EFFECTS OF DIRECT LIGHTING ON READABILITY AMONG YOUTH OF VADODARA CITY

APRIL-2023 JAHNAVI LUHAR

EFFECTS OF DIRECT LIGHTING ON READABILITY AMONG YOUTH OF VADODARA CITY

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By

JAHNAVI LUHAR

Department of Family and Community Resource Management

Faculty of Family and Community Sciences

The Maharaja Sayajirao University of Baroda

Vadodara

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Jahnavi Luhar

Institutional Ethics
Committee for Human
Research
(IECHR)

FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

Ethical Compliance Certificate 2022-2023

This is to certify that **Ms. Jahnavi Luhar's** study titled, **Effects of Direct Lighting on Readability among Youth of Vadodara city** has been approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Science, The Maharaja Sayajirao University of Baroda. The study has been allotted the ethical approval number **IECHR/FCSc/M.Sc./2022/05.**

Prof Shagufa Kapadia
Chairperson
IECHR

Prof Mini Sheth
Member Secretary
IECHR

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Estd. 1949

DEPARTMENT OF FAMILY AND COMMUNITY RESOURCE MANAGEMENT
FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
VADODARA

CERTIFICATE

This is to certify that the thesis entitled **"EFFECTS OF DIRECT LIGHTING ON READABILITY AMONG YOUTH OF VADODARA CITY"** submitted for partial fulfilment of the requirement for the Degree of Masters in the Faculty of Family and Community Sciences (Family and Community Resource Management) to The Maharaja Sayajirao University of Baroda, carried out by Ms. Jahnavi Luhar, is her original bonafide work.

Ms. Neha Rathore
Co – Guide

Dr. Sarjoo Patel
Research Guide

Prof. (Dr.) Uma Iyer
I/c Head
Department of Family and Community Resource Management
Faculty of Family and Community Sciences
The Maharaja Sayajirao University of Baroda
Vadodara

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CHAPTER- 1

INTRODUCTION

Sight is the sensory experience in which light reflects off of shapes, objects and surfaces. Vision is how the mind, interprets these images. Sight allows a person to witness an event, but vision helps the person understand the significance of that event and draw interpretations. Reading in dim light won't cause permanent damage to the eyes, but it can lead to short-term problems, such as headaches and eye strain. Whether reading a book, an e-reader or on a tablet, one should know that reading with proper lighting helps to avoid eye strain. Light is a form of energy without which there can be no vision. When the light strikes an object it may be reflected, absorb or pass through. It is also defined as electromagnetic radiation, which is capable of affecting the sense of sight.

There are different types of lighting schemes, one of them is Direct Light which is the most commonly used type of lighting scheme. In a direct lighting scheme, more than 90 per cent of the total light flux is made to fall directly on the working plane with the help of deep reflectors. Colour temperature is a way to describe the light appearance provided by a light bulb. It is measured in degrees of Kelvin (K) on a scale from 1,000 to 10,000. CCT (Correlated colour temperature) deals with the warmth and coolness of light provided by the light source.

1.1 Lighting

Light is electromagnetic radiation that can be detected by the human eye. Electromagnetic radiation occurs over an extremely wide range of wavelengths, from gamma rays with wavelengths less than about 1×10^{-11} metres to radio waves measured in metres. Within that broad spectrum, the wavelengths visible to humans occupy a very narrow band, from about 700 nanometres (nm; billionths of a metre) for red light down to about 400 nm for violet light. The spectral regions adjacent to the visible band are often referred to as light also, infrared at the one end and ultraviolet at the other. Light is normally taken into consideration as the visible part of the spectrum; however, in physics, light is described through all portions of the electromagnetic scale inclusive of invisible forms such as infrared, ultraviolet, x-rays, radio waves, and more. Light

energy can be defined as a wave, a particle (or photon), or an aggregate of both (known as the wave-particle duality). Another method is to consider light energy as a ray. The observations of the way light behave with matter demonstrate the diverse properties of a wave, particle, or ray. The specific properties of light are studied and applied in the area of Optics and Photonics. Besides light enabling us to see, it cuts and welds control electrical circuits, transmits sound, and is utilized in a notable variety of merchandise and industries. Uses have extended into regions that can be vital to the health and great of human life, and additionally the health of the whole planet.

1.1.1 Illumination

Illumination is the transport of energy from a light source to the desired surface. The unit for illumination is LUX

$$\mathrm{LUX} = \frac{\mathrm{Lm}}{\mathrm{m2}}$$

Here, Lm = Lumen, m = meter

It may also be defined as light output and flow of light from the source object. For example, Bulbs, T-five. This is also known as luminous flux.

1.1.2 Luminous flux

The amount of light energy radiated from a source/ an illuminating object in all directions per second is known as luminous flux. Its unit is lumen and is denoted by F.

1.1.3 Luminous Intensity

The amount of light radiated by a light source in a particular given direction is defined as luminous intensity. It indicates the concentration and strength of light. Its unit is the candela (cd).

$$\mathrm{I} = \mathrm{F}/\,\Omega$$

Ω (unit of solid angle), F= luminous flux, I= intensity

1.1.4 Luminance

The brightness of the light that is reflected or transmitted off the surface in a specific direction is called Luminance. It is also considered as human perception of brightness, or how bright one can perceive an object that is the amount of light falling on desired surface/ object.

$$\text{luminance} = \frac{\text{cd}}{\text{m2}}$$

Here, Cd= candela, m= meter

This will indicate how bright the surface would be.

1.1.5 Colour Rendering Index (CRI)

It deals with the ability to see colours in another aspect of lighting quality. Light sources vary in ability to accurately reflect the true colours of objects. The CRI is used to compare the effect of the light source on the colour appearance of the object. The scale defines the points from 0-100. A higher CRI means better colour rendering or less colour shift.

Table 1: **Colour Rendering Index (CRI)**

1st range	75-100	Excellent
2nd range	65-75	Good
3rd range	55-65	Fair
4th range	0-55	Poor

Sometimes higher CRI often tends to create an illusion of higher illumination levels.

1.1.6 Spatial distribution of light

This deals with the uniformity of illuminance that addresses how evenly the light had been spread on the task area. The two major factors which affect the uniformity of the light spread are improper fixture placement and fixtures which have add-on reflectors or louvres that narrow the light distribution. Non-uniform illumination causes several problems like inadequate light levels, visual discomfort, bright spots and patches of light.

1.1.7 Correlated colour temperature (CCT)

Correlated colour temperature (CCT) is a one-dimensional metric that aims to quantify the perceived visual quality of nominal white light sources. It is often used as a proxy for the colour quality of light sources due to its ease of use. It should be noted that CCT only provides information about the appearance of a light source, and it does not provide any information about object appearance under a light source. Colour temperature deals with the warmth and coolness of light provided by the source. A warm colour has a lower colour temperature.

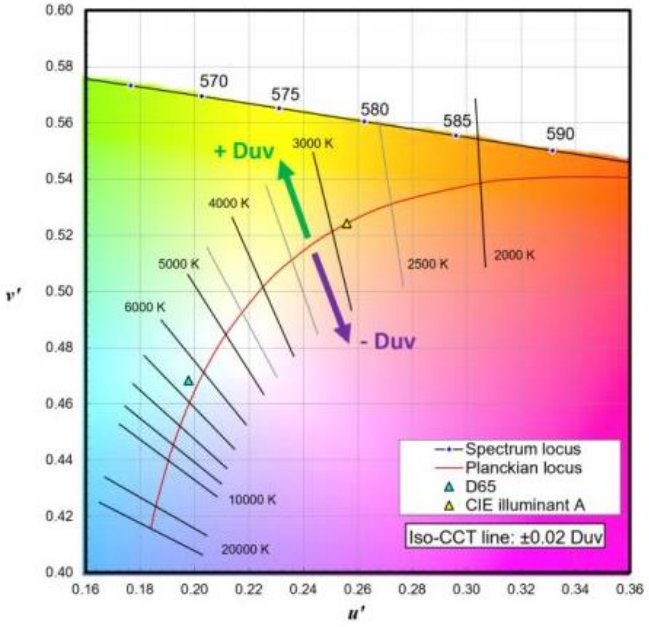

Plate 1: Correlated Colour Temperature

(Correlated Colour Temperature: use and limitations by D Durmus, 2021)

The spectrum locus (black line) represents monochromatic stimuli, which constructs the boundary of the CIE 1976 (u',v') uniform chromaticity diagram. The Planckian locus (red line) represents the chromaticity coordinates of the Planckian (blackbody) radiators at different temperatures. The yellow triangle represents the CIE standard illuminant A (incandescent), and the blue triangle represents the CIE standard daylight illuminant at 6500 K (D65). Isometric CCT lines are

identical CCTs with different chromaticity coordinates drawn for Duv = ±0.02. The positive Duv values (green arrow) are above the Planckian locus, and the negative Duv values (purple arrow) are below the Planckian locus. The background is derived from Davis and Ohno's CQS calculator64 for representation purposes only.

1.1.8 Glare

The most important factor concerning lighting quality is glare. Glare is a sensation caused by luminance in the visual field that is too bright. Discomfort, annoyance, or reduced productivity can result. A bright object alone does not necessarily cause glare, but a bright object in front of a dark background, however, usually will cause glare. Contrast is the relationship between the luminance of an object and its background. Although the visual task generally becomes easier with increased contrast, too much contrast causes glare and makes the visual task more difficult.

1.2 Direct Lighting

The term "direct lighting" describes lighting schemes in which the desired surface receives 90% or more of the light flow. This kind of lighting arrangement is generally seen in settings where lighting is most necessary for small-scale work or other tasks. for instance, companies, storage facilities, schools, and handlooms. It is important to quickly set the fixtures because this type of lighting arrangement often produces unpleasant shadows.

1.3 Visibility and Light

Large tasks generally require less illuminance, brightness, and contrast to be performed. Small detailed tasks may require task lighting to increase the light level significantly. The size, brightness, and contrast of a particular activity affect the lighting required to view that activity is known as task visibility. Knowing a description of the task is essential to designing the lighting for that task. The luminance or brightness of a task increases task visibility. Brighter tasks are easier to see, so long

as it is not so much brighter than their surroundings that it becomes uncomfortable or a source of direct glare. As task contrast decreases, the light level required to see it will increase. If the contrast is too low, it will be difficult to distinguish various components of the task, reducing visibility. Wayfinding refers to the visual guidance provided by the lighting system and the visual elements illuminated. This visual guidance may be illuminated signage that directs occupants to various destinations, or it may be more subtle aids such as continuity and hierarchy of lighting equipment that reinforces areas of similar use. By using the same luminaires for areas of the same use, a consistent pattern is established that visually guides and orients building occupants. Accent lighting can also be used to draw attention to specific areas by increasing the brightness.

1.4 Readability

Readability is commonly defined as the degree of easiness of reading texts which in turn indicates the degree of text comprehension. Readability indices appear practically useful, proxy ways to measure text difficulty and comprehension.

> “The sum total (including all the interactions) of all those elements within a given piece of printed material that affect the success that a group of readers have with it” (Chall & Dale, 1949)

1.5 Readability and Lighting

The difficulty of reading is not just an issue of the eyes; a decent reading light enables the utilization of several body postures and any suitable relationships between the book and the eyes. It takes a particular kind of attention to read a book, both physically and psychologically; it is the responsibility of the Architect to remove any disruptive aspects. For the information on the page or in the book to be readable, light energy is the first crucial requirement. As a result, the reading surface's light density or intensity must be at an ideal level. In order to avoid

distractions and insufficient lighting caused by short-term variations, it is crucial to maintain constant light levels in libraries for visual tasks.

1.6 Meaning of Visual Discomfort

Visual discomfort is pain or discomfort in or around the eyes, occasionally accompanied by symptoms like red, itchy, or watery eyes. It is frequently accompanied by headaches and/or nausea. Insufficient light for the activity at hand, stark changes in illumination around the task, shadows, hazy reflections, glare, and flicker are lighting situations that are likely to induce visual discomfort.

