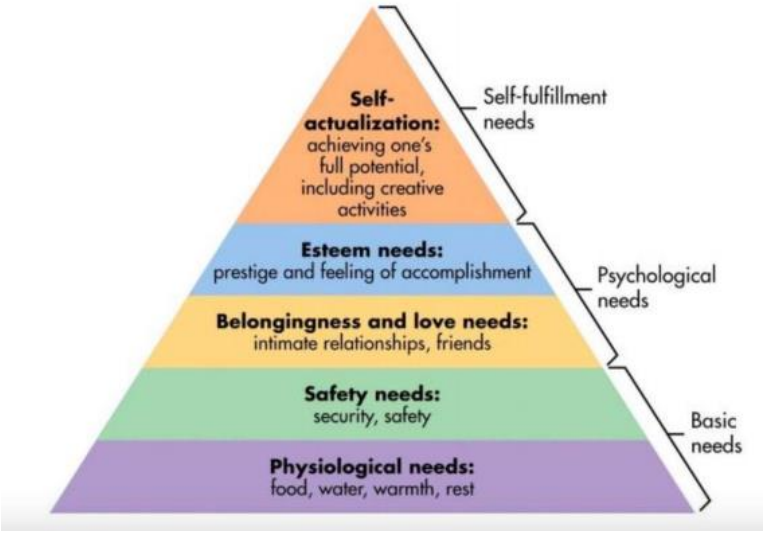


Figure 76 Hierarchy of space/human needs, Moscow 1943

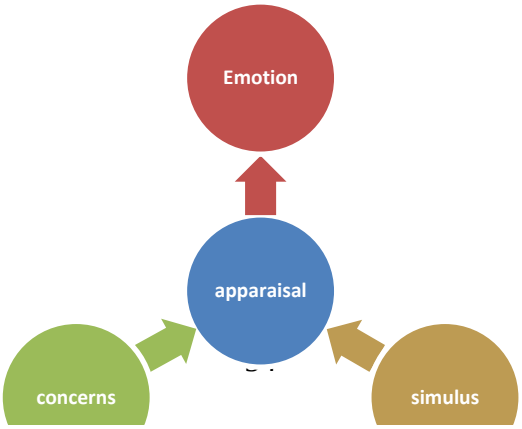


Figure 77. Basic model of emotions. (Pieter Desmet)

Examples:

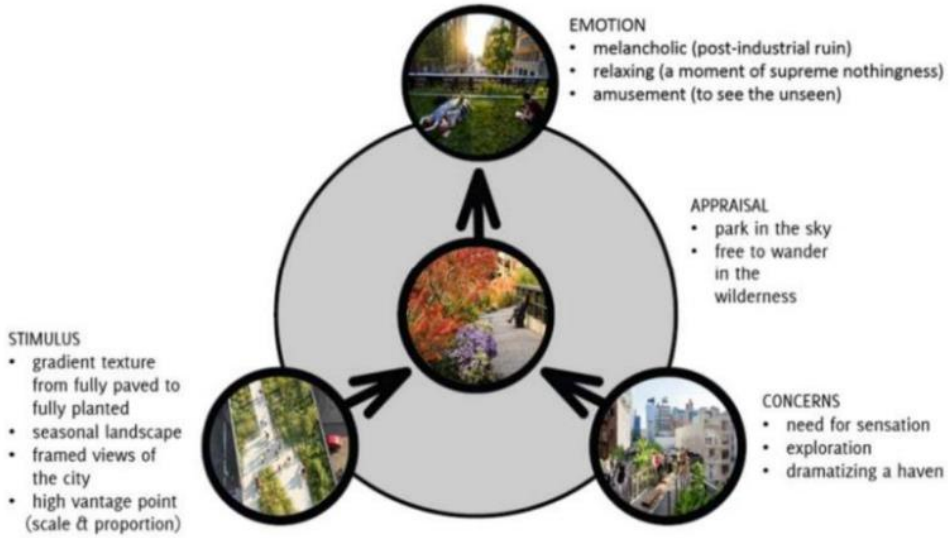


Figure 78 basic model of emotions example

Although people are influenced by spaces and the quality of moods emanating from them, it is important to realize that this is not about a simple transfer of moods. Indeed, it must always be kept in mind that **people also react subjectively, and vary in how receptive they are to spatial environments**. Although atmospheres are closely linked to **forms, materials, light, and colors, the possibility and intensity of the influence these exert also depend on people and their personal mood in the "here and now."**

2.4. The relationship people, color and space

As we did already see that the human being while living his daily life is always affected by his environment, and the elements that composes the spaces he lives in. and as we did say that color is one of the main factors that manipulates his feeling and triggers his emotions and impressions towards any space. [8]

A key role in the relationship between people and architectural space is played by the following related components, which should also always be considered in the broadest sense when developing color designs for architectural space:

Quality of impression

Invitational character

Conciseness

Appropriation.

Quality of impression	Invitational character	Conciseness	Appropriation
•refers to the psychological relationship people have with architectural space, to their psychological, emotional experience of space. The impressions our environment makes are a source of profound psychological forces; they exert a lasting influence on our physical and psychological well-being.	• Invitational character describes how the energy and quality of a space directly affect an individual's acceptance or rejection of it. Invitational character also signalizes certain possibilities for action. A user's cognitive evaluation of a particular space will mean this character facilitates or impedes actions	• Conciseness is an important factor in functional color design; it describes how clearly an architectural expression mirrors a space's functional significance. Concise design illustrates the functional goals and intentions of an architectural space in a clear, specific, and characteristic manner.	• Appropriation, according to environmental psychology, is a mechanism that encompasses all possible courses of action that serve to adopt or take possession of a space.

With a few exceptions, personal space can most easily and best be attained in private spaces such as houses or apartments. This is where appropriation can be manifested best, provided the spaces correspond to the true needs of the user.

Modern people generally spend more than 80 percent of their time in closed spaces. Developing an awareness of how important it is to live under the best conditions in these surroundings is the primary goal of effective design practice. For the development of color concepts, this means:

Holistic thinking and analysis with regard to people– color–architectural space

Sound knowledge of scientific research on the topic of "color"; willingness to consider peripheral areas of research in this field; remaining open to empirical findings

Combining these with intuition, creativity, a sense of aesthetics, and professional know-how.

Hesselgren summarizes the requirements for a positive relationship between people and architectural space as:

The emotions that perceiving a space triggers must be positive.

Architectural space must fulfill particular formal and aesthetic requirements to be experienced as beautiful and interesting.

Architectural expression must be experienced as true from an ethical standpoint.

A space must provide satisfaction in terms of functionality.

Another basic human requirement is the need to communicate. This encompasses the need for social bonding and a connection to the objects in one's surroundings, as well **as the need for identity. Identity develops from our fundamental, early childhood experience of security,**

confidence, and trust, followed by an upbringing that supports initiative, activity, and autonomous behavior and actions combined with appreciation. Extreme experiences and changes can unsettle an individual's sense of identity, but can be countered by outside support and one's own actions.

It is important to design spaces that convey a sense of trust and whose expression can be understood – **spaces that encourage people to engage with objects and that are open to and provide room for social relationships**. [10]

The complete system of our senses plays a major role in the process of the human-environment relationship. Psychology regards the following types of needs as effective:

In addition, people inherently seek harmony and beauty.

Below is a catalog of needs and requirements related to spatial environment:

Activation	Calm	Beauty	Affection
Challenge	Contact	Boundaries	Atmosphere
Closeness	Encouragement	Concentration	Attentiveness
Communication	Environmental compatibility	Exchange	Being accepted
Consolation	Feeling at home	Fostering a sense of identity	Clarity
Control	Finding a balance between the real and virtual worlds	Freedom	Creativity
Coziness	Hygiene	Freedom to develop	Dynamism
Debate and discussion	Independence	Incentives	Friendliness
Genuineness	Leeway	Nature	Harmony
Joie de vivre	Light	Pre-order	Openness
Order	Naturalness	Privacy	Participation
Relaxation	Orientation	Quality of material	Protection
Rituals	Respect	Recognition	Respect
Safety	Self-determination	Spirituality	Structure
Self-realization	Self-esteem	Stability	Thirst for conquest
Variety	Stimulus	Tenderness	Tolerance
Warmth	Well-being	Touch	Vitality

Figure 79. Basic space requirements.

(source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke,2007)

The physical-optical fundamentals described result in a principle of perspectival color perceptions in architectural space:

Warm, highly saturated, and bright colors (orange, ocher, sand yellow) advance to the foreground.

Colors that are neither clearly cold nor warm (green, violet, purple) are located in intermediate ground.

Cool and bright colors (light blue, lime green), as well as dark, warm and dark, cool colors (dark brown, dark blue) recede into the background.

The relationship between figure and ground is critical to using color **to create the illusion of space**. For example, “black can be placed in front of white if black is functioning as the figure rather than the ground. Otherwise, white is placed in front of gray, and gray in front of black, although surface proportion also plays a role.” [12]

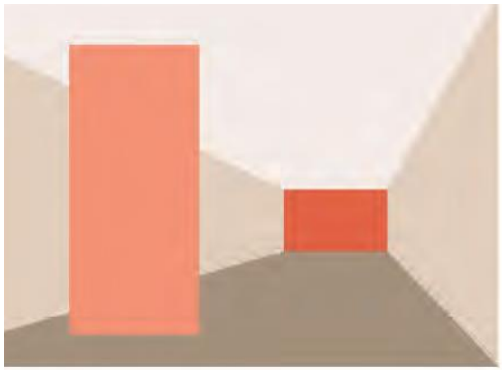


Figure 80. Near.

Figure 81. Far.

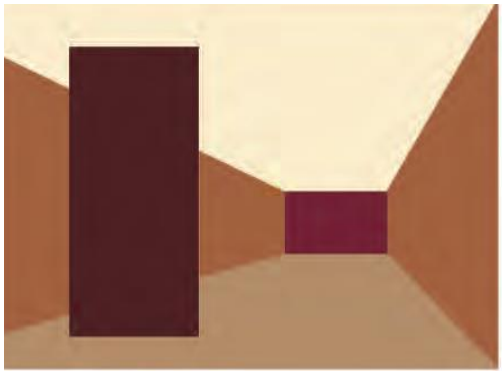


Figure 82. Narrow.

Figure 83. Wide.

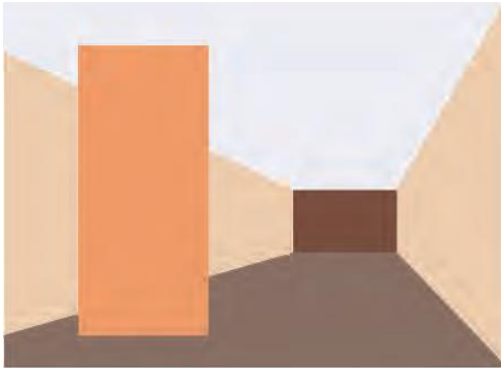


Figure 84. High.

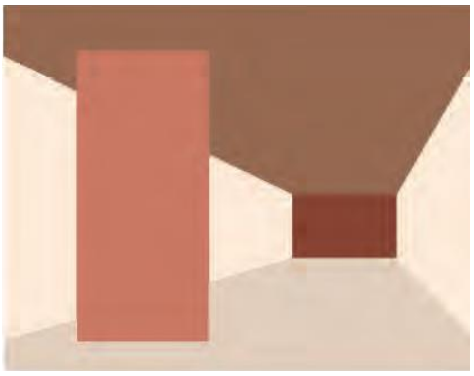


Figure 85. Low.