1.6.1 The underlying causes of Visual Discomfort are as follows:

- **Poor visibility**

Information that is challenging to retrieve is present in any visual activity with stimuli that are close to the detection threshold. Such poor visibility may raise the neurological demands on processing the visual signal and causes discomfort in the visual system.

- **Overstimulation:**

Overstimulation of the visual brain by broad-field, spatially or temporally repeated patterns can cause discomfort. Long-term labour under such circumstances can cause eye strain, headaches, and weariness.

- **Distraction:**

The wide peripheral field of the human visual system detects bright, moving, or fluctuating objects, which are subsequently analysed by the small, high-resolution fovea. If such peripheral field objects cannot be avoided, they turn into sources of distraction. It can be uncomfortable to look at things that instantly draw attention.

1.7.1 Lighting conditions likely to cause visual discomfort:

Two routes may be seen in the history of efforts to reduce visual discomfort brought on by illumination. The first case illustrates that, even if the cause may not always be apparent, one may tell when they are

feeling visual discomfort without the need for scientific evidence. However, in many circumstances, quick tests, such as protecting the eyes from a glare source, suffice to determine the cause and a strategy for reducing its occurrence. The second is more recent and has to do with the increasing value that society is placing on public health as well as the usage of electric lighting in all kinds of structures. Standards and general advice for lighting installation designers have been published as a result of these advancements.

- **Illuminance**

A well-developed and independently verified model of the impact of illumination on visual performance exists, but it is rarely applied because, in the majority of nations, there are legally enforceable minimum illumination recommendations that are much higher than what is required to provide adequate visibility. The majority of nations have their illuminance standards, but they all exhibit the variations that were predicted from the consensus process used to choose the recommended illuminances and have now become de facto minimums. Oddly enough, despite the recent focus on lowering electricity use, illuminance requirements that specify maximum illuminances are conspicuously lacking. At illuminations above 1000 lux and separately at illuminations above 2500 lux, there is some evidence for greater discomfort indoors.

- **Illuminance uniformity**

If properly matched to the task needs, illumination suggestions should ensure acceptable visibility, but they are insufficient on their own to prevent visual discomfort. It is also necessary to take into account how light is distributed throughout space. To do this, it is advised to use a homogeneity ratio, which is defined as the minimum/average illumination present across a fictitious working plan. According to numerous research, windowless workspaces should aim for a homogeneity ratio of 0.7 or higher. The illumination on a desk near a window, however, will be significantly more than on a workstation far from the window in large

rooms with huge windows. The illuminance uniformity ratio will then be significantly less than 0.7, although unless there is significant internal obstruction, few complaints are made.

- **Shadows**

When an opaque object deflects light coming from a specific direction, shadows are created. The quantity and type of shadows cast by a lighting installation are influenced by the size, number, and inter-reflective strength of the light sources. In a pitch-black space, a single-point source casts the thickest shadow. When the region of the light sources is large and the level of inter-reflection is high, weak shadows are created. The shadows generated by a large enough object, such as a major chemical plant with workers inside, will lower the illumination over a sizable region and hence reduce the visibility of things that must be seen.

- **Veiling reflections**

Another component of light dispersion that can occasionally be the cause of discomfort is veiling reflections. Veiling reflections are light reflections from semi-matt or specular surfaces that obstruct visibility by physically altering the contrast of the visual task. The geometry between the observer, the surface, and any sources of high brightness, along with the surface's secularity, define the type and size of veiling reflections. When a source of high brightness is at the mirror angle, produced by the observer and the object, veiling reflections happen on a specular surface. The most frequent occurrence of veiling reflections is when looking at a glossy book, although Veiling reflections provide another dimension to the way light is distributed, they are also simple to eliminate by altering the geometry of the relationship between the light source, the book, and the reader. However, veiling reflections can be a source of eye discomfort if this geometry cannot be altered and extended seeing of dimly light details is necessary.

- **Discomfort glare**

  The typical response is to cover the eyes or turn away when very high brightness is visible in the visual field. There are eight types of glare, and this behaviour can be interpreted as a sign that one is present. There has been research on glare from lights and lamps for almost 60 years, yet there is only one type that people typically encounter: discomfort glare.

- **Flicker**

  The reliability of the energy supply and the kind of light source being utilised determine how likely it is that a lighting fixture will cause a flicker. When a flicker is exposed across a vast region, some people may experience pain and even seizures.

JUSTIFICATION OF THE STUDY

Good quality lighting is critically important to carry out tasks efficiently and safely in work and educational environments. The significance of lighting is widely researched and claimed to be vital for occupants' performance. Also, lighting helps to create a visually stimulating environment which enhances the appearance of the indoor space. Research studies have shown the influence of lighting on the biological health of humans such as circadian rhythm, heart rate, and blood pressure. Besides emotional and biological effects, studies have indicated positive effects of lighting conditions on the speed and accuracy of completion of tasks and productivity of the occupants.

Lighting must be designed in a human-centric way, keeping in mind the tasks to be performed and the comfort of all the occupants. It is likewise claimed that inadequate illuminance, the flickering of lights, and lack of light controls in homes can result in fitness troubles like eye strain, headache, etc. The purpose of lighting in educational spaces is to a create visually stimulating environment in which the act of learning can be done in the best way with minimal discomfort. Carefully designed artificial light and the provision of adequate natural light are prerequisites of any intellectual learning space. Readability is important because it influences how clearly a text can be understood by the reader. A student needs to have appropriate lighting while reading because not having

the best reading lamp and reading in dim light can affect their eyesight. It can also cause headaches and eye strain.

After reviewing the available literature, the researcher found very less studies that focused on readability under Direct Lighting and even less on the CCTs of Direct lighting schemes. Hence, the present research aims to study the effects of direct lighting schemes under different CCTs on readability among the youth of Vadodara city.

The present study will help widen the database and strengthen the curriculum on Interior designing, Lighting and Ergonomics courses that are offered by the Department of Family and Community Resource Management, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda and various other institutes. Apart from it, this study will also be helpful for students and Interior designers / Architects in planning lighting for reading spaces. The study will also provide guidelines for creating better reading spaces for educational institutes and residential spaces.

STATEMENT OF PROBLEM

The present research attempts to study the Effects of Direct Lighting on Readability among the youth of Vadodara city.

OBJECTIVES OF THE STUDY

1. To study general visual discomfort while reading as perceived by the respondents
2. To study and compare the Extent of Readability under three different CCTs of Direct Lighting conditions.
3. To compare the Rate of Readability between different CCTs (Correlated Colour temperature) of Direct Lighting.
4. To develop guidelines for reading spaces concerning aspects of Direct Lighting.

DELIMITATION OF THE STUDY

1. The locale of the study will be limited to only Vadodara city.

2. The study will be limited to the age group of 18-28 years.
3. The source of Direct lighting for the present study will be limited to three types of CCTs (Correlated color temperature) of Direct Lighting namely Warm white light (3000k), Natural white light (4000k), and Cool white light (6500k).

HYPOTHESES OF THE STUDY

1. The Extent of Readability of the respondents will vary with their personal variables i.e. Gender, Age, Medium of language, and Glasses/ lenses tinted.
2. The Extent of Readability of the respondents will vary with Experimental variables of the study i.e. Three different CCTs (Correlated color temperature) of Direct Light.

CHAPTER 2

REVIEW OF LITERATURE

A review of literature is a “comprehensive study and interpretation of literature that addresses a specific topic”, (Aveyard, 2010). It allows the researcher to become aware of the studies conducted in the related area. It also serves as a guide to formulate new research by considering its vital elements that could be undertaken with different locales or adding an unexplored element. To make the review clear and understanding, the present chapter is divided into the following sections:

2.1: THEORETICAL ORIENTATION

2.1.1 Evolution of Light

2.1.2 Lighting Schemes

2.1.3 Visual Ergonomics related to reading

2.1.4 The Visual Receptor system

2.2: EMPIRICAL STUDIES

2.2.1 Researches conducted within India

2.2.2 Researches conducted outside India

Conclusion

2.1: THEORETICAL ORIENTATION

Theoretical Orientation is the section which describes the theoretical content related to the topic of the study. These are discussed independently in the succeeding description.

2.1.1 Evolution of light

Before electricity, the first artificial light and heat source used by humans was the fire. After that candles were invented by the Egyptians. Western cultures primarily people rely on candles made from animal fat. The torch came into existence in B.C. 1300. William Murdoch was the first man who used flammable gas as lighting. In the early 1790s, Murdoch began experimenting with various types of gas, finally settling on coal gas as the most effective. After the existence of electricity Gas-discharge lamps were made as a form of artificial light sources that generate light by sending an electrical discharge through an ionized gas, a plasma. Humphry Davy was the first person to make a working light bulb. It was not bright enough nor did it last long enough to be practical but it laid a foundation for modern light bulbs. The light bulb with a longer life span was invented by Thomas Alva Edison in 1880. The tungsten halogen lamp was developed by Elmer Fridrich and Emmett Wiley in 1959. A halogen lamp is an incandescent lamp that has a small amount of a halogen such as iodine or bromine added. In 1976 Edward Hammer invented compact fluorescent lamps (CFLs). This light was considered to be energy efficient light compared to other traditional lights. But the LEDs i.e. Light emitting diode considered to be the most energy-efficient lighting invented by Nick Holonyak, Jr. in 1962. Nowadays, LEDs are the most commonly used light.

2.1.2 Lighting Schemes

- **Direct Lighting**

  Direct Lighting refers to the lighting schemes in which 90% or more light flux falls on the desired surface. This type of lighting scheme is generally observed at the places where minute work or work needs the most use of light. e.g. factories, warehouses, educational institutes and

Handlooms. This type of lighting scheme often creates hard shadows so the placement of the fixtures should be promptly done.

- **Semi-Direct lighting**

  In this lighting scheme, 60-90% of the total flux falls on the desired surface. This lighting scheme plays a midway role between the Direct lighting scheme the and Indirect lighting scheme.

- **Indirect lighting**

  In an Indirect lighting scheme generally, the reflectors are often used to defuse the Direct light flux from the source. 90% of the total flux radiated is being directed towards the ceiling which leads to direct reflection hence attaining the diffused light. This type of scheme can be used where the subtle ambient light has to cater. The prominent feature of this lighting scheme is that the lighting fixture is not seen. Such a type of lighting scheme is often used to highlight or emphasize the ceiling.

- **Semi Indirect lighting**

  It is the type of lighting scheme in which 60-90% of the light flux is redirected to the ceiling and left open. In this scheme there are chances of getting mild shadows. Similar reflectors are being used in the angle of infusion and play a major role in the output of the lighting.

- **General ambient lighting**

  This type of lighting scheme is the combination of direct and indirect light most practised form of lighting scheme which adheres and caters to all the purposes of the residential and commercial spaces.

2.1.3 Visual Ergonomics related to reading

To execute seamless scanning and tracking, both of which require eye movement abilities, is necessary for the user to make precise visual movements. In order to locate the required image, the eyes scan the entire scene with the potential to see many images at once. Reading involves tracking, which involves making brief jumps at regular intervals to maintain an organised progression. The eyes are focused closely when reading printed text; typically, this distance is between 14 and 16 inches. Through the process of accommodation, the eye is able to focus.

It is possible to lessen the strain on the muscles regulating each eye's lens by holding this position for extended periods of time without taking a break. The eyes can see up close more clearly and with less effort once they have acclimated. It appears as though the muscles become comfortable in a relatively close position. Most lighting standards are based on task lighting. These occasionally include lighting guidance for various tasks, however, the majority of standards concentrate on the amount of light required. As always, meeting the necessary standards is not enough to create decent lighting. Whatever the task, it is important to consider the users' perspectives so that they can see what is needed. It is important to make sure that the lighting setup does not interfere with the current task. This may entail eliminating glare from reflective surfaces or other visible light sources, or it may simply entail making sure that users don't throw shadows on the thing they are attempting to inspect due to improperly placed luminaires.