(source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke,2007)

CHAPTER-II- Light and color as psychological factors

Colors can be employed to create meaning based on the rules of color perspective. They can generally be **used to influence the effect of room proportions**, such as wide, narrow, high, low. Here, the synesthetic (intermodal) quality of experience (light or heavy in terms of weight) plays a role. **Bright colors are experienced as being light in weight, and dark colors are experienced as heavy.**

Concerning hues of equal brightness:

Passive colors (e.g. green, green-blue) seem lighter in weight

Active colors (e.g. red) seem heavier

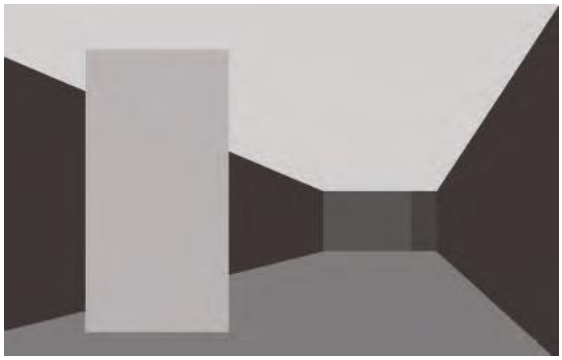


Figure 86. High, light tone.

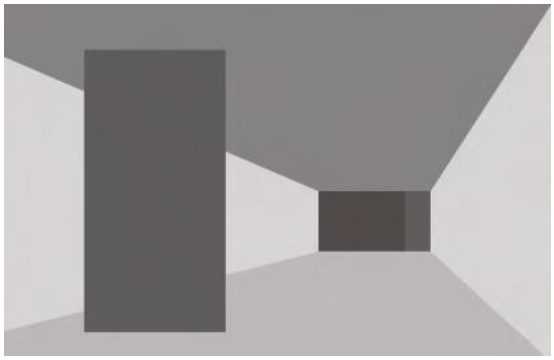


Figure 87. Low, heavy tone.

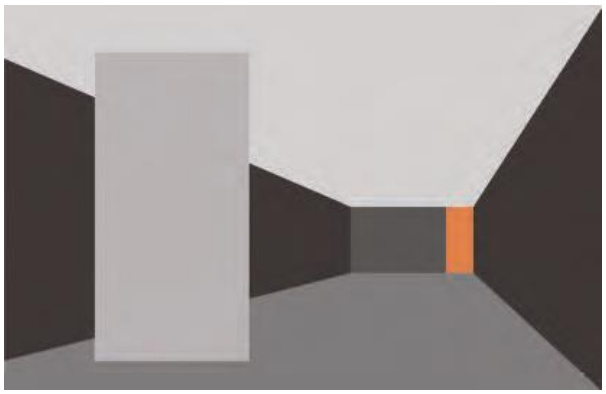


Figure 88. Changes in the impression using light/dark contrasts between dominant, subdominant, and accents.

(source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke, 2007)

For a balanced color design, it is also important to give equal **attention to the proportions of area and color as well as form and color.** The larger the surface area and the more varied the form, the more subtle the color statement should be. Ultimately, the color schemes of spaces where people spend large amounts of time should be unobtrusive yet expressive enough to

accommodate the personal design preferences, imagination, creativity, and freedom of each individual user. Instead of overpowering us, colors should serve our needs.

2.5. The relationship space, color and function

Color design of spatial elements, the relationship and interplay of colors and space, is extremely important. Color design is not an end in itself; it only fulfills its purpose when all elements of interior design harmonize and complement one another**. Color design requires a professional and qualified analysis of the effects of colors in a spatial context**, taking into account physiological, ergonomic, psychological, functional, and aesthetic demands. The colorful appearance of spaces where people work and spend time is a decisive, holistic influence. As a result**, the spatial environment needs to be systematically analyzed and planned. Architectural spaces, perceived and experienced in their entirety, have to meet the requirements of color design.** This is the only way to achieve a design that is tailored to people's needs. An environment that conveys information about spatial function, provides space for individuals, and contributes to the quality of life enhances our well-being, behavior, and actions.

This is true for all areas of interior design, in:

- Educational institutions
- Sports and recreational facilities
- Workplaces
- Healthcare
- Retirement homes
- Restaurants
- Private homes…etc.

In order for color to be used effectively to serve the needs of people, the architectural space, its function, and its elements, the following interrelated aspects are of key importance:

- Relationship of people to color: (physiological requirements, psychological requirements)
- Relationship of color to building and spatial function.
- Relationship of color to space and its elements.
- Orientation.
- Environmentally friendly materials and paints that are also safe for human health.

- Aesthetic qualities.

Figure 89 Balanced, low-key color schemes are beneficial for spaces where people spend long periods. Panama Werbeagentur, Stuttgart,

(Source: pinterest.com)

Figure 90 highly saturated color stimulation and intense contrasts are only recommended for spaces where people spend short periods.

(source: Color – Communication in Architectural Space, Meerwein Rodeck Mahnke, 2007)

CHAPTER-II- Light and color as psychological factors

One of the main objectives of effective design is to create a **suitable framework for specific functions**. The overall design of a building and its spaces should reflect a clear purpose. Based on their symbolic meaning and associative effect**, colors are able to symbolize functions**, thereby giving each building and space utilization an **appropriate purpose-oriented atmosphere that corresponds to the users and activities** that (should) take place in a given space. According to J. Pankoke, color symbolism essentially uses colors to transfer subconscious messages **by linking impressions and associations with our intuitive conceptions of color.** On this level, it is possible to establish relationships between users, their activities, and the architectural space. Color links these factors, thereby establishing an identity. It affects our body and mind deeply, influences our well-being and "psychological comfort." Color atmospheres send signals that direct our actions.

Figure 91 Library interior light, color and materials

(Source; Archdaily.com)

2.6. Light and color design in different types of spaces

So after concluding that light and color parameters and uses differ from a function to another or from a field to another, we will explore some examples from the next list of diferent fields to understand the strategies aof lighting and the color palettes used in these fields, the list is the next:

- Offices
- Hospitals
- Educational
- Sports
- Display

2.6.1. Offices

The office workplace is undergoing major changes. Globalization and worldwide business networking, the transition from an industrial to a knowledge society, pose new challenges for managers and employees. Creativity, information, knowledge, and close cooperation are required to be successful. Employee creativity is an important element of this success. Based on the realization that creativity is best enhanced in an environment that is free of suppression (i.e. one that allows self-determination and independence, and creates important sociopsychological, atmospheric, and material conditions), special areas called interactive creativity landscapes have been introduced to the workplace. These areas reflect the latest findings in creativity research and place special emphasis on an atmosphere that stimulates the senses.

Offices are one of the programmes where the requirements of vision are critical, and therefore the **daylighting design must meet stringent requirements in terms of illumination level, and glare control; but where the intangibles are also of importance**, such as the view out.

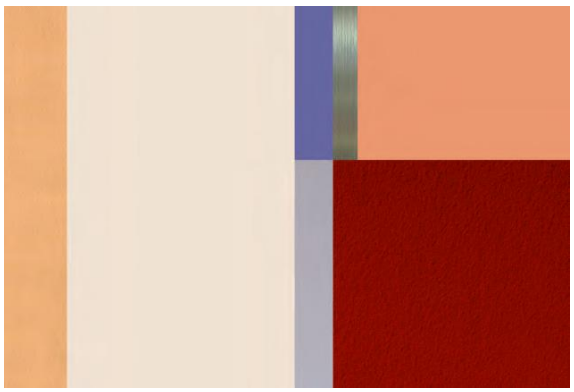


Figure 92. Chill-out room palette.

Figure 93. Cellular office, Braun.

(Source: Daylighting: Natural Light in Architecture Derek Phillips, 2004.)

Responsible color design requires a professional, qualified approach to the effects of colors in an architectural and spatial context, with due consideration given to ergonomic and functional demands. **An ergonomic color design should meet the following fundamental physiological and psychological requirements: light conditions and color schemes should aim to avoid visual disturbances, concentration difficulties, and fatigue from glare, reflections, low contrast, harsh dark-light contrasts, intensive color stimuli, and irritating patterns in a direct line of vision.** The balance of surface brightness plays a key role in creating conditions for good vision at the workplace. Accordingly, the brightness of all large surfaces and objects in the field of vision should be as similar as possible. We should avoid light-dark contrasts, such as

black tables in front of white walls and windows, or light office machinery on extremely dark work surfaces. Spaces outside the direct line of vision and the direct working environment may feature starker contrasts.

When positioning the screen, it is essential to ensure that there is no direct or reflected glare, and a balanced luminous density distribution:

The screen should not be positioned so the user is facing a window or a light wall

Lateral light entry is desirable

Reflections from rear light walls, light, and windows should be avoided.

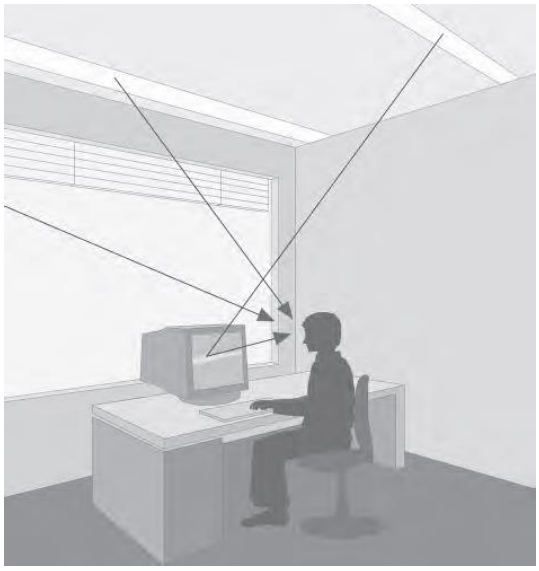


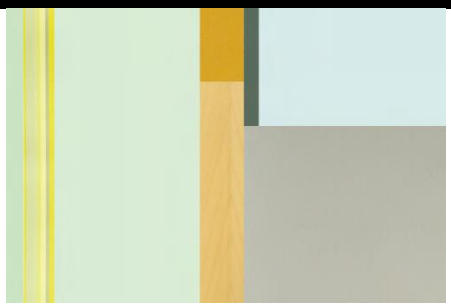
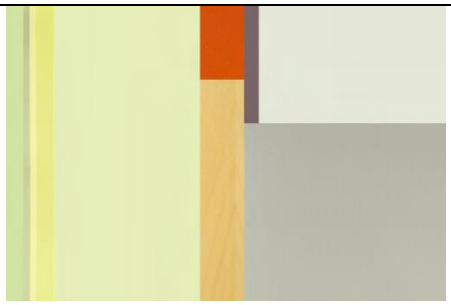
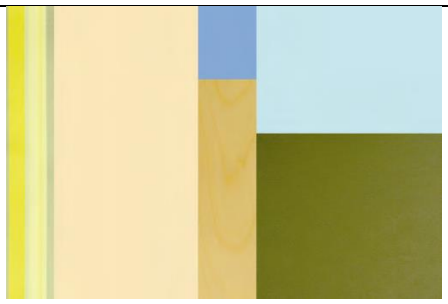
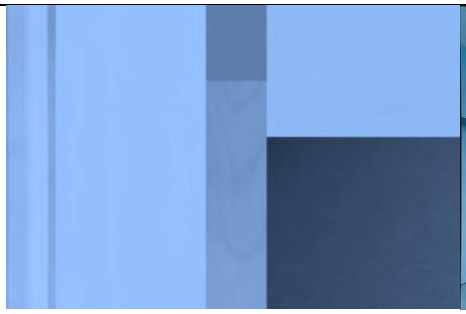
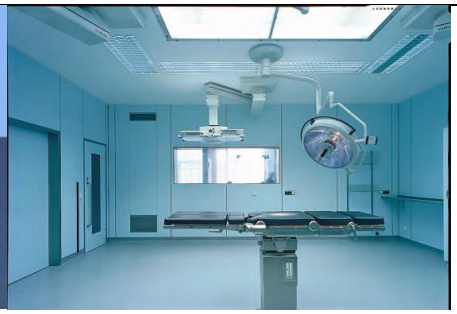
Figure 94. Common glare factors at the work place

Figure 95 Conference room, Braun AG, Melsungen

(source: Archdaily.com) Architecture: Sterling, Wilford, Schupp

2.6.2. Hospitals

Therapeutic facilities include hospitals, rehabilitation clinics, psychiatric clinics, residential care for people with disabilities, nursing homes, etc. Their basic function is to house people with physical, psychological or psycho-physical illnesses, handicaps or disabilities, and to treat and care for them over the short or long term. When designing therapeutic environments, we must differentiate between facilities for short-term stays, (such as hospitals, rehab clinics) and long-term stays (such as homes for disabled people, nursing homes, and some psychiatric clinics), in order to best cater for the different needs of the user group. [14]

Space	Light	Color	
Ward 1	Natural (windows) Artificial controlled white lighting		
Ward 2	Natural (windows) Artificial controlled white lighting		
Patient's room	Natural (windows) Artificial white light with some spot lights		
Operating room	Artificial white light controlled, and using projected light and diffused light.		