The light needed for urgent tasks like reading, typing, or manipulating machinery is commonly thought of as task lighting, but a skilled designer should take a far broader definition into account. Because a person engaged in a detailed activity does not exist in a vacuum, the designer should consider the entire lighted surroundings to be a part of the task light. If the surroundings appear dark and dangerous, even bright lighting on a book won't help the reader focus. A good task light produces the right amount of intensity and direction for a certain job, but in many cases, allowing some user control results in the greatest user experience. A sense of control is a constant factor in workplace satisfaction surveys, and locally controllable luminaires make it simple to create one. Traditional methods entail designing upward from the most fundamental ambient lighting minimum standards and adding any feature lighting on top, which needs high illuminances to penetrate the ambient light. As an alternative, start by adding user-controlled desk lights and feature lighting as you create the visual hierarchy, adding ambient light only where it is required. By doing this, the feature lighting becomes an essential part of a comprehensive plan rather than an add-on that will probably get lost in the initial cost-cutting effort.

2.1.4 The Visual Receptor System

When the image is focused, it finally reaches the retina at the rear of the eye. The size, wavelengths, and luminance of the image can all be used to describe it. This is a common way to describe image size. When an object of height H is observed from a distance D, its visual angle is roughly equal to arctan (H/D), or the angle whose tangent is H/D. One can calculate this ratio by knowing the size of an object and its distance from the viewer. When visual angles are smaller than about 10 degrees, the angle can be approximated by the formula by expressing it in minutes of arc rather than degrees (60 minutes = 1 degree).

$$VA = 5.7\ X\ 60\ X\ (H/D)$$

The placement of the picture on the back of the retina is particularly significant because it determines the kinds of visual receptor cells that are in charge of converting electromagnetic light energy into electrical impulses of neural energy that are then transmitted up the optic nerve to the brain. The two types of receptor cells are rods and cones, and each has six distinctly different features. The combined effects of these numerous traits have a significant impact on how the eye process visual information.

- **Location**

  Cones are the only cells that reside in the fovea, the central portion of the retina that covers an area of around 2 degrees of visual angle. Both rods and cones live outside of the fovea, but as one moves away from the fovea tip, the density of cones gradually decreases with increasing eccentricity.

- **Acuity**

  When the image falls on the closely spaced cones rather than the more sparsely greased regions, a greater amount of fine detail can be resolved. An acuity of 1.0 indicates that the operator can resolve a visual

angle of 1 minute of arc (1/60 of a degree), which is commonly represented as the inverse of the smallest visual angle (in minutes of arc) that can just be noticed. It is not surprising that the best capacity to discern detail is in the fovea, where the cone density is highest, as acuity is higher with cones than with rods. When looking at items that need high visual acuity as a result, which involves rotating the eyeball such that the image focuses on the fovea. When compared to visual acuity, which rapidly deteriorates in the periphery, motion sensitivity declines much more quickly. We frequently use our relatively high sensitivity to peripheral motion as a signpost for something significant that we will later fixate on. In other words, when moving the eyes focus on the moving object when we perceive motion in the background.

- **Sensitivity**

  Cones are superior to rods in terms of acuity, but rods are superior to cones in terms of sensitivity, which refers to the threshold, or the smallest amount of light that can be detected. The relationship between sensitivity and threshold is reciprocal; when one value rises, the other falls. It is not unexpected that our fovea is particularly bad at picking up weak illumination because there are no rods in the fovea (i.e., it has a high threshold). Scotopic vision is the term used to describe night-time vision when only rods are active. When both the rods and the cones are sufficiently illuminated, this is referred to as photopic vision.

- **Colour Sensitivity**

  Rods are unable to distinguish between distinct light wavelengths (unless they also differ in intensity). Rods are "colour blind," therefore the ability to distinguish between hues is diminished at night and in peripheral vision, where fewer cones are present and when only rods are operating.

- **Adaptation**

  When exposed to light, rods lose their sensitivity quickly, and after they are placed back in the darkness that makes up their "ideal viewing

habitat," it can take them a while (up to an hour) to regain it. This phenomenon explains the momentary "blindness" one feels when walking into a dimly lit movie theatre on a sunny afternoon. Environments where users frequently need to use their scotopic vision but are occasionally exposed to strong light are highly disruptive. Contrary to rods, light stimulation has little impact on the cones' limited sensitivity. Cones, however, can develop hypersensitivity after minimal stimulation. This is where strong lights, especially at night, get their glare.

- **Differential wavelength sensitivity**

  Rods are particularly insensitive to long (i.e., red) lengths, whereas cones are normally sensitive to all wavelengths. As a result, at night, red objects and surfaces appear almost black. More importantly, the rods' ability to adapt to the dark won't be harmed by shining red light on items in an otherwise dark environment.

2.2: EMPIRICAL STUDIES

2.2.1 Researches conducted within India:

Jaju (1999) carried out an exploratory research on “An Exploratory Study of Artificial lighting in the kitchen”. The main objective of this research was to study the existing status of residential kitchens concerning artificial lighting and natural lighting. The data was collected from the kitchens of 208 residential units through a questionnaire cum observation sheet. The results showed that the findings pertinent to values and goals held by the housewives about kitchen lighting projected a similar picture of the housewife's perception of kitchen lighting. It distinctly revealed that the majority of the housewives found work efficiency, comfort and the economy as essential aspects in kitchen lighting and thus desired to achieve them by having a lighting system that would provide adequate illuminance in the kitchen and at the same time would not lead to heavy expenditure on the electricity bill.

An Informal experimental research was carried out by **Chokshi (2010)** on the “Comparison Between Psycho-physiological effects of light emitting diode lamp (LED) and other light fixtures used by selected students of Architecture” from Vadodara city. The study was conducted on 5 Architectural girl students and was taken as a sample by Multi-purpose sampling technique. The data was collected by questionnaire and record sheet. The findings indicated that the shadows on the work surface were there by both the task lights (LED and IL). The task light was found to be insufficient for the work.

Umrajkar (2010) carried out formal experimental research on the “Effects of selected General Lighting Fixtures on Visual Acuity of Elementary School children”. The samples were collected from two schools in Vadodara city by multi-purpose sampling technique. The data was collected from 45 Elementary school children who were studying under

general lighting fixtures at their homes. The findings showed that in 26.7 per cent of the rooms of the respondents, the overall quality of Physical components was low and in 40 per cent, it was high.

A Descriptive research was carried out by **Amin (2015)** on “LEDs in Residential and commercial establishments, knowledge, usage and satisfaction of the consumers”. The sample of the study was 120 (60 from residential and 60 from commercial). This research was conducted in Vadodara city. The interview method was used to collect data. The findings indicated that there existed a significant relationship between the extent of satisfaction experienced on usage of LEDs of residential and commercial respondents.

Mukherjee (2016) undertook exploratory research on “An Overview of Energy Efficient Lighting System Design for Indoor Applications of an Office Building” in Kolkata, India. The main objective of this study was to give an overview of energy-efficient lighting systems. The results showed that the value of the Lighting Power Density of each room or each area is less than the ideal Lighting Power Density values (Space Function Method, ECBC Code). Also, the value of the Lighting Power Density of every single floor of different buildings was less than the ideal Lighting Power Density values (Building Area Method, ECBC Code). Proper Lux levels are also maintained with cost-effectiveness. All the areas of all different types of buildings were energy efficient and all the buildings satisfy at least one characteristic of green building. As mainly LED luminaires are used so, there is no UV emission. The office building was illuminated with a sustainable, energy-efficient, environment-friendly and technologically advanced lighting system.

Singh and Arora (2016) conducted descriptive research on **“**Classroom Illuminance: Its impact on Students’ Health Exposure & Concentration Performance**”** in New Delhi, India. The purpose of this study was to identify the influence of classroom illuminance on students’ concentration performance. The study was conducted on 30 students between the age group of 14-15 years by using a questionnaire and interview schedule. The

finding of the study shows that classroom lighting has a significant relationship with students' concentration performance (p-value- 0.013) but there was no correlation found between lighting and health exposure (p-value 0.929). The satisfaction of students of the green-rated school towards both classroom daylight and artificial light was higher than the satisfaction of students of the non-green-rated school.

Sathya and Natarajan (2016) undertook experimental research on the **"**Effect of energy-efficient light sources on the readability of students – an experimental approach**"** in New Delhi, India. The objective of this study was to investigate the effect of light sources on the readability of students using psychophysical methods. The study was conducted on 55 prospective students between the age group of 18-21 years belonging to the same classroom and was taken as a sample by simple random sampling technique. The results showed that the visibility and colour contrast sensitivity of the students were high in the LED illumination. The quantitative measure of readability under different circumstances showed that the lightness difference in the text under different colour combinations and font size affected their readability. The computed average results confirmed that the luminance and colour contrast was improved in LED illumination and also proved a high readability measure in the experimentation. Both the results of the psychophysical test proved that LED lighting was the best lighting system suitable for colour distinction and readability.

A cross-sectional study was carried out by **Singh et al., (2020)** on the **"**Impact of Lighting on the Performance of Students in Delhi Schools**"**. The main objective of this research is to study the design features of the classrooms of the selected schools; monitor existing lighting/illuminance and assess students' perceptions, satisfaction, concentration and performance regarding their classroom lighting conditions. The data were collected using a questionnaire and interview schedule from 738 students from four different private schools in New Delhi selected by systematic sampling technique. The results of the study showed that a strong correlation exists between classroom lighting and the performance of the students. Classroom lighting between 250 and 500 lux was linked with

increased concentration of students, which translated into higher scores and improved performance.

An Experimental research was carried out by **Yarramsetty et al., (2020)** on "Adaptive lighting comfort in the classrooms of educational building and student hostel rooms". The main objective of this study was to assess the indoor lighting comfort in the classrooms and hostel rooms. A questionnaire survey was distributed among students to collect their responses regarding daylight sensation and indoor comfort environment. The results showed that the majority of the respondents found the daylight intensity between 250-400 lux comfortable which is below the recommended intensity of 500 lux for study purposes in classrooms. The need for artificial lighting was felt only below the intensity level of 200-250 lux. Students sitting at the window sides reported glare and thermal discomfort when the lighting intensity is recorded at more than 800 lux.

2.2.2 Researches conducted outside India:

Banu (2005) undertook experimental research on "An experimental study on the appraisal of the visual environment at offices about colour temperature and illuminance". The main objective of this study was to show the influences of two variables, colour temperature and illuminance, on the subjective impressions of people. For the study, subjective impressions were evaluated as perceived brightness, change in the saturation level of colours, being comfortable and relaxed, and impressions of spaciousness. A questionnaire survey was distributed among 56 office workers in Istanbul, Turkey. The results showed that the change in colour temperature and illumination level has affected the visual appeal of a space. An illumination level of 2000 lx was preferred to 500 lx for impressions of comfort, spaciousness, brightness and saturation evaluation. A 4000 K colour temperature was preferred to 2700 K for impressions of 'comfort and 'spaciousness', while a 2700 K temperature was suggested for 'relaxation' and the 'saturation evaluation'.

Rim et al., (2012) undertook analytical research on "Cognitive Effects on Lighting Environment for Improvement of Spatial Satisfaction and

Psychological Comfort". The main objective of this study was to analyse Occupants' visual perception, psychological responses and spatial satisfaction under various indoor lighting environments. This study was conducted in Korea. Results imply that worse visual comfort was reported under direct lighting conditions that exposed light sources to occupants. To improve spatial satisfaction in space, lighting environments should lessen visual thresholds and distractions. Also, necessary illuminance levels should be kept with the appropriate colour of light that occupants prefer. Worse spatial satisfaction was reported under direct lighting environments, and spatial satisfaction was strongly relevant to visual comfort.

Lewis and Torrington (2012) undertook experimental research on "Extra-care housing for people with sight loss: Lighting and design". This study aimed to investigate whether existing extra-care housing schemes comply with current guidance on design for people with visual impairment and satisfy the needs of those extra-care scheme residents with sight loss. A survey was done and interviews were taken with 41 owners of Apartments/bungalows from the UK. The findings of the scheme survey suggest that many extra care housing schemes provide adequate electric light illuminance levels and a good distribution of light in kitchens and bathrooms. However, electric light illuminance levels in lounges and bedrooms are below that recommended in the specialist guidance, lighting systems afford little control, and few schemes feature colour schemes that enhance the legibility of spaces.