Admissions	Natural (windows, entrance doors) Artificial white light with some spot lights	

Hospitals and therapeutic facilities require a lot of attention towards the light and color aspects and parameters because it has a direct effect on the patients psychology and it must be welcoming and secure and provide a feeling of trust and hygiene, using neutral and light, and some warm nuances the design of this type of facilities and spaces require to target these points:

- Warmth, security, trust, stability
- Comfort, feeling at home
- Stimulation, differentiation, and sensitization of perception by means of different spatial qualities
- Communication and contact with the spatial and personal world
- Activity and vitality
- Attention, concentration
- Peace, relaxation
- The ability to retreat into a personal-private sphere.

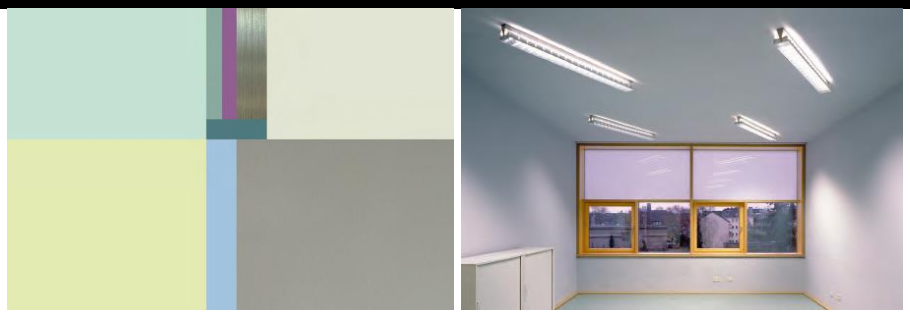
2.6.3. Educational

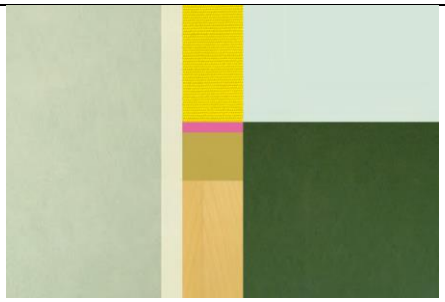
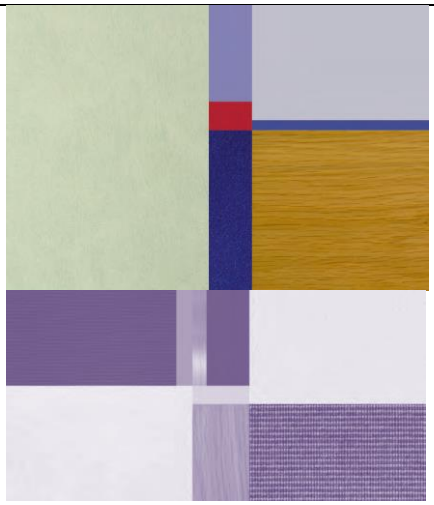
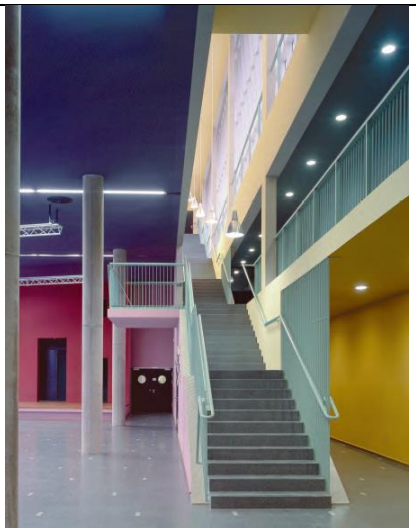
Educational institutions are the visible manifestations of the “learning culture.” They provide information about philosophical perspectives and “notions of humankind”; about the concepts of teaching and learning, which form the base for education; as well as architecture, and interior design. These buildings’ spatial appearance refers to the teaching and learning activities taking place within them; they also indicate whether the chief objective of educational and creative intentions is to teach assimilation and subordination, or rather autonomy, creativity, and respect for humanity. The use of color as an element of design in educational institutions is a topic that focuses on individuals and their educational environment. It thus pertains to a sphere of activity that demands great responsibility and humane design. Material and color designs determine how conducive the spatial framework of these institutions is to ways of learning and living that are

stimulating and supportive, that foster identification and well-being, support individual and social processes of development, as well as pedagogical attitudes and actions.

Figure 96 Facade of the Montessori School, Aachen
Architecture: Kasper-Klever Color design: Friedrich Schmuck

Educational theory has focused on methodological and didactic topics and the social conditions of learning processing, neglecting **the determining factors of material and space. As in school, disinterest, fatigue, poor concentration, and a lack of motivation** can be traced back to inadequate, under stimulating interior designs. Just as the spaces used for adult education must fulfill certain **functional requirements in terms of equipment and furnishings,** they also need to take the emotional needs of their users – the teachers and students – into account. If they do this successfully, they can contribute to **an atmosphere that fosters well-being and the development of creative potential. We need spaces that make lifelong learning an enjoyable experience.**

Space	Light	Color
Classroom	Natural (windows) Artificial controlled white lighting	

cafeteria	Natural (windows, curtain walls) Artificial controlled white lighting, and distributed lamps		
Hallway	Natural (windows, curtain walls) Artificial controlled white lighting, and distributed lamps and lamp spots		

The educational facilities and spaces need are mostly affected by the design of light and color. In general, it can be said that architectural design affects:

- School climate and classroom atmosphere
- The psychosomatic health of teachers and students
- Pedagogical behavior
- Individual learning and social behavior
- Group learning and actions, social behavior in groups and with each other.

The properties and the design of spaces need to be effective and to provide the next qualities to the space:

- Motivates learners to work together and as equal partners in a sense of dialog and democracy
- Dismantles hierarchical structures
- Fills learners with enthusiasm for dialog and thus also for tolerance
- Stimulates the senses
- Supports exploratory learning
- Encourages action-oriented learning
- Fosters didactic autonomy in interior design among teachers and students

- Supports self-directed learning processes
- Helps in the differentiation of aesthetic awareness
- Sparks creativity and imagination

"An educational space should provide its users with a positive experience involving a high degree of perceptual stimulation and lasting memories."

2.6.4. Sports

Indoor sports arenas are very important for socializing within a group. Participating in team sports builds slf-confidence, allows players to work off aggression, measures strength in a fair way, fosters integration, and is a healthy activity. **Based on a color design in this larger context, the quality of the spatial experience in the arena should be significantly improved.** It should project a sense of effortlessness, **visually enhance dynamic activity, and achieve a synesthetic temperature equilibrium.** It is recommended to choose a balance between cool and warm nuances of color and material. By carefully considering the spatial dimensions of a given building, wall surfaces can be made more dynamic, creating a stimulating, delightful, and fun atmosphere. A lack of knowledge of the correct use of colors is no excuse for forgoing their pleasurable, refreshing, rhythmic, and fanciful effect in sports architecture. [14]

Figure 97 Swimming pool, Bad Elster
Architecture: Günther Behnisch, color design: Erich Wiesner

Figure 98 Vollmersbachhalle Idar-Oberstein

Architecture: Ulrich Pasucha, color design: Gerhard Meerwein

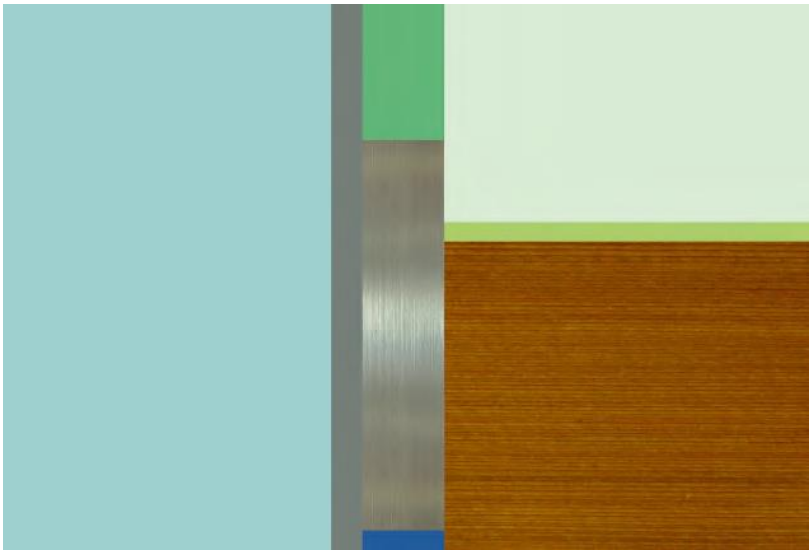


Figure 99 Matching colors used in the sports/gym (Source:

The development over recent decades in indoor sports arena construction has been influenced by different factors:

Growing interest in indoor arena sports

Increase in available space and training opportunities

Increase in the diversity of the school system and improved school sports opportunities

Increasing need for community facilities (sports clubs).

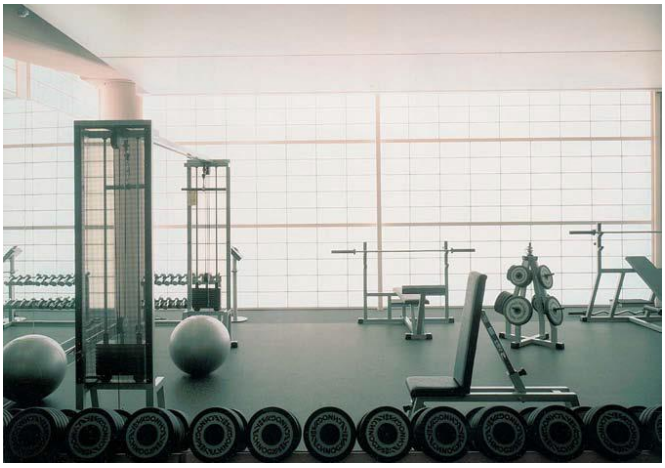


Figure 100 Interior of a working space

The artificial lighting had **to provide glarefree light to the interio**r, so as not to be disturbing to the members, some of whom may be carrying out exercises lying on their backs looking upwards to the ceiling. The solution adopted is to stretch membrane ceilings between the beams, which **are back lit by concealed fluorescent lamps.** This solution, which is a method of daylight linking, is very successful providing a light level which can be varied from low for exercises such as yoga, to high levels where this is required. The combination of daylight received **through the panels and variable artificial light from the stretched membrane panels provides a calm soft light with no hard shadows, ideal for the sporting activities below**. [14]

2.6.5. Display

Display means exposing, and display spaces are the spaces where we find exposed products, pieces of art or anything visual such as light installations or light paintings. These projects require a precise and deep working on the design of the exposing space because every **color in that space does count in the general picture of the art exposition order,** and so for the lighting, **it needs to be perfectly adjusted according and depending on the nature of the displayed objects or pieces**. The diversity of the nature of the displayed items offers us a variety of solution depending on its nature. Some arts and items require natural lighting and other artificial one; some require an intense lighting while others requires a weak lighting.