Yang and Kim (2013) undertook experimental research on "A Study on White LED Lighting of Interior Space for the Readability by Age". This study took place in Korea. The main purpose was to study the readability by age in White LED lighting of Interior space. The results of the study represented that a teenager does not show a sensitive reaction to changes in colour temperature and illuminance. People in their 20s and 30s prefer neutral white LED lighting and are very sensitive to changes in the light environment. People in their 50s and 60s prefer high illumination and cool white LED lighting series. People of all ages highly appraise

6000K of 700 lux and 4000K in the illuminance range of 700 lux to 1000 lux for readability. The white LED lighting of colour temperature 4000K is estimated as a suitable environment for readability in a wide range of illumination.

Seo and Kim (2015) undertook experimental research on **"**The Effect of Illuminance and Colour Temperature of LED Lighting on Occupants' Perception and HRV". The main objective of this research was to carefully study the indoor luminous conditions of the built environment to promote comfort and occupants' well-being. The data were collected using a questionnaire survey from 50 (25 males and 25 females) graduate and undergraduate students from the Korea Institute of Ecological Architecture and Environment. The result showed that an indoor luminous environment designed for relaxation purposes should display luminance levels of at least 150 lx and 3800 K of colour temperature to provide a visually comfortable environment suitable for the occupant's relaxation while at the same time promoting the psychological and HRV well-being of resting occupants.

Gattullo et al., (2015) carried out experimental research on the "Effect of Text Outline and Contrast Polarity on AR Text Readability in Industrial Lighting". The main aim of the research was to experiment with the effects of two background illuminances levels, two commercially available head-worn display technologies, variable outline widths and contrast polarity of text and to analyze the performance of 12 subjects by collecting about 3,400 measurements using a specific test application and followed by qualitative interviews in Italy. The findings showed that with high illuminances, VST performed better than OST, regardless of contrast polarity and outline width. This result of the study found that negative contrast polarity was preferable with VST and that just a minimum outline (1 px) around black text was optimal. On the contrary, positive contrast polarity should be used with OST and the outline was not effective. The evaluation shows the usage limits of the OST by sampling its contrast sensitivity function.

Korte et al., (2015) undertook an experimental study on “Personal environmental control: Effects of pre-set conditions for heating and lighting on personal settings, task performance and comfort experience”. The study aimed to evaluate the effect of pre-set environmental conditions of temperature and lighting on the preferred personal settings of office workers and the consequences of this on comfort and task performance. This study took place in the Netherlands. The data was collected from 20 office workers through a questionnaire. The results showed that preferred personal settings are dependent on the initial, pre-set values of radiant heating power and illuminance. Higher pre-set values result in higher adjusted operative temperatures and higher illuminances on desks, although the differences for heating were too small to show a convincing effect. After adjustment, visual comfort was higher, but it was not dependent on the pre-set values. For thermal comfort, no differences were found. The Performance on individual tasks was unaffected.

Odabaşioğlu and Olguntürk (2015) carried out experimental research on the “Effects of coloured lighting on the perception of interior spaces”. The goal of this study was to assess the perceived appearance and subjective interpretation of a space when coloured lights are used; specifically, whether an interior space would be perceived differently depending on the hue of the surface colours of that space. Perceptions were expected to differ for the various colours. The data was collected from 97 subjects of which 59 were women and 38 were men in the age group of between 18-31 years from Istanbul, Turkey. The result shows that the colour of the light had a significant effect on the perception of space regarding the evaluative factors.

An experimental research was undertaken by **Lege et al., (2017)** on “Measuring the effects of lighting on the readability of electronic devices”. This study aimed to understand to what extent people can read e-paper devices under various conditions of ambient illuminance that can occur indoors. The data was collected through a questionnaire from 110 young to elderly respondents from Tokyo, Japan. The results indicated that

backlit and front-lit devices are easier to read at less than 200 lx and the reflective device was easier to read at levels above 500 lx.

Kim et al., (2018) conducted experimental research on the “Comparison of Reading Speed after Bilateral Bifocal and Trifocal Intraocular Lens Implantation”. The main objective of this study was to evaluate and compare visual acuity and reading speed for the Korean language between a diffractive bifocal and trifocal intraocular lens (IOL) of the same material and haptic design. The result shows that Fourteen eyes (7 patients) were included in the bifocal group and 32 eyes of 16 patients in the trifocal group. There were no statistical differences between the two groups concerning UCDVA, UCNVA, CDVA, and CNVA. The UCIVA (0.35 vs. 0.22 logarithm of the minimum angle of resolution [logMAR], $p < 0.01$) and DCIVA (0.34 vs. 0.20 logMAR, $p < 0.01$) were significantly better in the trifocal group than in the bifocal group. The mean reading speed for logMAR 0.5 optotypes (point 10) was 86.50 words per minute (wpm) in the bifocal group and 81.48 wpm in the trifocal group without a significant difference ($p = 0.70$).

Yu et al., (2018) undertook experimental research on the “Effect of character contrast ratio of tablet PC and ambient device luminance ratio on readability in low ambient illuminance”. The main objective of this study was to examine the relationship between the ambient and surface luminance needed to obtain optimal and minimum allowable device (paper and tablet) readability in low ambient illumination environments (illuminance of less than 300 lx). This study took place in Japan. The results showed that in low ambient luminance, the optimal and minimum allowable surface luminance of the tablet did not show any statistically significant difference by character contrast ratio. In low-lighting environments, tablet illuminance should be set higher than the ambient luminance, while that of paper can be lower than the ambient luminance if the surface luminance is at least 27 cd/m2.

Makaremi et al., (2018) carried out experimental research on the “Effects of surface reflectance and lighting design strategies on energy

consumption and visual comfort". The purpose of this research was to investigate the effects of applying different design strategies on lighting energy use and visual comfort level. Surface finishing reflectance, type, number and mounting height of luminaires were variables in the study. This study was carried out in Italy. The findings indicate that the type of luminaire is the most decisive parameter in the quantity and quality of light in an indoor environment. The increasing indoor surface reflectance plays a key role in improving energy efficiency and visual comfort. The results show the possibility of electrical energy savings of up to 45% by increasing surface reflectance properties.

An Experimental research was carried out by **Castilla et al., (2018)** in the "Emotional evaluation of lighting in university classrooms: A preliminary study". The general objective of this paper was to evaluate and compare the subjective evaluation of students' pre-formed opinions to lighting provided by two types of lamps. A questionnaire was distributed among 427 students of the School of Architecture, Spain. The results showed significant differences in students' subjective evaluation. This finding highlighted the existence of symbolic or functional attributes of the usefulness perceived by the student that could influence investigations in which different types of lighting are compared.

An Experimental research was undertaken by **Pracki (2018)** on the "Impact of Direct Lighting Luminaires' Luminous Intensity Distribution on Lighting Quality in Interiors". The purpose of this research was to assess the impact of luminaires' luminous intensity distribution on selected qualitative metrics of interior luminous environment. This research was conducted in Poland. The results presented in this paper were limited to the uniformly arranged luminaires with assumed luminous intensity distributions and reflectance in interiors. The substantial limitations of direct lighting luminaires for general lighting should be regarded with great concern if visual comfort for people in interiors is to be provided.

Mandala (2019) undertook experimental research and a case on the "Lighting Quality In The Architectural Design Studio (Case Study:

Architecture Design Studio at Universitas Katolik Parahyangan, Bandung, Indonesia)". The study aimed to evaluate the lighting quality in the studio and provide lighting design recommendations to improve the user's productivity and creativity. The data was collected through observation and questionnaires. The results showed that despite the below-standard illumination level, respondents still well-rated the studio lighting quality. Visual comfort perception was higher than the room atmosphere perception. The lighting techniques, illumination levels, light colours, room reflection factors, and daylighting contribution were the factors that most affect the room quality.

An Experimental research carried out by **Napanee and Tuaycharoen (2019)** on "Task lighting for Thai older adults: Study of the visual performance of lighting effect characteristics" The purpose of this project was to study a variety of task lighting conditions and identify the most favourable conditions for visual performance and subjective preference as judged by Thai older people in which the bedroom context was chosen for the research. The study was carried out on 24 Thai older adults in the age group 62-76 years. The results showed that the Thai older adults believed illuminance and CCT significantly affected the NVT measure as well as other subjective measures. The results also showed that, for the bedroom, 1,250 lux appeared to produce the highest visual performance while 750 lux and 6,500K CCT and up/down light output characteristic (40/60) was the most preferred by the Thai older adults.

Kim et al., (2020) undertook experimental research on "Analysis of Difference in Brain Activity Depending on Video Type and Illuminance Level" The purpose of this study was to analyse the difference in brain activity depending on the nature of video type and illuminance level. The data was collected from 24 (12 males and 12 females) respondents from Korea. The results of this study showed that the scenery visual stimulation felt by the subjects varied depending on the video type and that the illuminance level when the videos were watched also had an influence.

An Experimental research was undertaken by **Murakami et al., (2020)** on the “Effect of lighting on the readability of colour printing for various ages”. The purpose of the study was to develop a method that can predict the readability of colour printing under different light for various ages using the latest colour difference formula and a 7-point scale. 18 Japanese students between the age group of 21-22 participated as subjects. The result showed that the colour differences calculated by the CIEDE2000 formula(ΔE00) were smaller than the colour differences calculated by the CIE76 formula(ΔE*ab) under all conditions. However, the readability could not be predicted with the colour difference calculated by the CIEDE2000 formula(ΔE00).

Rucinska and Trzaski (2020) carried out exploratory research on “Measurements and Simulation Study of Daylight Availability and Its Impact on the Heating, Cooling and Lighting Energy Demand in an Educational Building” The objective of this study was to analyse the distribution of illuminance resulting from the use of daylighting in an educational room. This research was conducted in Poland. Results of the analysis indicated that, due to the high share of lighting demand (reaching up to 78% of the primary energy balance), there is a need to take into account the efficiency of lighting systems during the design process to correctly determine the actual energy balance of a building, increase the quality of the design of lighting systems, as well as to select the optimal parameters of windows.

An Experimental research was conducted by **Chidinma and Osomkume (2020)** on the “Readability level of secondary school students in selected secondary schools in Obioakpor local government area, rivers state, Nigeria”. The objective of this study was to ascertain the current readability level of secondary school students in the ObioAkpor Local Government Area of Rivers State. To investigate the foundational strength of secondary school students towards their ability to read comprehensibly and to determine the influence of the foundational strength of secondary school students towards reading on their readability level. The result showed that most secondary school students do possess a moderate

readability level. It was concluded that secondary school students do possess a varying level of readability and these variations are simply hinged on the kind of foundational strength that every one of them is being exposed to at their early stage.

A case study was carried out by **Soleimani et al., (2021)** on “Improving Daylight Availability in Heritage Buildings: A Case Study of Below-grade Classrooms in Tehran”. The main objective of this study was to assess the impact of four groups of non-destructive daylight retrofit strategies on daylight performance and compare their individual and cumulative impact on daylight availability and uniformity and Define the most promising alternatives in below-grade classrooms in reused heritage buildings. The study was done on 57 alternatives including 12 individual and 45 integrated daylighting systems, which were assessed in the Department of Interior Architecture, Tehran, Iran. The results showed that the spatial distribution of natural light in the classroom seemed to be acceptable with an average UDI of 300-3000 lux of 65.1% of the occupancy time. The annual analysis of illuminance level showed that students might suffer insufficient daylight access during a certain time of the year, which was the main issue with the case study classroom.

Vries et al., (2021) carried out experimental research on “Putting the ceiling centre stage – The impact of direct/indirect lighting on room appraisal”. This study aimed to investigate the ratio of direct/indirect light and lighting distribution on the ceiling in an open-plan office setting while keeping work-plane illuminance constant and measured their impact on room appraisal, atmosphere, and visual comfort. This study was conducted in the Netherlands. The data was collected from 32 participants (14 males, 18 females) ranging from 22 to 39 years old, through a questionnaire. The analysis showed a significant effect of the direct/indirect light ratio on appraisal, atmosphere, and comfort. The distribution of the light over the ceiling did not affect these attributes, except for the distinct/radiant appraisal.

Conclusion

The collected review of literature focused on the meaning of visual discomfort, the eyeball and the optic nerve, the visual receptor system, and visual ergonomics. The Researches have mainly focused on Illumination, Daylight intensity, and Illuminance levels. The studies conducted outside India also emphasized Lighting and Visual Discomfort. It was also found that lack of adequate lighting can cause visual discomfort and also affect work efficiency. The studies conducted within India mainly focused on the consumption of lighting and energy efficiency. The data showed that the visual appeal of the area has been impacted by the change in colour temperature and illumination level. The perception of space was significantly influenced by the colour of the light. Apart from these studies, researches has been carried out on mood and lighting. Moreover, the researcher came across very few studies that focused on effects of lighting and readability. Based on this, a dearth has been felt by the researcher to conduct the present research that was thought out to be most significant by studying the effects of direct lighting on readability among the youth of Vadodara city.

CHAPTER-3

METHODOLOGY

The methodological part of the research contains –the research design, variables under the study, sample size and sampling procedures, tools for data collection, and operational definitions of the terms used in the study, which are explained briefly in this chapter. The present investigation was undertaken to gather information regarding the Effects of Direct Lighting on Readability among youth. To achieve the aims of the present study, a detailed and sequential procedure was followed which is presented in this chapter under the following sub-headings:

3.1 Research Design

3.2 Variables and Conceptual framework under study

3.3 Operational Definitions

3.4 Locale of Study

3.5 Unit of Inquiry

3.6 Sampling size and Sampling procedure

3.7 Selection, Development, and Description of the tools

3.8 Data Collection

3.9 Data Analysis

3.10 Development of Guidelines for reading spaces

3.1 Research Design

According to Andrew B Kirumbi (2018) research design is the set of methods and procedures used in collecting and analyzing measures of the variables specified in the research problem. The design of the study defines the type, research problem, hypothesis, independent and dependent variables, experimental design, and if applicable data collection methods and statistical analysis plan. The research design for the present investigation will be experimental in nature. A design in which some of the variables being studied are manipulated or which seeks control conditions within which a person is observed. Here 'control' means holding one-factor constant while others are free to vary in the experiment (Zikmund 1988). In this research, a simulated darkened room with artificial Direct Lighting of different color temperatures was prepared for the reading task. Experimental treatment means "alternative manipulation of the independent variable that is being investigated". In this research, there is one experimental treatment i.e. CCT (Correlated color temperature)

3.2 Variables and Conceptual framework under study

A variable is a characteristic that takes on two or more values. It is something that varies (Ahuja 2020). There are three sets of variables for the present study: Independent, Experimental and Dependent.

3.2.1 Independent Variables of the respondents: The variables that are antecedents to the dependent variable are termed as the independent variable (Kothari, 2014). For the present study, the independent variables were:

Personal Variables of the respondents: Personal Variables of the respondent include Gender, Age (in years), Medium of Language, and Occupation of the respondents.

3.2.2 Experimental Variables of the respondents: An Experimental variable is an independent variable that is manipulated by the researcher to

determine its relationship to or influence upon some outcome or dependent variable. For the present study, the Experimental variable was: CCT of Direct Lighting

3.2.3 Dependent Variables of the respondents: A variable that depends upon or is a consequence of another variable is termed as a dependent variable (Kothari, 2014). For the present study dependent variable was: Readability in three different CCTs of Direct Lighting

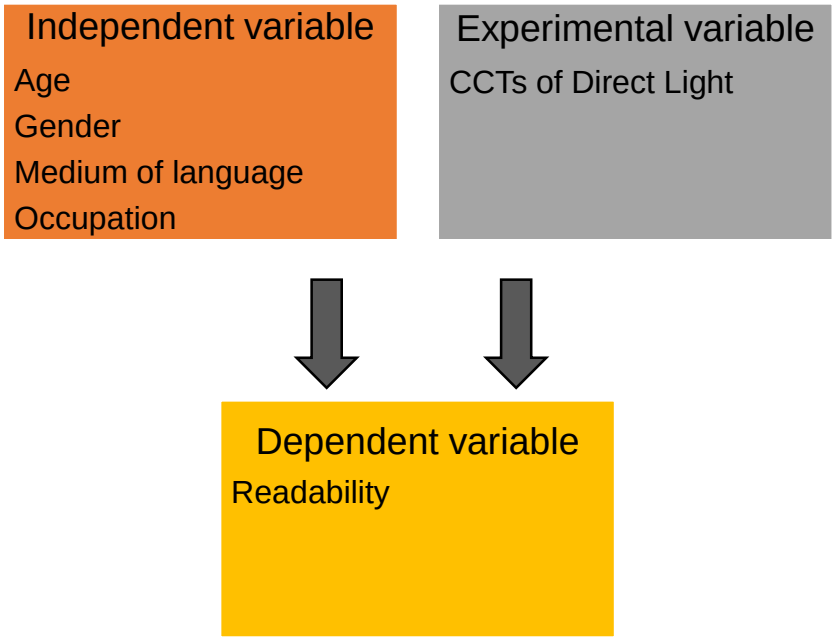

Figure 1: Schematic Framework to show Hypothetical relationship among variables under the study

3.3 Operational Definitions

The operational definitions formulated for the present research study are given below:

3.3.1 Direct Lighting: Direct lighting for the present study refers to the lighting scheme in which 90% or more light flux falls on the desired

surface. The source of lighting for the present study, Syska Smart Pumpkin Wi-Fi 9W Bulb 3 in 1 color (3000k-4000k-6500k)

Plate 2: Syska Smart Pumpkin Wi-Fi 9W Bulb 3 in 1 color (3000k-4000k-6500k) used for the study

3.3.2 Extent of Readability: The Extent of Readability for the present study refers to the perception of the respondents regarding their ability to read under three different CCTs namely, Warm white light (3000k), Natural white light (4000k), and Cool white light (6500k).

3.3.3 CCT (Correlated color temperature): For the present study the CCT is the color of the Direct Light and in this research three types of CCTs was used namely, warm white (3000k), natural white (4000k), and cool white (6500k).

3.3.4 General Visual Discomfort: For the present study General visual discomfort refers to discomfort experienced by the respondents while general reading.

3.3.5 Medium of language: For the present study the medium of language is defined as the language in which the respondents are fluent in reading, speaking and understanding.

3.4 Locale of the study

The locale of the study was Vadodara, Gujarat, India. It is the third largest city of Gujarat, is situated on the banks of the river Vishwamistri and is famous as the cultural capital of Gujarat as well as a center of educational activities. Vadodara was originally known as Vadapradaka, which means a

village amidst Banyan trees. Archaeological findings show that there was human habitation here from pre-historic times. Vadodara passed through the hands of the Imperial Guptas, Chalukyas, Rashtrakutas, Solankis, Sultans of Delhi, the Mughals, and finally the Marathas. Present-day Vadodara owes its grandeur to Maharaja Sayajirao Gaekwad III, a great ruler, a socio-economic reformer, and a patron of arts, architecture, and music. It was he who visualized the development of Vadodara. Today Vadodara is a city of palaces, gardens, and industrial giants.

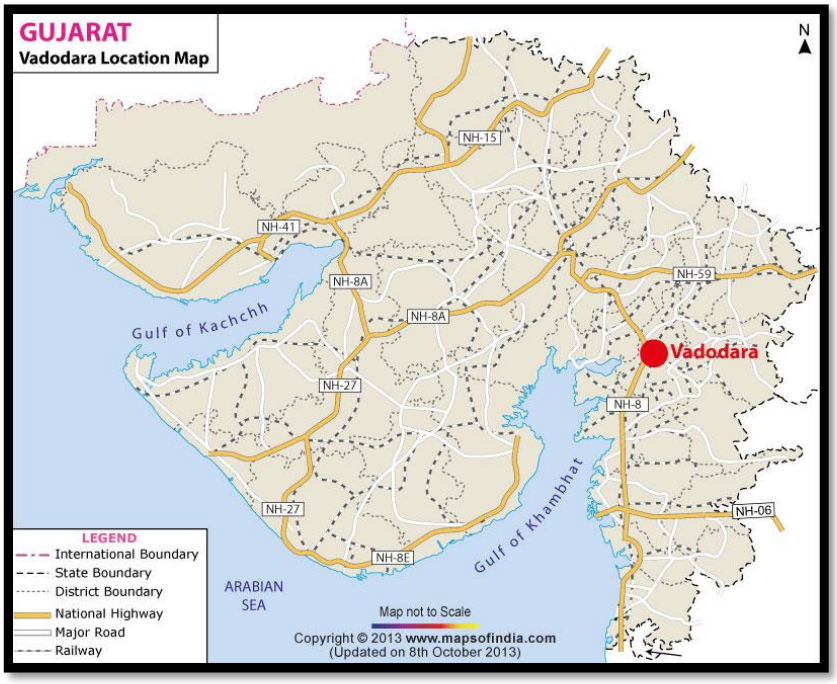

Plate 3: Map showing Vadodara, Gujarat.

Image source: https://www.mapsofindia.com/india/where-is-vadodara.html

3.5 Unit of Inquiry

The unit of inquiry for the present study was the Individuals who fall in the age group between 18-28 years and who willingly participated in the experiment and provide information as asked in the tool.

3.6 Sampling size and Sampling Procedure

For the present study, the purposive sampling technique was considered to be the most appropriate. The Individuals who were in the group between 18-28 years was selected for the present study. After taking their consent, the data was collected from 61 respondents.

Inclusion Criteria:

- The study included respondents from Vadodara city.
- The respondents who gave their consent was included in the study
- The respondents of age between 18-28 years was included in the study.
- The respondents having medium fluency in English language were included in the study.

Exclusion Criteria:

- The Individual having any medical conditions related to vision were excluded from the study.

3.7 Selection, Development, and Description of the tools

3.7.1 Selection of the tool

For the present study, an Interview schedule was used for collecting the data.

Advantages of using an interview schedule:

- An interview schedule facilitates the conduct of an interview. Since the questions have already been prepared beforehand, it is easier to carry out and complete the interview.
- It increases the likelihood of collecting accurate information or data. The questions, which were already prepared beforehand, are expected to be well-thought-out and have focus, so they target thereby ensuring that the answers obtained are correct or accurate.

- Interview schedules can increase the reliability and credibility of the data gathered. It allows interviewers and researchers to get more information since they can ask follow-up queries or clarifications to the questions they have prepared. Thus, the information gathered is more relevant and useful. (Lindlof & Taylor, 2002)
- The rate and amount of responses are higher. It offers flexibility and high customization and may be used when interviewing different types of people. The interviewer can prepare it with the respondents in mind.

  In the light of objectives framed for the present study, the Interview schedule was developed to find out the Effects of Direct Lighting on Readability among the youth of Vadodara City. The Interview schedule consisted of Sections: Section 1 consisted of background information of the respondents, Section 2 consisted of statements regarding General information on visual discomfort and Section 3 Included statements concerning the effect of Warm white light (3000k) CCT of Direct lighting on their reading ability. Section 4 Included statements concerning the effect of Natural white light (4000k) CCT of Direct lighting on their reading ability. Section 5 Included statements concerning the effect of Cool white light (6500k) CCT of Direct lighting on their reading ability. The Interview schedule was found to be the most appropriate tool for data collection as the present study was experimental in nature and it helped the researcher to get the desired information from the respondents while they were present at the simulated set-up.

3.7.2 Development and Construction of the tool

Based on the information collected during the review of literature, experts' guidance, and personal observation of the researcher, the interview schedule was developed. Considering all the aspects, all statements were included that would elicit the information needed to attain the objectives of the study. The statements were made in such a manner that there are no cues that might force the respondents to elicit a desirable response.