Figure 101“Salle des Etats” of the Louvre in Paris

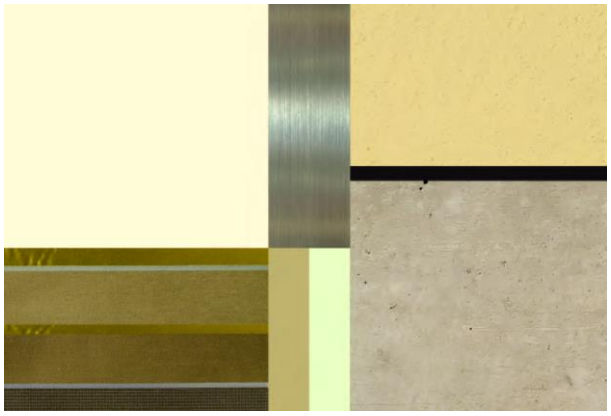


Figure 102 the used color for the display space

Lighting is vital for spatial impression and enjoyment of art. Different light colors and beam spreads, different designs and arrangements of luminaires and lamps create different lighting situations – light spaces – designed to meet the relevant needs of the exhibition.

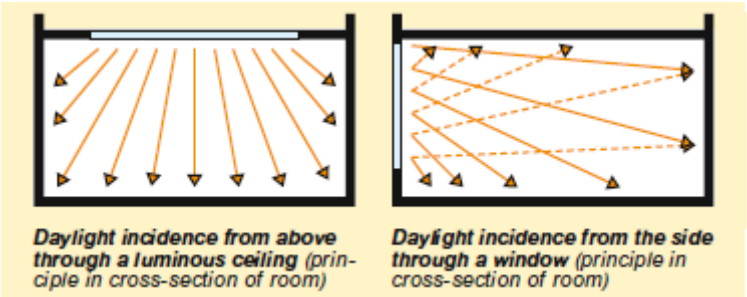


Figure 103 Lighting strategy used in the space

Figure 104. The directional light of spot lamps raises the brightness for exhibits – here with an appropriate beam angle for paintings.

Figure 105. The colors used on the space2.

Figure 106. The room is relatively dark, the higher Illuminance.

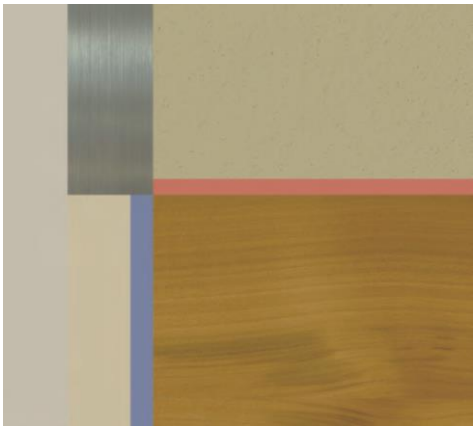


Figure 107.The colors used on the space3.

2.7. Conclusion

After collecting, reading and going through many books, publications and articles and understanding the two parameters whom this thesis concern "Light and Color". We come to understand the physical properties of light and color and their uses, and also their psychological and emotional effect on people's brains and their conscience, we come to conclude that after all the subjective matters and factors that influences the one's decisions, impressions and feeling, **light and color come as one of the main factors to have an effect on the human brain and conscience which lead to a triggered emotion, that is after that translated to visible or non-visible behavior**. Light and color also play a major role in deciding either the space is going to be suitable for its main function or it is going to be unpleasing and boring or disturbing in terms

of the visual comfort or the psychological side which is perceived as a discomfort, that's why specialist and before every design process studies need to be done to decide which colors are going to be applied to certain space. Therefore colors and light also can be used as a motivating element or an attraction element to visitors, by using warm and cheering colors or spectacular and captivating lighting.

The main objective of spatial light and color design is to select effective light and color areas and contrasts that meet the needs of users, functions, and specific situations. Dominant, subdominant, and accentuating colors, and their respective proportions, should be planned according to the elements that link or differentiate them. When developing a color design, consideration should be given to:

- The spatial relationship, its position with regard to other spaces (the size, shape, and compass orientation of the room)
- The lighting conditions (type of light and lighting)
- The furnishings
- The materials used
- The interplay of colors in space.

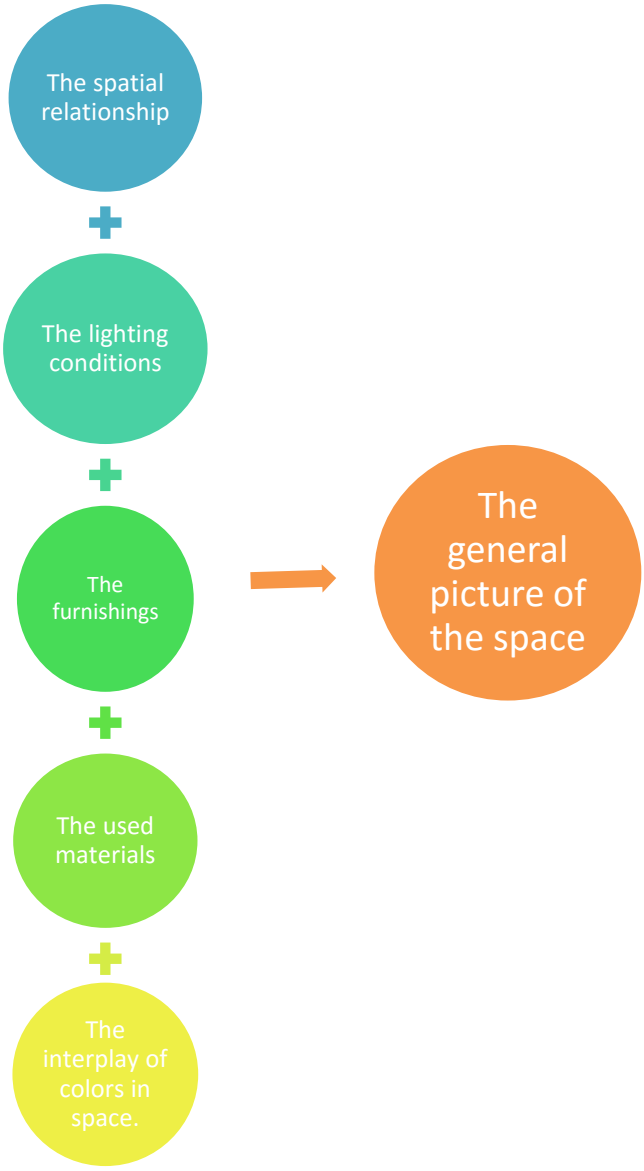


Figure 108 general scheme explaining the main components of the space

Colors in space are not perceived independently. As a result, attention should be paid to the various interactions and consequences of using color in a design, for example, the simultaneous contrast, the successive contrast, and the reflection of colored surfaces on other surfaces.

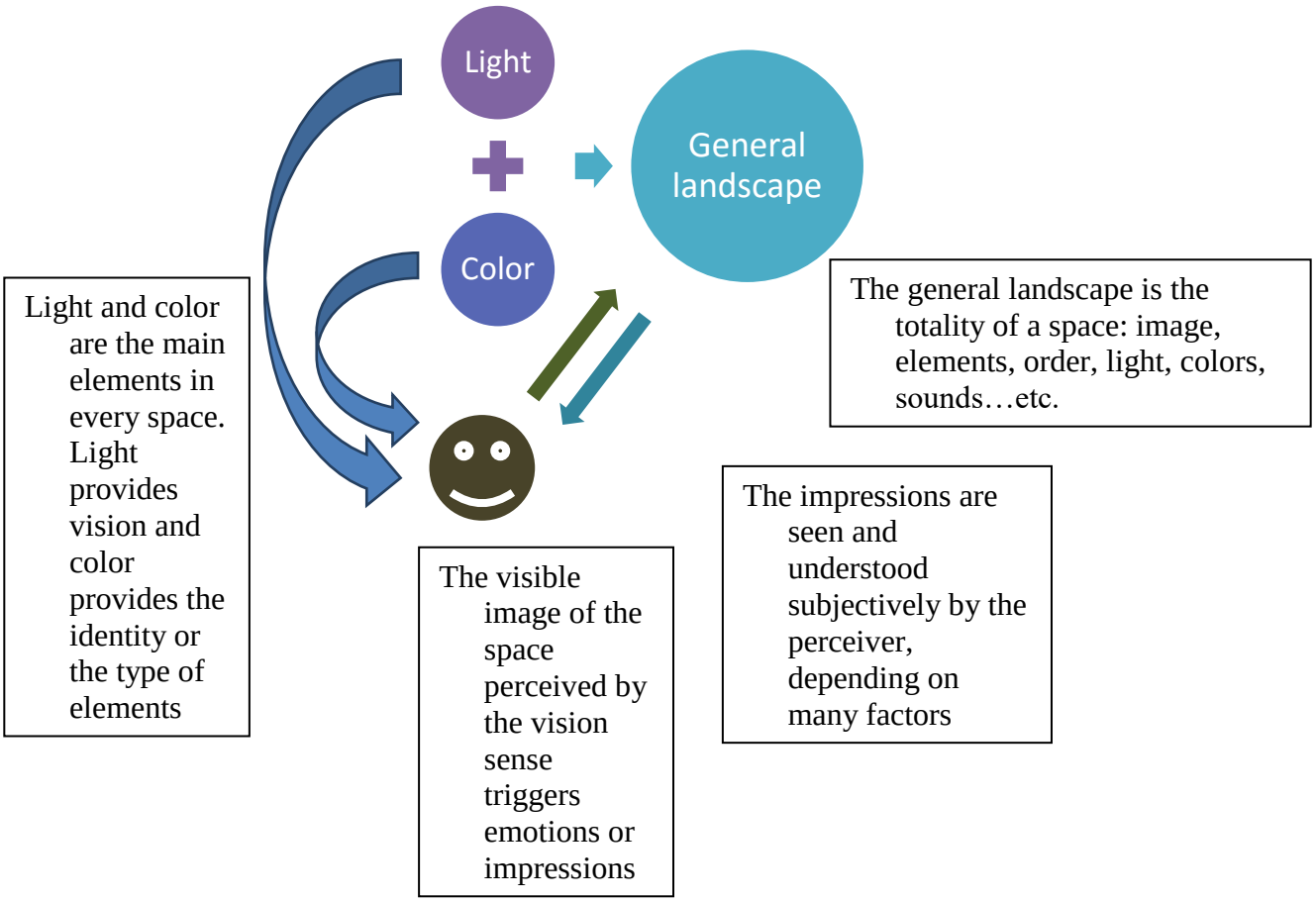
The requirements, demands, and conditions of color design vary from project to project and always present new challenges. Light, material, and color should always be planned as an integrated component of an overall architectural and interior design concept aimed at achieving a humane and environmentally friendly objective; a synthesis of economy, ecology, ergonomics, and aesthetics. This objective can best be achieved through continuous, interdisciplinary teamwork right from the start.

2.8. General Conclusion

After going through many works, studies and examples we can understand the role of the light and color as structural elements of the space. They have two main roles on the space, tangibles and an intangible one:

As a tangible component “light and color”, are the most principal elements. Through light we can perceive distinguish and see things and it gives the space the ability to expose itself through different parameters of the lighting depending on the nature and type of the space. And through color we can understand the nature of the elements, distinguish their materiality and understand significance. So light and color are the main elements to provide the landscape or the view.

As an intangible component “light and color”, do affect directly the brain of the visitor of our space through his visual sense. The different degrees on the intensity of light have different effects from intense to weak and from calm to cheerful, and also for the colors we must chose the colors wisely because for every different palette or nuance there’s a different significance, symbolism and ideas, and each color does effect differently from exciting and energetic to heavy and chill. So light and color are the main elements to control the nature and the essence of a space by triggering and targeting the stimulated emotions and impressions that the different parameters provide for us.



So from this point we can say that light and color can change the nature and the function of a space, and change its identity or essence just by changing the setting of our space. We can add joy to a space just by increasing the light and the cheerful by using shiny and bright colors, or make a space more meditating and calm by reducing the temperature or its palette and use plane and neutral and warm and heavy colors.

Finally we got close to identify some of the main effects of light and color on the space and on the human's behavior, and we can say that light and color are crucial elements and every little visible aspect in the space is related directly to light and color.

Chapter III:

Study of the examples and articles.