3.7.3 Description of the tool

- **Section-I Background information:** This section contained questions regarding the personal information of the respondents covering details on Age (in years), Gender, Medium of language, Occupation.
- **Section-II General information on visual discomfort:** This section contained statements regarding General Visual discomfort experienced while reading.
- **Section-III Respondent's perception of reading in simulated lighting condition -Warm white light (3000k):** It consisted of statements concerning respondent's perception while reading in Warm white light (3000k) CCT of Direct lighting on their reading ability.
- **Section-IV Respondent's perception of reading in simulated lighting condition -Natural white light (4000k):** It consisted of statements concerning respondent's perception while reading in Natural white light (4000k) CCT of direct lighting.
- **Section-V Respondent's perception of reading in simulated lighting condition - Cool white light (6500k** It consisted of statements concerning respondent's perception while reading in white light (6500k) CCT of direct lighting.

3.7.4 Establishment of Content Validity

To test the validity of the scales prepared, the entire tool was given to the panel of 9 experts of the Family and Community Resource Management Department. All the judges were Experts in Interior Design, and Ergonomics, teaching UG and PG courses and had relevant research experience in the field. The judges were requested to see whether the listed items on the scales were clear, ambiguous, relevant, or irrelevant. The items on the scales that had 80% agreement by the experts were finally selected for the scales to be used to judge the Effects of Direct Lighting on Readability among the youth of Vadodara city.

3.7.5 Establishment of the Reliability

a) Pre-testing

Pre-testing was conducted in a pilot study from randomly chosen 30 respondents.

b) Reliability of the Scales

A test is reliable to the extent that it measures whatever it is measuring consistently. Amongst all the types of reliability, the researcher found the Average inter-item correlation method of testing reliability best suitable for the selected tool for the present study. Average inter-item correlation is a method of analyzing internal consistency reliability. The average inter-item correlation for the present study was computed using Cronbach's Alpha.

$$\propto = \frac{N.\bar{c}}{\bar{v} + (N-1).\bar{c}}$$

Where:

N = the number of items.

c̄ = average covariance between item pairs.

v̄ = average variance.

Table 2: Reliability of Scales

Scales	No. of Item	Values
General Visual Discomfort	9	0.773
Respondent's perception of reading in three different CCTs of Direct Lighting	33	0.868

3.8 Data collection

In this research, a simulated darkened room was prepared wherein the only light source was a table lamp with a programmable CCT (Correlated color temperature) of light i.e. Syska Smart Pumpkin Wi-Fi 9W Bulb 3 in 1 color (3000k-4000k-6500k) used for the study for the reading task. Respondents were given the Ishihara colorblindness test after which they were made to read a paragraph below the distinctive CCT of a Direct Lighting fixture i.e. the table lamp, their reading time was recorded under each CCT of Direct

Light; Lux meter reading has also been recorded before switching to another CCT of Direct Light. The windows of the room were covered with black paper to make sure that no natural light enters the room while conducting this research. The respondents were given 60 seconds break before reading in another CCT of Direct Light, after which their perception was recorded with the interview schedule.

Plate 4: Lamp used for the study

Plate 5: Lux meter used for the study

Plate 6: Stopwatch used for the study

Plate 7: Respondent attempting Ishihara Colorblindness test

Plate 8: Respondent reading in Warm white light (3000k)

Plate 9: Respondent reading in Natural white light (4000k)

Plate 10: Respondent reading in Cool white light (6500k)

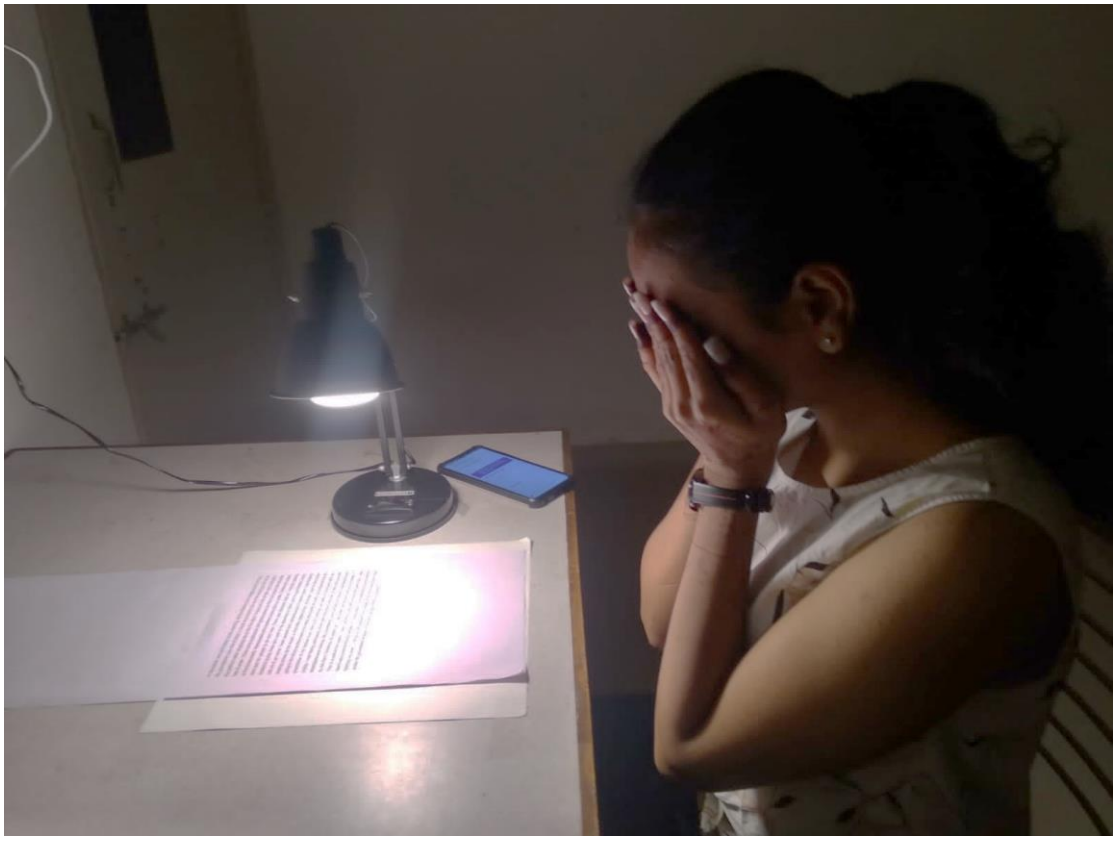

Plate 11: Respondent resting for 60 seconds after reading in each CCT

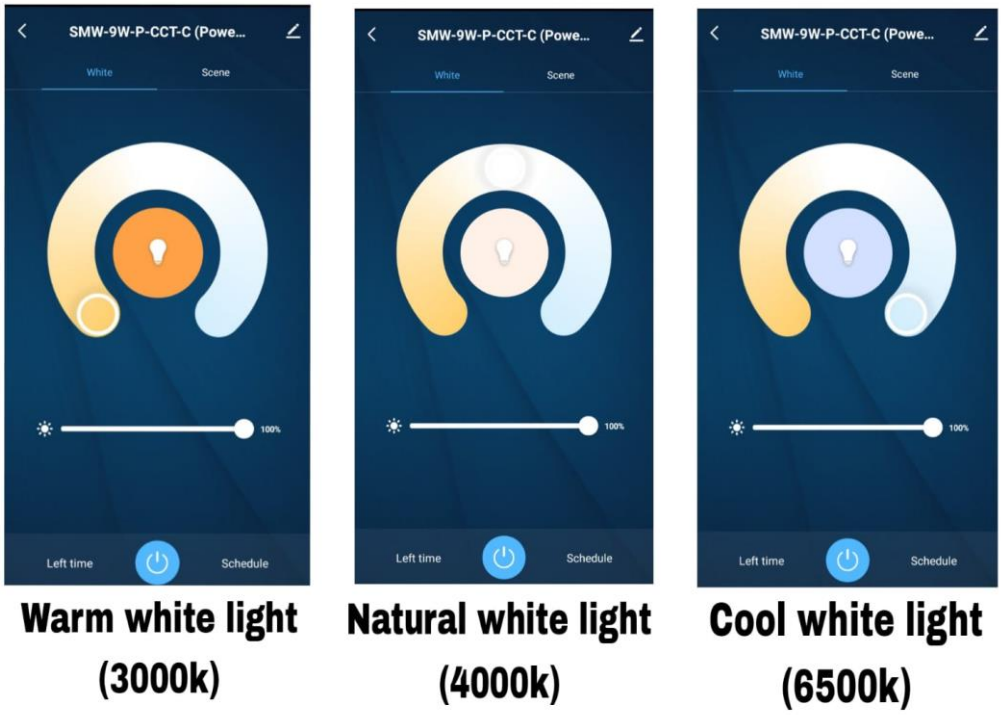

Plate 12: Controlling of Bulb to change CCTs (Correlated color temperature) with the use of application 'Syska Smart Home'

Warm white light (3000k)

Cool white light (6500k)

Natural white light (4000k)

Plate 13: Three different CCTs (Correlated color temperature) used in the Experiment

3.9 Data Analysis

The procedure used to analyse the data of the present study were coding, tabulation, categorization, and statistical analysis.

3.9.1 Categorization

I. **Age (in years)**: It referred to the age of the respondents at the time of data collection. The obtained range of the age of the respondents based on equal intervals are as follows:

1. 18-20 years
2. 21-24 years
3. 25-28 years

II. **Gender of the respondents**: It referred to the gender of the respondents and was categorized as follows:

1. Male
2. Female

III. **Medium of Language:** It referred to the languages known by the respondents and was categorized as follows:

1. English
2. Hindi
3. Gujarati

(*****Multiple responses)

IV. **Occupation:** It referred to the occupation of the respondents and was categorized as follows:

1. Student
2. Service
3. Homemaker
4. Part-time job

V. **Time taken by the Respondent**: It referred to the time taken by the respondents while reading in each CCT of Direct Light.

1. 60 seconds – 120 seconds
2. 121 seconds – 180 seconds

Table 3: Categorization and range of scores for the extent of General Visual Discomfort while Reading:

Extent of General visual discomfort while reading.	**Range of scores**
High Extent of Visual Discomfort	**22-27**
Moderate Extent of Visual Discomfort	**15-21**
Low Extent of Visual Discomfort	**9-14**

It referred to the extent to which the respondents were experiencing general visual discomfort while reading. The scoring was computed using a Likert rating

scale where responses were ‘Always’, ‘Sometimes’ and ‘Never’ and scores of 3, 2, 1 were ascribed respectively. The scores of each of the items of the scale were summated and the possible range of minimum and maximum scores were divided into three categories having equal intervals which were ‘High Extent of Visual Discomfort’, ‘Moderate Extent of Visual Discomfort’ and ‘Low Extent of Visual Discomfort’. The minimum score was 9 and the maximum score was 27 to study the Extent of Visual Discomfort among respondents. Higher scores represented a high level of Visual Discomfort among respondents

Table 4. Categorization and range of scores for the extent of Readability in different CCTs of Direct Lighting:

	Extent of Readability in different CCTs of Direct Lighting	**Range of scores**
A.	**Warm White Light (3000k)**	
	High Extent of Readability	**26-33**
	Moderate Extent of Readability	**19-25**
	Low Extent of Readability	**11-18**
B.	**Natural White Light (4000k)**	
	High Extent of Readability	**26-33**
	Moderate Extent of Readability	**19-25**
	Low Extent of Readability	**11-18**
C.	**Cool White Light (6500k)**	
	High Extent of Readability	**26-33**
	Moderate Extent of Readability	**19-25**
	Low Extent of Readability	**11-18**

It referred to the extent of Readability in each distinctive CCT of Direct Lighting. The scale to study the extent of readability was sub-categorized into Reading under Warm White light (3000k), Natural white light (4000k), and Cool white light (6500k). The scoring was computed using a Likert rating scale where responses were ‘Agree’, ‘Undecided’, and ‘Disagree’ and scores of 1, 2, 3 were ascribed respectively The scores of each of the items of the scale were summated and the possible range of minimum and maximum scores were divided into three categories having equal intervals which were ‘High Extent of Readability’, ‘Moderate Extent of Readability’’ and ‘Low Extent of Readability’’. The minimum score was 11 and the maximum score was 33 to study the Extent

of Readability among respondents. Higher scores represented a high level of Readability among respondents.

Table 5: Categorization of respondents on the basis of Rate of Readability

Page No.	CCT of Light	Words count
Page 1	Warm white light (3000k)	294 words count
Page 2	Natural white light (4000k)	286 words count
Page 3	Cool white light (6500k)	298 words count
		Average words count: 293 words

The text given to read under three different CCTs was divided into 3 pages. The word count on page 1 was 294, on page 2 was 286 and on page 3 was 298. To calculate Rate of readability the average of word (293 words) was computed. The reading time recorded for each of the respondents in each CCT of the light. The average time was computed to calculate the Rate of Readability.

For the present study Rate of Readability is total number of words per average time taken to read in each CCTs of Direct light. The Rate of readability was calculated using this formula

$$\textbf{Rate of readability} = \frac{\text{Total number of words (count)}}{\text{Average time taken (seconds)}}$$

Coding: Coding operation is usually done at this stage through which the categories of data are transformed into scores that was tabulated and counted. Scores was given to each response, then the information from each section of the questionnaire was transferred on the excel sheet.

Tabulation: Tabulation is a part of the technical procedure wherein the classified data are put in the form of tables. The data was transferred from excel sheet into tabular form to give a clear picture of findings.

Statistical analysis: The data were analysed employing descriptive as well as relational statistics as depicted in table 5.

Descriptive statistics: The data were presented in frequencies, percentage, mean and standard deviation (f, %, μ, SD)

Relational statistics: Analysis of Variance (ANOVA), Co-relation and t-test were carried out to test the hypotheses postulated for the study.

Table 6: Relational statistics applied to test the Hypotheses

Test	Independent and Dependent Variables
Anova	**Independent Variable:** Age, Medium of Language and glasses/lenses tinted **with** **Dependent Variable:** Extent of Readability
	Experimental Variable: Three different CCTs of Direct Light **with** **Dependent Variable:** Extent of Readability
T-test	**Independent Variable:** Gender, Eye sightedness and Colour-blindness test **with** **Dependent Variables:** Extent of Readability
(Co-relation) r-test	**Experimental Variable:** Three different CCTs of direct light **With** **Dependent variable:** Extent of readability

3.10 Development of Recommended Guidelines with respect to General Lighting for Reading Spaces

The researcher reviewed available literature and web articles on Lighting, Reading, Ergonomics and Interior Design to select the content for recommendations to include in the Guidelines. The Guidelines, once

developed was given to 1 expert of Interior design; 1 expert of Ergonomics of department of Family and Community Resource and an Eye specialist for content validation. Suggestion given by the experts were incorporated. The Guidelines included general Suggestions about Reading spaces in the context of Ergonomics and Interior Design and things to be kept in mind while Reading. The Guidelines were then shared with the respondents via email and WhatsApp.

CHAPTER-4

FINDINGS AND DISCUSSION

The present study aims to find out the Effects of Direct Lighting on readability among the youth of Vadodara city. This chapter deals with presenting, interpreting, and discussing the findings obtained through analysis of the data collected through the questionnaire. The results are presented in the following sections:

Section:1 4.1 Background Information of the respondents

Section:2 4.2 General Information on Visual Discomfort related to Reading

Section:3 4.3 Extent of General Visual Discomfort while Reading

Section:4 4.4 Respondent's Perception of reading in simulated lighting - Warm white Light (3000k)

Section:5 4.5 Respondent's Perception of reading in simulated lighting - Natural white Light (4000k)

Section:6 4.6 Respondent's Perception of reading in simulated lighting - Cool white Light (6500k)

Section:7 4.7 Extent of Readability of the respondents while reading in Different CCTs of Direct Lighting

Section:8 4.8 Rate of Readability among respondents while reading in Three different CCTs of Direct Lighting

Section:9 4.9 Development of Recommended Guidelines with respect to General Lighting for Reading Spaces

Section:10 4.10 Testing of Hypotheses

Section:1

4.1 Background Information of Respondents

This section comprises data related to the background information of the respondents. It includes Age (in years), Gender, Medium of language Occupation, Eye sightedness, tinted Glasses/lenses and Ishihara colour-blindness test result.

4.1.1 Age (in years): The age range of the respondents falls between 18 to 28 years where the mean age of the respondent was 21.09 years **(Table 7 and Fig 2)**. Less than one-half (45.90%) of the respondents belonged to the age group of 18- 20 years. Slightly less than one-half (49.18%) of the respondent belonged to the age group of 21-24 years. Whereas less than one-tenth (4.92%) of the respondents belonged to the age group of 25-28 years.

Table 7: Distribution of the respondents according to their Age (in years)

(n=61)

Age (in years)	f	%
18-20	28	45.90
21-24	30	49.18
25-28	3	4.92
Mean		21.09
S.D		1.43

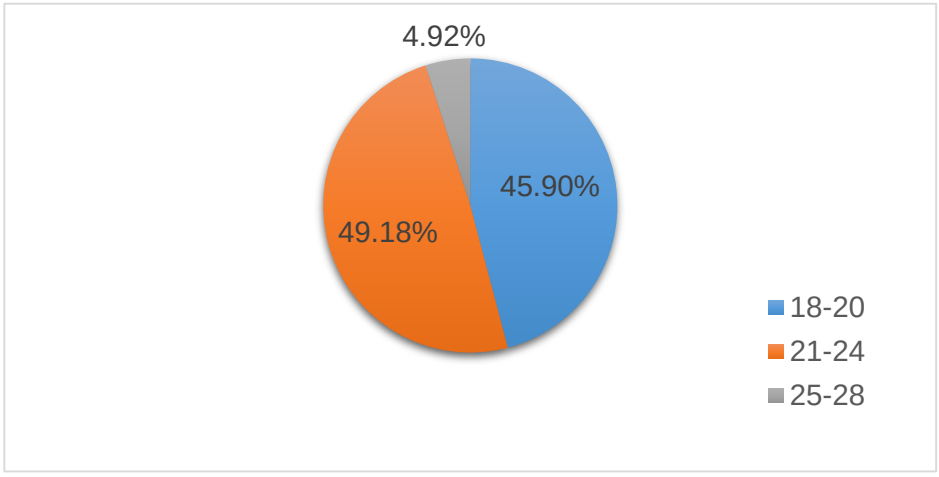

Figure 2: Percentage distribution of the respondents according to their Age (in years)

4.1.2 Gender: The data presented in **Table 8 and Fig 3** shows that slightly more than one-third (34.43%) of the respondents were male and slightly less than two-third (65.57%) of the respondents were female.

Table 8: Distribution of the respondents according to their Gender

(n=61)

Gender	f	%
Male	21	34.43
Female	40	65.57

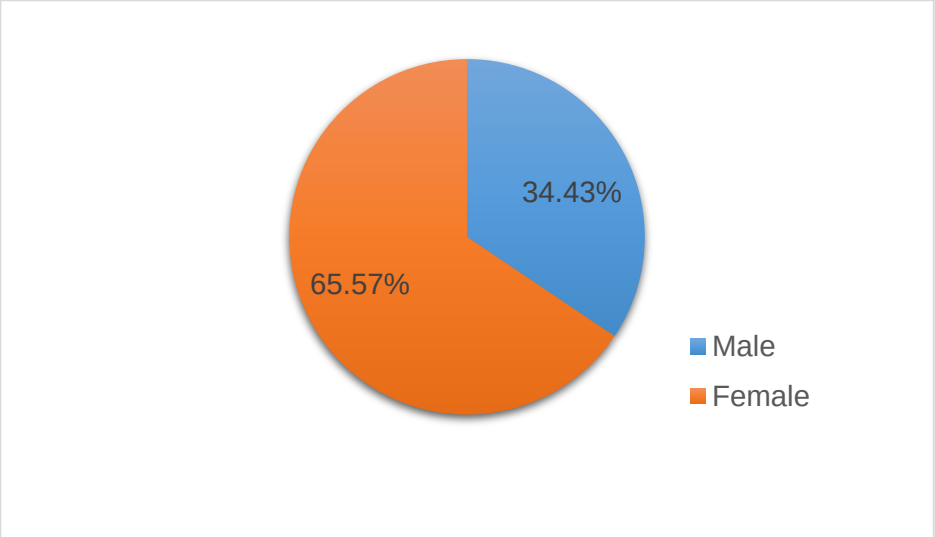

Figure 3: Percentage distribution of respondents according to their Gender

4.1.3 Medium of language: For the present study the medium of language is defined as the language in which the respondents are fluent in reading, speaking and understanding. Option were given in such a manner that the respondents can select more than one language. The findings presented in **Table 9** on the Medium of Language of the respondents revealed that majority (98.36%) of the respondent's medium of language was English. More than one-third (39.34%) of the respondent's medium of language was Gujarati. More than one-tenth (16.39%) of the respondent's medium of language was Hindi.

Table 9: Distribution of the respondents according to their Medium of Language

(n=61)

Medium of Language	f	%
English	60	98.36
Gujarati	24	39.34
Hindi	10	16.39

***Multiple responses**

4.1.4 Occupation: The findings presented in **Table 10 and Fig 4** on the Occupation of the respondents revealed that majority (91.80%) of the respondents were students. Less than one-tenth (4.92%) of the respondent's occupation was Private or Government service. Very less than one-tenth (1.64%) of the respondents were homemakers. Very less than one-tenth (1.64%) of the respondents were doing a part-time job.

Table 10: Distribution of the respondents according to their Occupation

(n=61)

Occupation	f	%
Student	56	91.80
Service	3	4.92
Homemaker	1	1.64
Part-time job	1	1.64

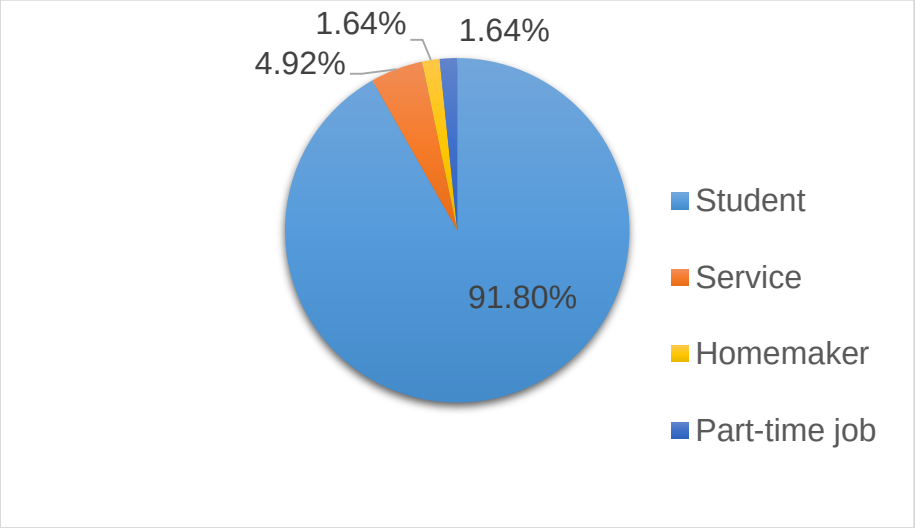

Figure 4: Percentage distribution of the respondents according their Occupation

4.1.5 Eye Sightedness: The findings presented in **Table 11 and Fig 5** on the Eye sightedness of the respondents revealed that more than one-third

(39.34%) of the respondents were wearing lenses/glasses**.** Less than two-third (60.66%) of the respondents had normal vision.