CHAPTER-III- Analyse et Interprétation des résultats

Study of the examples and articles

3.1. The relation between the project and the theme

3.1.1. Visual arts

are the arts which produce objects essentially perceived by the bare eye, it includes the plastic arts and arts which introduce new techniques and newly founded arts such as photography and digital arts, and also applied arts and decorative arts and architecture,

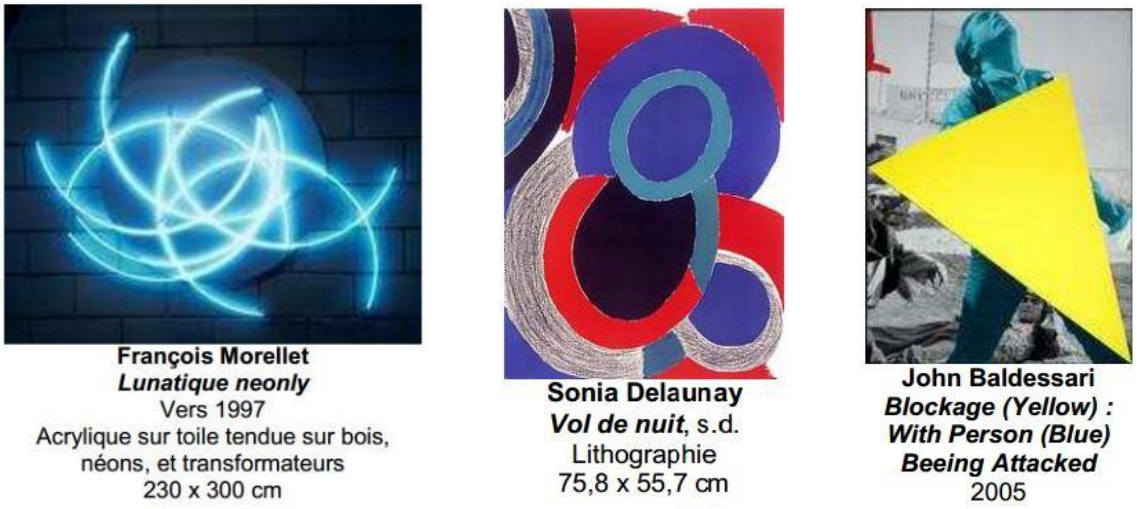


Figure 109. Different paintings. (source: arch2o.com)

3.1.2. Visual arts center

a cultural and educational facility that beholds all sorts of artistic activities that includes visual arts, it's destined to public use and for educational and cultural purposes, it includes artistic events and expositions, art galleries and installations,

Figure 110 San Francisco State University Mashouf Performing Arts Center. source: archdaily.com

Figure 111 Contemporary Arts Center Córdoba Nieto Sobejano Arquitectos source: archdaily.com

3 ith the theme

CHAPTER-III- Analyse et Interprétation des résultats

The project is in a direct relation with the theme of the study because of its artistic nature and its function, that is linked directly to the artistic space and it's configuration, generally these spaces are treated depending on their main function which is determined by its spatial configuration ,determined by the type of lightening and the type of colors and their significance to unveil the character of that space, art projects are projects that almost of the time has a certain use of color and shape to serve an idea, a significance, an emotion or a philosophy, that serves directly the purpose of our research.

Figure 112. Visual arts center. Colors.

(source: deezen.com)

Figure 113. Casa del artes, visual art center.

(source: archdaily.com)

After understanding the relation between the theme and the project now we have to go further by reading and understanding some articles that treats this topic and comparing them to extract the needed knowledge to carry the research

3.2. Study of the articles

	The importance of lighting to the experience of architecture **(Ciro Vidal Fontenelle)**	Color and Light in Architecture and its Effects on Spirits of Space Users in a Psychological View **(Reza Babakhani)**
Problematic	▪ How does light affect the perception of the space? What difference does it make to the architecture? ▪ The Natural lighting methods and the studied and measured methods. Which one is the right to reach the desired ambiances? ▪ The artificial lighting and the new 3d models results comparing to the real space impressions.	▪ The architectural design factors to influence viewing satisfaction ▪ The color and light design process to reach an efficient space ▪ The triggered emotions by light and color ▪ The nature on a space and the effects of light and color on that space

Objectives	▪ How is light analyzed in competitions where only graphic material is submitted? ▪ Do the new 3d models express the real lighting situation, or is the tool used for another purpose? ▪ Is it important to have a criterion of day lighting studies? ▪ How conscious of the daylight situation in the site is the international jury? ▪ Should the artificial lighting design also be incorporated in the program? ▪ For the existing competitors' buildings, is the jury's visit done under similar lighting conditions?	▪ Understand the effect of colors and their variety on the daily life of people ▪ The effect of light and color on human psychology ▪ The Relation between light and color design and efficiency
Methodology	▪ This article's method is trying to understand and answer the question by analyzing different types of documents, first by literature reading, and investigating about terminology in the juries comments, and researches in Swedish magazines and websites about architecture's competitions	▪ Many books, papers and journals used which are published in the field, in an experiment for six months lighting change and rooms color change are studied to investigate their effects on the individual's communications and spirits.
Results	The list of the seven basic terms for description of the light in the space by the visual experience quoted by the jury: - level of lightness - spatial distribution of brightness - shadows - reflections - glare - color of light - colors	-The research indicate that design and planning for appropriate use of color and light increases efficiency, and provide proper and safe communication between space users. Light and color effects on human life changed into an inevitable fact affecting all human life aspects, one can say that color effects is deep and supernatural, since spaces where people live have different light and colors, due to endurable the light and color`s effects are deep. - Manipulating the nature of environment by correcting interior design and using lights and color seriously. Light and color is an extended issue in which it can do many works

CHAPTER-III- Analyse et Interprétation des résultats

	I Investigation of the Luminous Environment in Louis I. Kahn's Kimbell Aart Museum **(SEDA KACEL, BENSON LAU)**	An Evaluation of Light Distribution in the E exhibition Areas of the Mimesis Art Museum D Designed by Alvaro Siza **(Chang Sung Kim)**
Problematic	▪ The mixture of daylight and artificial light in galleries, which one is the predominant and which one is most useful. ▪ Lighting excess in exposition spaces and the reflectivity of materials and surfaces. ▪ The museum architecture as a conceptual and philosophical process.	▪ The architectural design factors to influence viewing satisfaction in the museum ▪ The environmental considerations to offer stable exhibition spaces in the museums ▪ The visitors' satisfaction under the lighting condition of the museum ▪ The glare problem in exhibition areas of the museum ▪ The visitors' satisfaction under the natural lighting condition of the museum
Objectives	▪ This research aims at investigating the lighting the gallery spaces in this museum from both subjective and objective perspectives.	▪ Understand the typologies of natural lighting used in the galleries and how to reach satisfactory lighting mixing natural daylight with ▪ Answer the questions and measure the visitors' opinions on architectural factors for museum design such as size of exhibition area, exhibition method, exhibition time, visitors' circulation, exhibition environment and rest area.
Methodology	▪ Reading and understanding some literature and paperwork and analyzing it. ▪ The performative studies were conducted by using Autodesk ECOTECT / RADIANCE. ▪ Collecting data, and measurements and analyzing the results.	▪ Reading literature and publications and understanding it ▪ Providing a survey to the visitors with questions, and analyzing the answers.. ▪ Collecting data, and measurements of lit spaces and analyzing the results.
Results	▪ Kahn created this unique luminous environment by using both top light and side light to enrich and enhance the lighting conditions inside the gallery spaces. ▪ Tempering the light through light reflector, vaulted ceiling and internal light courts, undesirable glare which may potentially caused by the overhead sun in Texas has been skillfully avoided	▪ The works of Alvaro Siza have been referred that they were not the theoretical architecture but the sensual and experiential one, and they were designed on the base of their locality. ▪ The light endowed the museum with a sense of continuity that helped guide the visitors' movements. ▪ The results of the measurements showed that the illumination levels of the Mimesis Art museum on the first floor were effectively controlled to display the art works.

CHAPTER-III- Analyse et Interprétation des résultats

After reading, understanding and comparing these articles, we come to collect some knowledge concerning the light properties in the display spaces, and the effect of light and color on people in a psychological level.

3.2.1. The collected knowledge is:

1- Listing some overall demands for good lighting:

- stimulating surroundings
- Adequate visibility of detail information
- Opportunity of individual adjustment
- Daylighting as far as possible
- Attention to running costs and energy

2- The articles do signify that design and planning for appropriate use of color and light increases efficiency, and provide proper and safe communication between space users. Light and color effects on human life changed into an inevitable fact affecting all human life aspects, one can say that color effects is deep and supernatural, since spaces where people live have different light and colors, due to endurable the light and color`s effects are deep.

3.3. Analysis of the examples

3.3.1. Project's presentation

Visual Arts Building at the University of Iowa	Black Family Visual Arts Center
Architects Steven Holl Architects **Location** Visual Arts Building, Iowa City, IA 52246, United States **Project Year** 2016 **Area** 11706 m² 	**Architects** Machado and Silvetti Associates **Location** Hanover, New Hampshire **Project Year** 2012 **Area** 9760 m² 

3.3.2. The contextual analysis

3.3.2.1. The project's environment

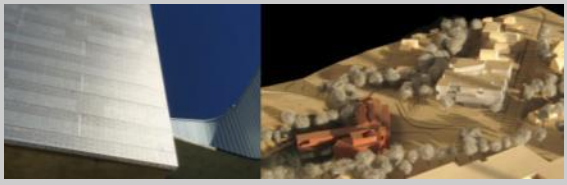
3.3.2.1.1. Scale of projects

Visual Arts Building at the University of Iowa	Black Family Visual Arts Center
• The project's size is medium comparing to the environment it is inserted in. • The neighborhood is composed of different art facilities and departments which are close to each other in the matter of scale.  • The project is composed of 4 levels • The surrounding projects are two types, residential and cultural facilities and that has a harmonious height that is between 2 and 4 levels  That has a harmonious height that is between 2 and 4 levels. 	• The project's size is medium comparing to the neighborhood it is inserted in.  • The project is composed of a ground levels + 2 other levels • The project's height is one level higher than the building facing it's south  • The project is composed of a ground levels + 2 other levels • The project's height is equal to the facing building on the west-south  • The project is composed of a ground levels + 2 other levels • The project's height goes harmoniously with the heights of the buildings around

3.3.2.2. Stratification

Visual Arts Building at the University of Iowa	Black Family Visual Arts Center
• The project is standing out in its environment and integrated by contrast and it created by the reflective material used in its façades. 	• The stratification of the main layers of the landscape 
• The stratification of the main layers of the landscape 	• The stratification of the main layers of the landscape • The project is melting in the landscape and it is well integrated by color and texture 

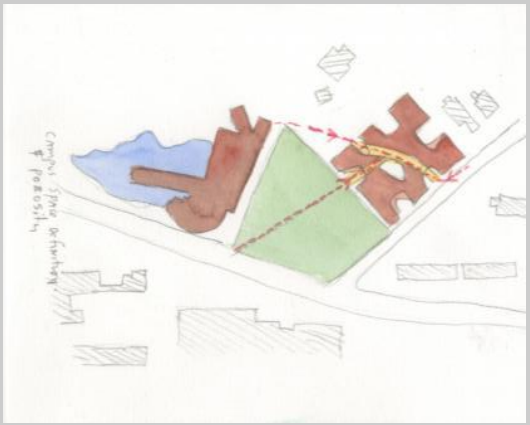
3.3.2.3. Integration

Visual Arts Building at the University of Iowa	Black Family Visual Arts Center
• The project is integrated in its own environment by contrast, with aluminum (reflective material) façades and an irregular shape that is composed of different slices. • The projects stands out of its neighborhood by its unique shape 	• The project is harmoniously integrated in its environment by the use of a regular shape and the use of Color, texture and materials 

3.3.2.4. Relation / street

Visual Arts Building at the University of Iowa	Black Family Visual Arts Center
• The project establishes a direct relation with the street and the neighborhood, by its ground flood plan and the front open public space used as an emerging spot. • The site is composed of two parts :the project / an emerging open public space 	• The site is divided to two parts : • A built part which groups all the building and its facilities in one stack of blocks • An open space part in front of the main façade that is destined for public use. 

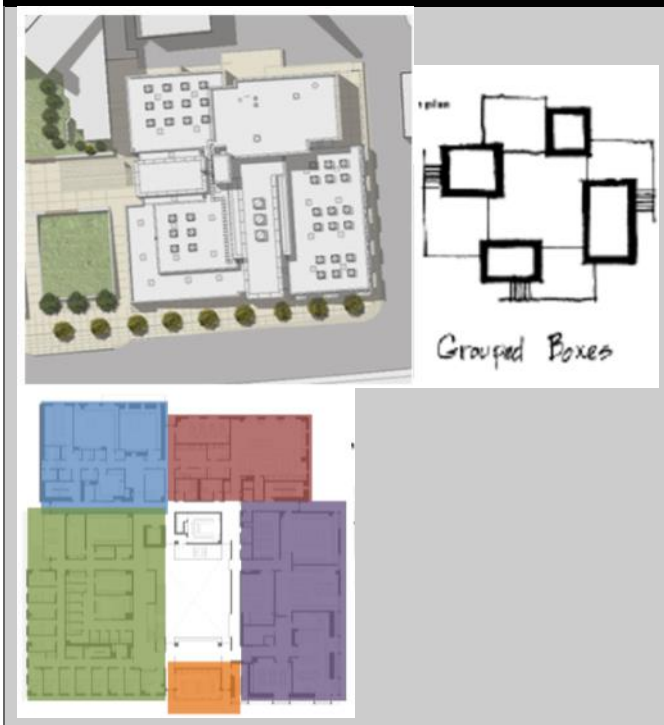
3.3.2.5. Relation Exterior / Interior

Visual Arts Building at the University of Iowa	Black Family Visual Arts Center
• The relation between the exterior and the interior of the project isn't really clear, the relation is provided by two axes set by the architect to set the project in a link between the project and the library next to it and to the exterior walking path way. 	• The relation between the exterior and the interior of the project isn't clearly provided, the project is composed of many blocks gathered around a large central atrium • There are some spaces that are in a relation with the exterior visually by the transparency that offers a direct view to the outside. 

3.3.3. Organizational analysis

Black Family Visual Arts Center	
	The project has a grouped spatial organization due to its function, it's about working and teaching spaces gathered around a central space to offer more interactivity between the spaces and the disciplines.

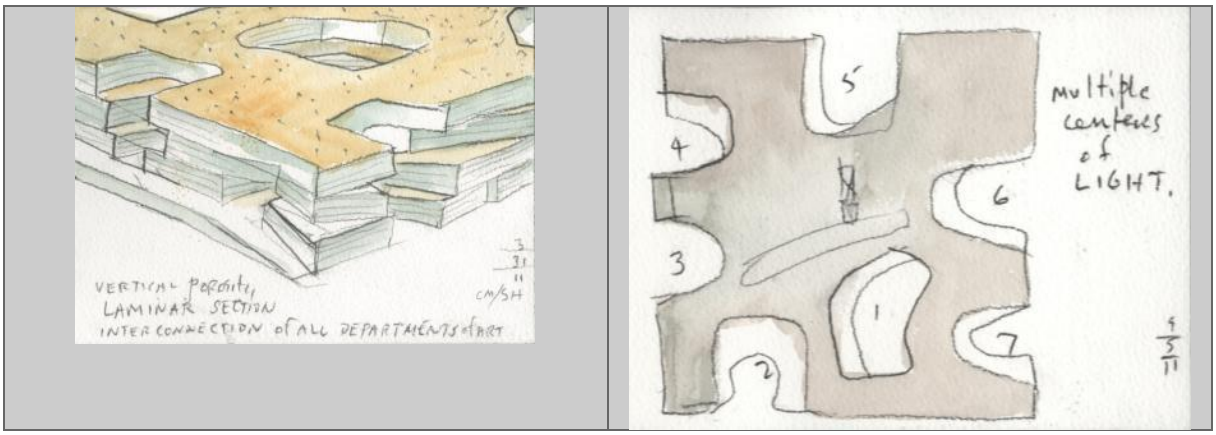
Figure 114 the project's plans source: stevenholl architect

Visual Arts Building at the University of Iowa	
	**Grouped boxes** The project is composed of many blocks gathered around a large central atrium.

3.3.4. Conceptual analysis

3.3.4.1. Interconnexion and light

Interconnexion	Light
In a school of the arts today, interconnection and crossover are of fundamental importance. Today digital techniques open up increased interconnection between all the arts. Interconnection between all of the departments is facilitated in the vertical carving out of large open floor plates. Students can see activities ongoing across these openings and be encouraged to interact and meet. Further interconnection is facilitated by Glass partitions along the studio walls adjacent to internal circulation.	Natural light and natural ventilation are inserted into the deep floor plates via the "multiple centers of light." Seven vertical cutouts encourage interaction between all four levels. These spaces of glass are characterized by a language of shifted layers where one floor plate slides past another. This geometry creates multiple balconies, providing outdoor meeting spaces and informal exterior working space. Multiple Centers of Light



3.3.4.2. Circulation, relations and strategies

Circulation	Relations	Strategies
• Stairs are shaped to encourage meeting, interaction and discussion. Some stairs stop at generous landings with tables and chairs, others open onto lounge spaces with sofas. • Stairs as Vertical Social Condensers: Corridors as Horizontal Meeting Spaces	**Campus Space Definition/Porosity** • The original grid of the campus breaks up at the river, becoming organic as it hits the limestone bluff. The Arts West building reflects this irregular geometry in fuzzy edges. The new building picks up the campus grid again in its simple plan, defining the new campus space of the "arts meadow."	**Material Resonance, Ecological Innovation** • Natural ventilation is achieved via operable windows. A punched concrete frame structure provides thermal mass at the exterior while "bubble" slabs provide radiant cooling and heating. A Rheinzink skin in weathering blue-green is perforated for sun shade on the • Southwest and southeast.

CHAPTER-III- Analyse et Interprétation des résultats

By collecting the information from both of the analyzed projects and comparing and extracting the most important and useful spaces we can conclude and provide a functional project with the sufficient and balanced program.

3.3.5. The projects program

The proposed program is

Spaces

Photography and video-making	Wood and metal works and sculpture
Graduate studio	
Photo studio	Wood shop classroom
Printing	Wood shop studio
Computer classroom	Digital cutting
Offices	Prototyping studio
Equipment work-room	Electroforming
BFA studio	Spray booth
Computer lab	Custodial
Seminar	Offices
Dark rooms	Maintenance work-room
Special projects studio	Heavy equipment
Classrooms	Bloc control
Edit studio	Sculpture studio
Recording	Ceramic shell
Sound design studio	Glazing/mixing
VR lab	Ceramic studio
VR cave	KLN room
Equipment check	Plaster studio
Storage	Graduate studio
Forum	Offices
Maintenance work bench	Storage
Custodial work-room	Install lab
Telecommunication	Studios
Staging	Metal lab
Print making studios	Metal hot
Acid room	Spray booth
Relief room	Dust exit
Hot hazard	Metal cutting
Editing	Metals workshop
Common area	Amphitheatre
Seminar	equipment work-room
Materials library	

7 project's proposed program

3.4. Site analysis

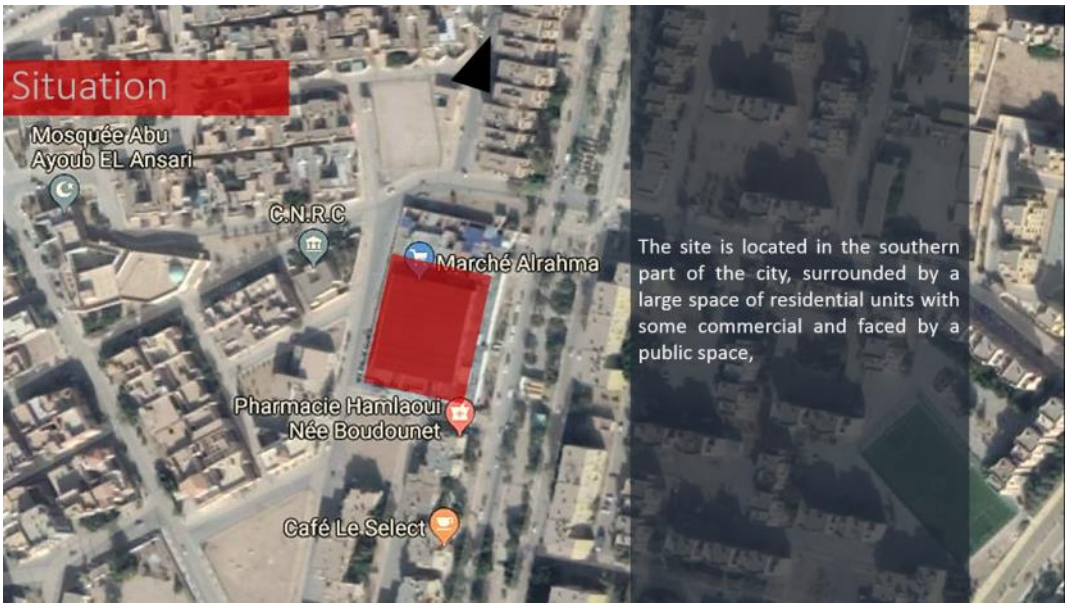


Figure 115 project's location1 source: author picture from google

The project is located in the southern part of the city, in the middle of a large residential city and some little commercial facilities. The location is facing a public space and a large avenue which has from medium to high pedestrian and mechanical flux during the day and especially working days.

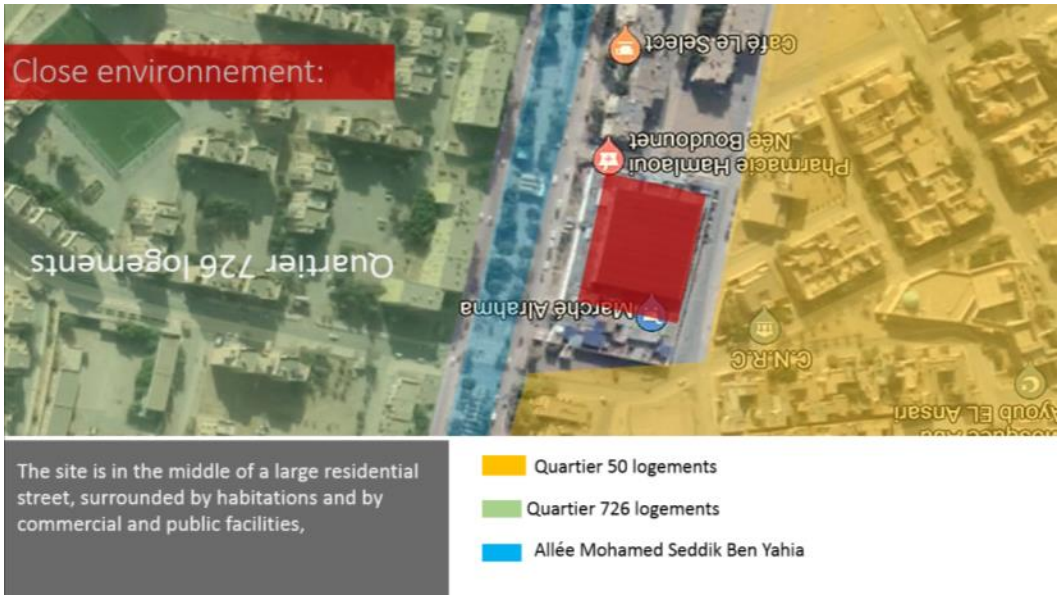


Figure 116 project's environment 1 source: author picture from google

Figure 117 the project's envornment 2 source: author picture from google

The site is surrounded by two main roads and a secondary way, and also is facing a large public pathway for the pedestrians among other pathways.

Figure 118 pedestrian traffic source author picture from Google

Figure 119 Sun pathway using sunpathcalc picture from google

3.4.1. Sun pathway

The site is fully exposed to the sun all the day. The surrounding buildings aren't high enough to provide shading or any solar protection for the project.

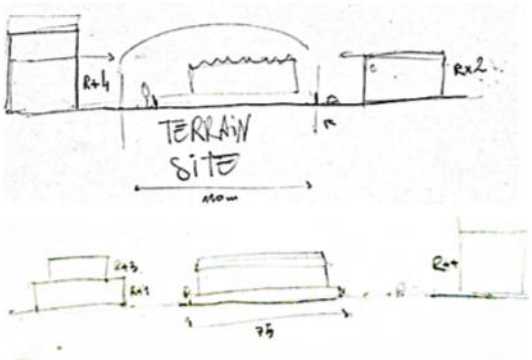


Figure 120 surrounding heights of the Project source : authour

3.4.2. Understanding the project's environment:

Figure 121 stratification of the street's landscape source: author

After dividing the landscape and analyzing the environment, we can see that the colors in this views are randomly gathered, there's no harmony below and also the intensity and the hue of colors are low which makes the landscape lack of vitality and of excitement and of life.

Figure 122 Stratification of the street's landscape 2 source: author

3.4.2.1. The site's positive and negative point

- **Positive points:**
  1- In the center of a large residential habitations and other public and commercial facilities, which provides a strong link between the project and the functionality of the city
  2- Easy to find, easy to access
  3- A large public space in the front façade
- **Negative points:**
  1- The environment of the project lacks of solar protection
  2- The environment is chaotic in terms of proportions and color harmony

3.4.2.2. The proposed solutions for the site and the project

- Create a volume which is composed from different blocs to integrate in the general landscape and to provide shading by the change of the heights
- Add a new palette of colors to the landscape, which contrasts with the original one and adds cleanness and purity to the landscape.
- Using the general shape as solar protection method by using blank facades, shape divides, introverting the openness and using reflective colors to reduce the transmitted solar rayon.

Chapter IV:
The design process of the project.

The design process of the project

4.1. The concept/idea

The first thought was to create a pathway through the project and to reinforce the pedestrian flux around and through the project, and to create a powerful and direct link with the environment of the project.

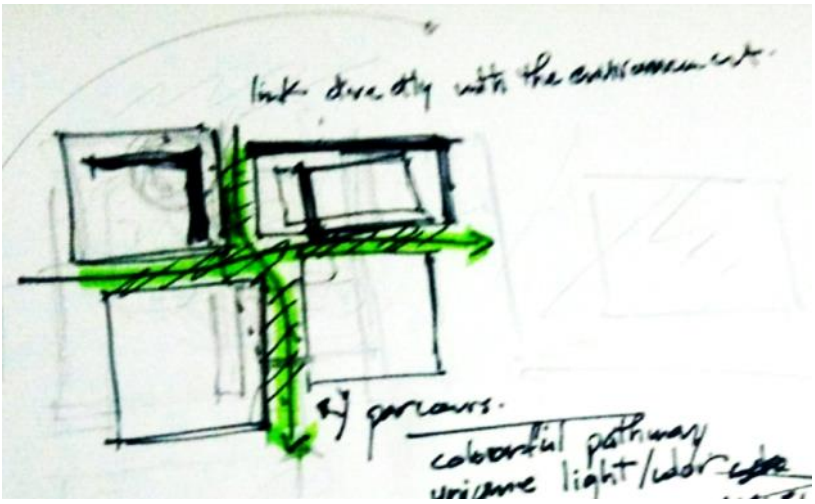


Figure 123 Sketch shape 1 source : author

The main single bloc was divided to 4 blocs which are functionally related to create a pathway through it,

It was resized to be proportionally stable, moved the block to create different perspectives

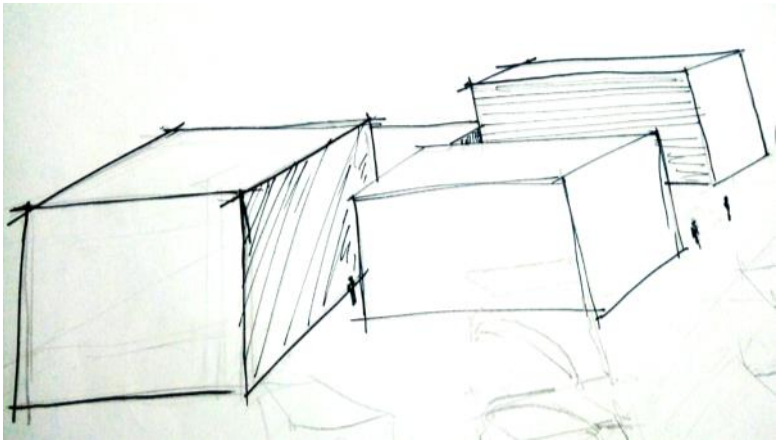


Figure 124 sketch volume1 source : author

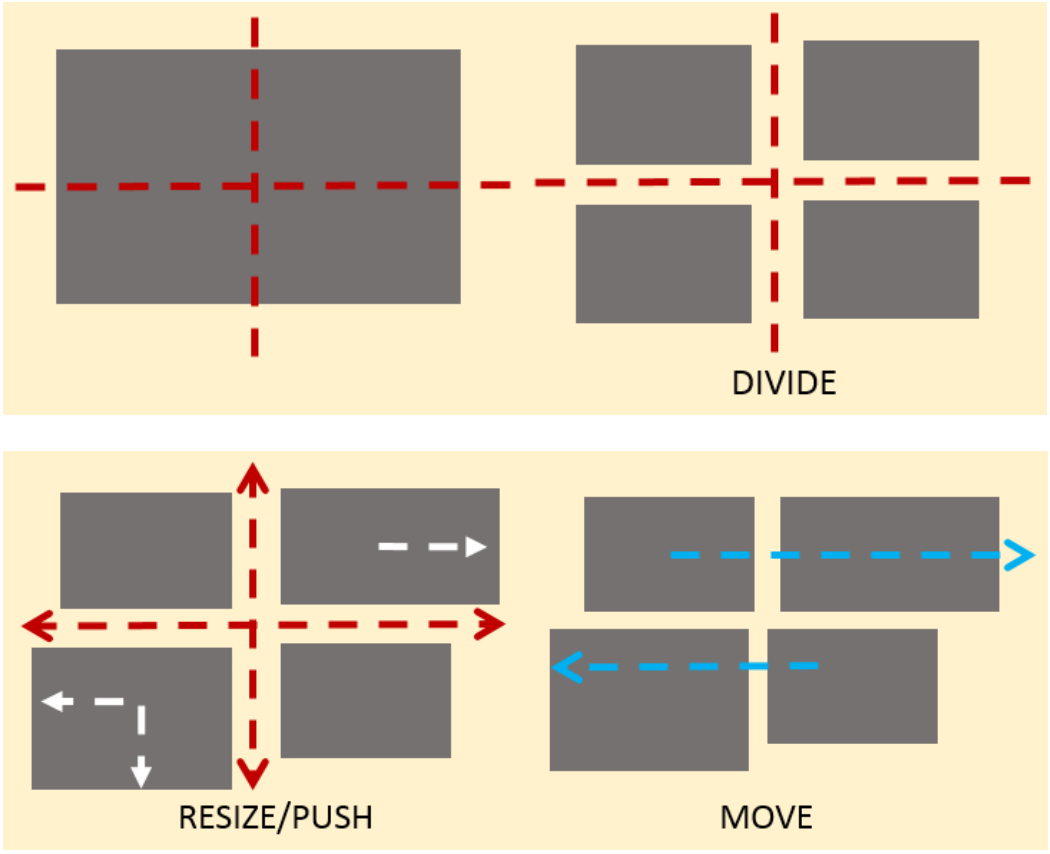


Figure 125 explaining scheme 1 (source: author).

Create a core that links between all 4 blocks in one large core, which allow to walk through (under).

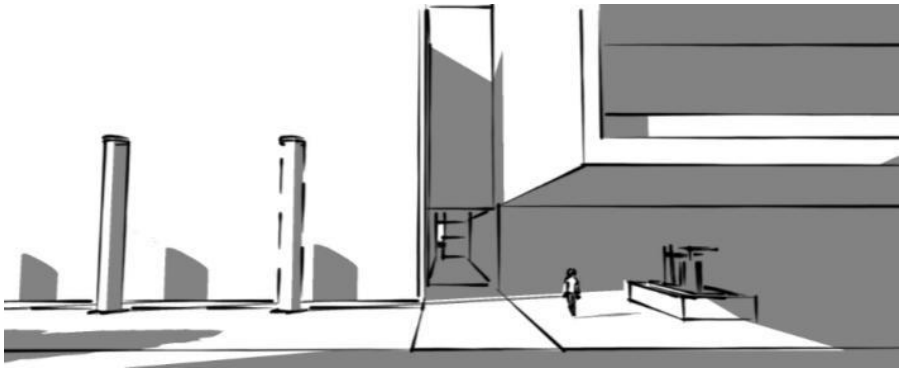


Figure 126 digital sketch1 source : author

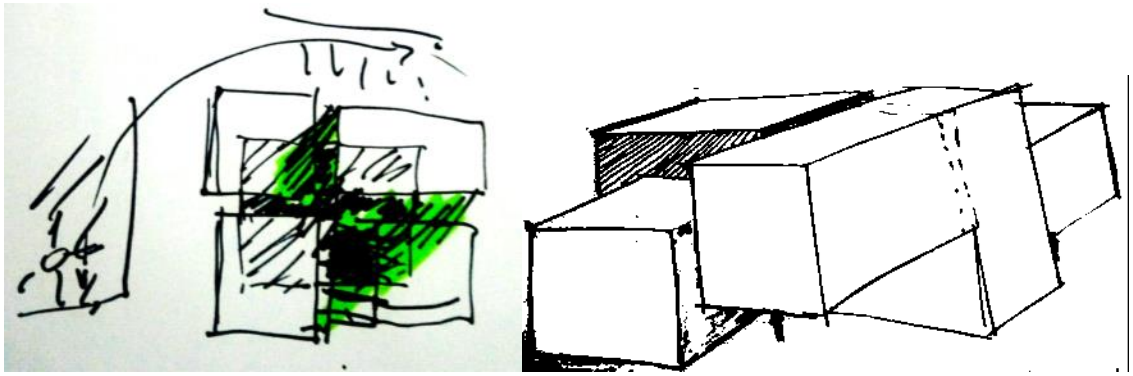


Figure 127 handmade sketches

source: author

The composition is about blocs connected by a single core, the geometry and shapes are inspired by the suprematist modern sculptor Donald Judd.

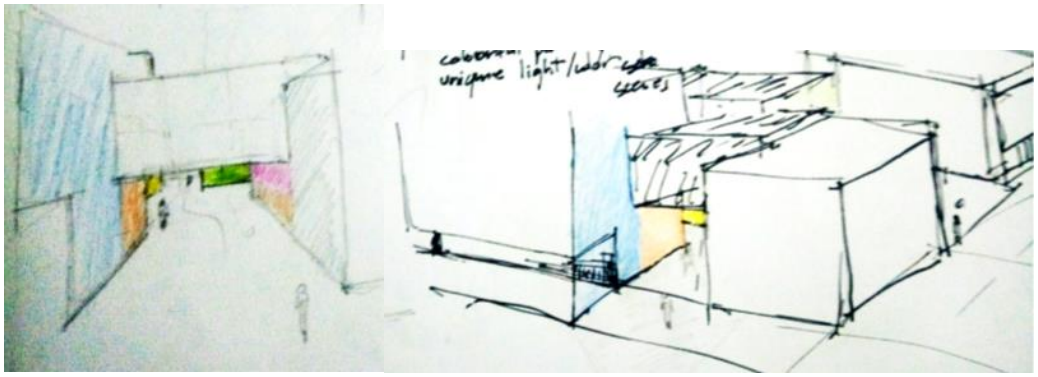


Figure 128 handmade color sketches sources: author

Creation of different perspectives, scenes by ways and colors. Using colors as a triggering element. The creation of a central spaces that is shaped by a conic shape which crafts the center of the composition.

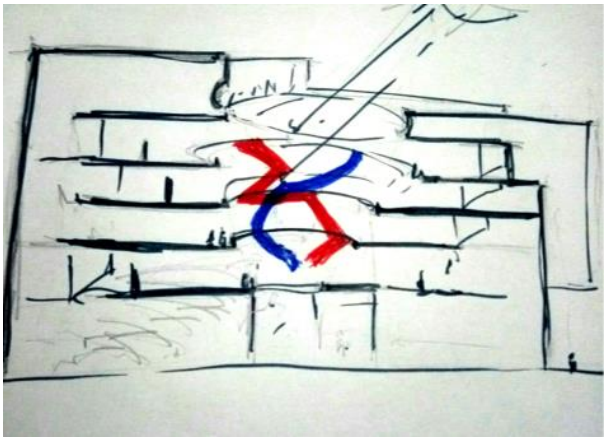
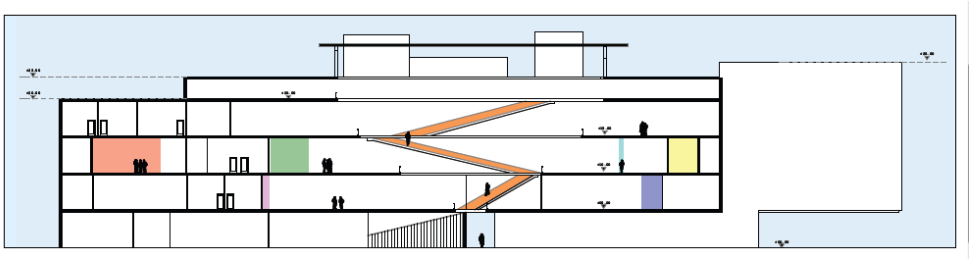


Figure 129 handmade sketch central core source: author

This central space is the core of the vitality of the project, it engenders the energy that is based on the exchange and the community.



These ramps provide a certain continuity in the walkthrough inside the project, it allows us to have an uninterrupted journey through the views and the different disciplines inside the building.

4.2. The digital sketches

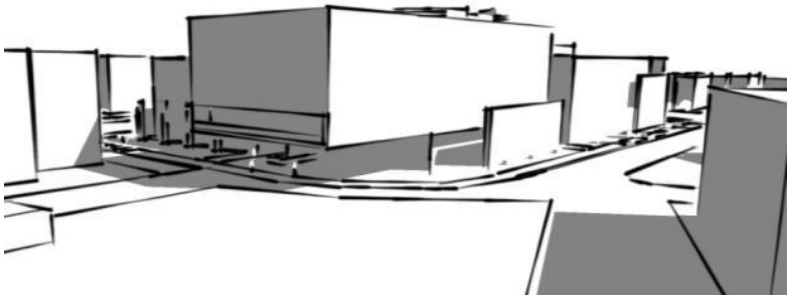


Figure 130 digital sketch1 source : author

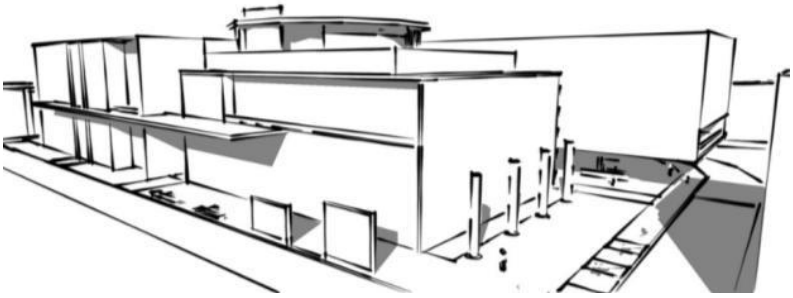


Figure 131digital sketch2 source : author

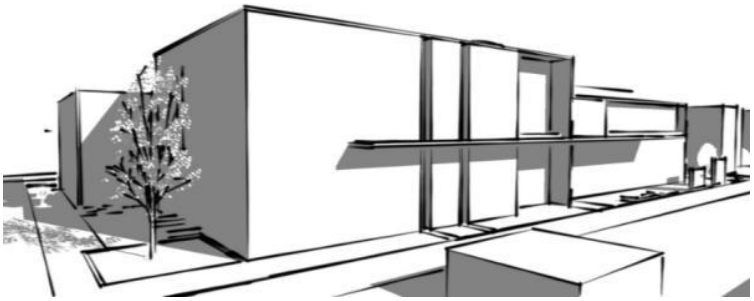


Figure 132 digital sketch3 source : author

4.3. Primary sketches and views

Figure 133Monochrome perspective silhouette source : author

Figure 134 Digital sketch entrance perspective source: author

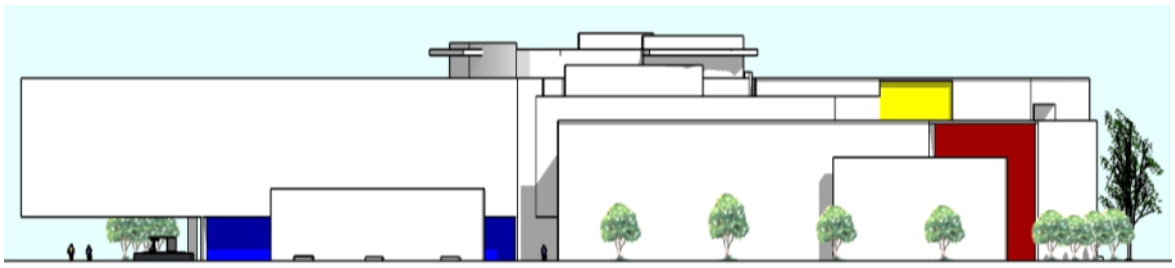


Figure 135 sketch West elevation source: author

Figure 136 Sketch east elevation source: author

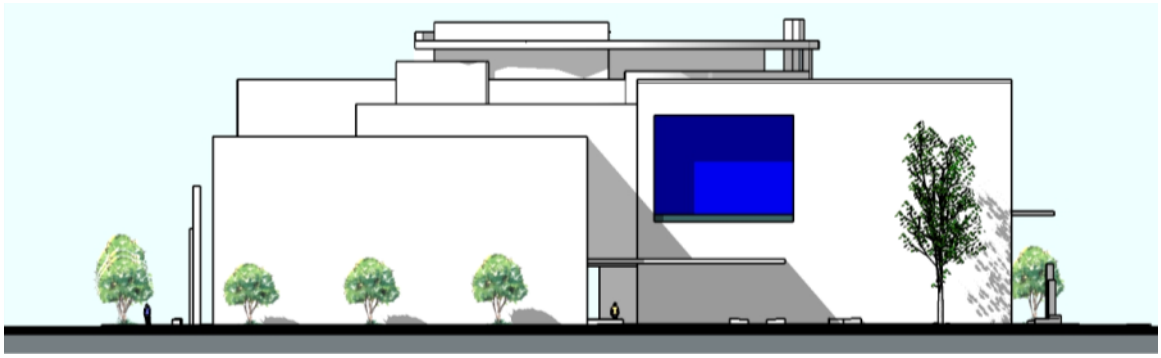


Figure 137 Sketch South elevation source: author

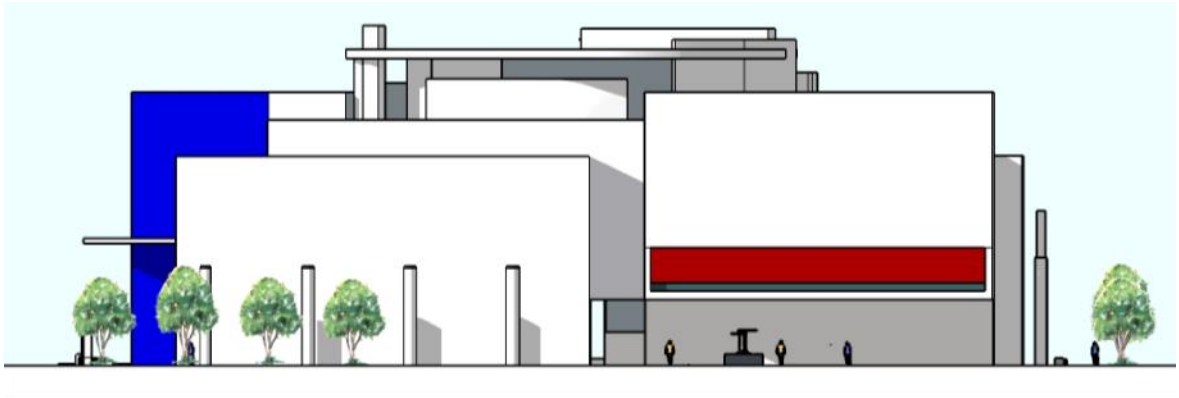


Figure 138. Sketch north elevation source: author

Références

[1] Derek Phillips, "***Lighting in Architectural Design*** ", New York, US: Mc Graw-hill Book Co., p. 310, **1964**.

[2] Derek Phillips, "***Lighting Historic Buildings*** " Architecture Series, 1st ed.: McGraw-Hill Professional, p. 224, **1997**, ISBN: 978-0070498648.

[3] Derek Phillips, "***Daylighting: Natural Light in Architecture***," Architecture Series, Jordan Hill, Oxford, UK: Architectural Press, p. 240, **2004**, ISBN: 978-0750663235.

[4] Derek Phillips, "***Lighting modern buildings***," Architecture Series: Routledge, **2013**, ISBN: 008049613X.

[5] Nick V. Baker, Aldo Fanchiotti, and Koen Steemers, "***Daylighting in architecture: a European reference book***," Routledge (Taylor and Francis Group), p. 380, **2013**, ISBN: 9781134253708.

[6] Building Research Establishment (BRE), "***Office Lighting for Good Visual Task. Conditions***," BRE Electronic Publications, **1981**.

[7] Skarlatou Alkistis-Zoi, "***Light effects in the design process: a theoretical investigation of designers' perceptions of light effects and an empirical study of how they use them in architectural lighting design***," Thesis (Doctoral), Bartlett Faculty of the Built Environment, Department of Architecture, UCL (University College of London), London, UK, p. 543 (Appendices included), **2010**.

[8] Keith W Jacobs, and Frank E Hustmyer Jr, "***Effects of four psychological primary colors on GSR, heart rate and respiration rate***," *Perceptual and motor skills*, vol. 38, no. 3, pp. 763-766, **1974**. DOI: 10.2466/pms.1974.38.3.763.

[9] Frankl Viktor E., "***Logotherapie und Existenzanalyse: Texte aus sechs Jahrzehnten, Quintessenz***," 3rd ed., Munich, Germany: BeltzPVU, p. 334, **1998**, ISBN: 3621274103.

[10] Frankl Viktor E., "***Ärztliche Seelsorge. Grundlagen der Logotherapie und Existenzanalyse. Und Vorarbeiten zu einer sinnorientierten Psychotherapie. (Gesammelte Werke, 4).***" 1st ed., Köln, Germany: Böhlau Verlag, p. 620, **2011**, ISBN: 9783205786191 und 320578619X.

[11] Gebessler Renate, "***Zeichen einer humanen Arbeitswelt***," in: Arno Votteler: Ideen für eine neue Bürowelt - Catalog for the exhibition "*Lebensraum Büro*", at the Orgatec in Cologne, 22.10–27.10.1992, Oktagon-Verlag, Munich, **1992**

[12] Gerard Robert Marius, "***Differential effects of colored lights on psychological functions***," PhD thesis, University of California, Los Angeles, p. 301, **1957**. Doc. N°:37990827.

[13] Richard Langton Gregory, "***Seeing in the light of experience***," *Lighting Research & Technology*, vol. 3, no. 4, pp. 247-250, **1971**. DOI: 10.1177/096032717100300401.

[14] Meerwein Rodeck Mahnke, "***Color – Communication in Architectural Space",*** 2007