Table 11: Distribution of the respondents on the basis of their eye sightedness

(n=61)

Eye sightedness	f	%
Corrected vision	24	39.34
Normal vision	37	60.66

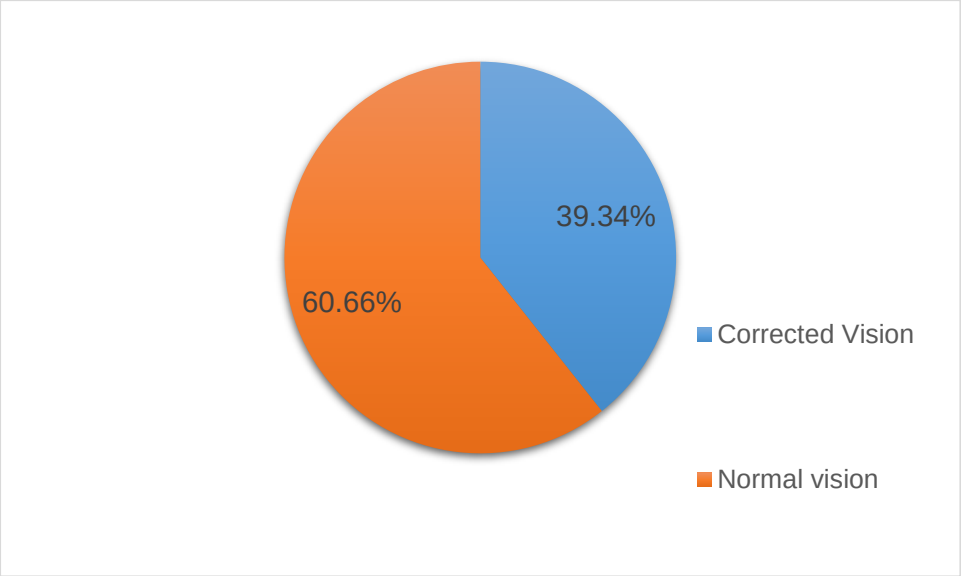

Figure 5: Percentage distribution of respondents according to their Eye sightedness

4.1.6 Power of Eye sight: The findings presented in **Table 12 and Fig 6** revealed that one-half (50.00%) of the respondents were having their power of eye sight of the right eye between (-0.1) – (-2.4) and One-half (50.00%) of the respondents were having their power of eye sight of the left eye between (-2.5) – (-5). Slightly less than two-thirds (62.5%) of the respondents were having their power of eye sight of the right eye between (-0.1) – (-2.4) and slightly more than one-third (37.5%) of the respondents were having their power of eye sight of the left eye between (-2.5) - (-5).

Table 12: Distribution of the respondents based on their power of Eye sight

(n=24)

Eye sightedness	Right Eye		Left eye	
	f	%	f	%
(-0.1) – (-2.4)	12	50.00	15	62.5
(-2.5) – (-5)	12	50.00	9	37.5

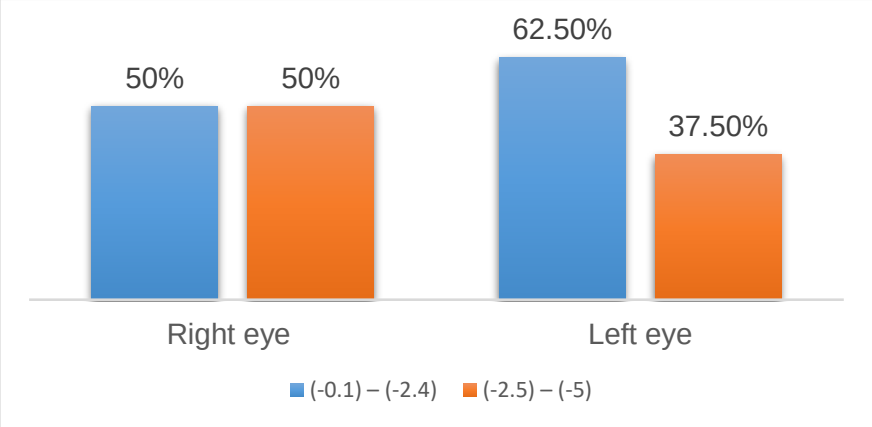

Figure 6: Percentage distribution of respondents based on power of Eye sight

4.1.7 Glasses/ lenses tinted: The finding presented in **Table 13 and Fig 7** revealed that more than one-half (58.33%) of the respondents had tinted glasses/ lenses. Slightly less than one-tenth (8.33%) of the respondents did not have glasses/ lenses tinted. More than one-third (37.5%) of the respondents had UV-protected glasses/ lenses

Table 13: Distribution of the respondents based on whether their glasses/lenses are tinted or not.

(n=24)

Glasses/ lens tinted	f	%
Tinted	14	58.33
Not tinted	2	8.33
UV protected	9	37.5

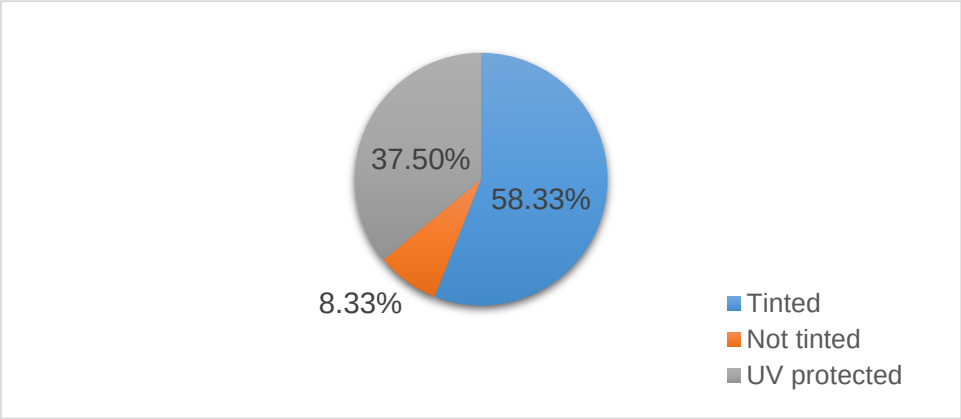

Figure 7: Percentage distribution of respondents according to whether their glasses/ lenses tinted or not

4.1.8 Ishihara colour blindness test: Ishihara colour-blindness test is a test in which respondents have to look at the images, which have numbers embedded in dots of colour. It contains 12 plates having numbers in different colours than the background. On the basis of respondent's ability to identify correct number, percentage of coloured vision is shown as result. (Shinobu Ishihara, 1917; Revaluated by Marey, H. et.al [2014]) The finding presented in **Table 14 and Fig 8** revealed that less than one-tenth (6.55%) of the respondents were colour-blind. Majority (93.44%) of the respondents were having normal colour vision.

Plate 14: Ishihara colour blindness test used for the study

Table 14: Distribution of the respondents according to their results of the Ishihara colour-blindness test

(n=61)

Colour-blindness test results	f	%
0-50%	4	6.55
51-100%	57	93.44

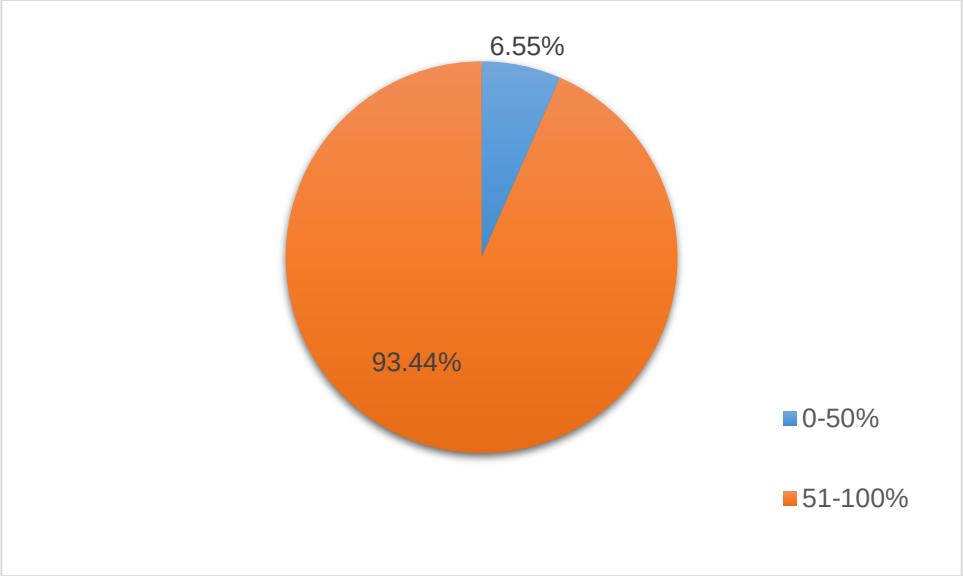

Figure 8: Percentage distribution of respondents according to the Ishihara Colour-blindness test results

Section:2

4.2 General information on visual discomfort related to reading

For the present study General visual discomfort refers to discomfort experienced by the respondents while general reading. In order to find out the General Visual discomfort experienced while reading among the respondents, an interview schedule was used. The scoring was computed using Likert rating scale where responses were ‘Always’, ‘Sometimes’ and ‘Never’ and scores of 3,2,1 were ascribed respectively. The findings presented in **Table 15 and Fig 9** revealed that less than one-tenth (4.02%) of the respondents ‘Always’ felt that their eyes felt watery while viewing striped pattern. Slightly less than one-third (32.78%) of the respondents ‘Sometimes’ felt their eyes watery while viewing striped pattern. Slightly less than two-third (62.3%) of the respondents ‘Never’ felt that their eyes were watery while viewing striped pattern.

More than one-tenth (18.03%) of the respondents ‘Sometimes’ felt dryness in their eyes while viewing striped pattern. Majority (81.96%) of the respondents ‘Never’ felt dryness in their eyes while viewing striped pattern.

Very less than one-tenth (1.63%) of the respondents ‘Always’ felt that their eyes were watery while reading magazine or newspaper. Slightly less than one-fourth (21.31%) of the respondents felt it ‘Sometimes’ and slightly more than three-fourth (77.04%) of the respondents ‘Never’ felt their eyes were watery while reading magazines or newspaper.

Less than one-tenth (8.19%) of the respondents ‘Sometimes’ felt their eyes were red while reading. Majority (91.80%) of the respondents ‘Never’ felt their eyes were red while reading.

Less than one-tenth (8.19%) of the respondents ‘Always’ felt the need to use a pencil or finger to maintain focus when reading a page of text in a novel or magazine. A little more than one-third (36.06%) of the respondents felt it ‘Sometimes’ and more than one-half (55.74%) of the respondents ‘Never’ felt the need to use a pencil or finger to maintain focus when reading a page of text in a novel or magazine.

Upon asking about unintentionally reading the same line, very less than one-tenth (3.27%) of the respondents ‘Always’ unintentionally reread the same line. Slightly more than one-half (57.37%) of the respondents did ‘Sometimes’ and more than one-third (39.34%) of the respondents ‘Never’ unintentionally reread the same line.

Very less than one-tenth (3.27%) of the respondents ‘Always’ felt that they lose focus on letters while reading. A little less than one-half (47.54%) of the respondents felt it ‘Sometimes’ and Slightly less than one-half (49.18%) of the respondents ‘Never’ felt that they lose focus on letters while reading.

Table 15: Distribution of Respondents on the basis of their responses related to General Visual Discomfort while Reading.

(n=61)

Perceived visual discomfort while general reading	Always		Sometimes		Never	
	f	%	f	%	f	%
Feeling of watery eyes while viewing striped pattern	3	4.92	20	32.78	38	62.3
Feeling of dry eyes while viewing stripped pattern	-	-	11	18.03	50	81.96
Feeling of Watery eyes while reading newspaper or magazine	1	1.63	13	21.31	47	77.04
Redness in eyes while reading newspaper or magazine	-	-	5	8.19	56	**91.80**
Feeling the need to use a pencil or finger to maintain focus	5	8.19	22	36.06	34	55.74
Unintentionally rereading the same line	2	3.27	35	57.37	24	39.34
Losing focus on a page while reading	2	3.27	29	49.18	30	49.18
Moving, blinking or rubbing eyes while reading	3	4.91	22	36.06	36	59.01
Headaches due to sensitivity to light	4	6.55	33	54.09	24	39.35

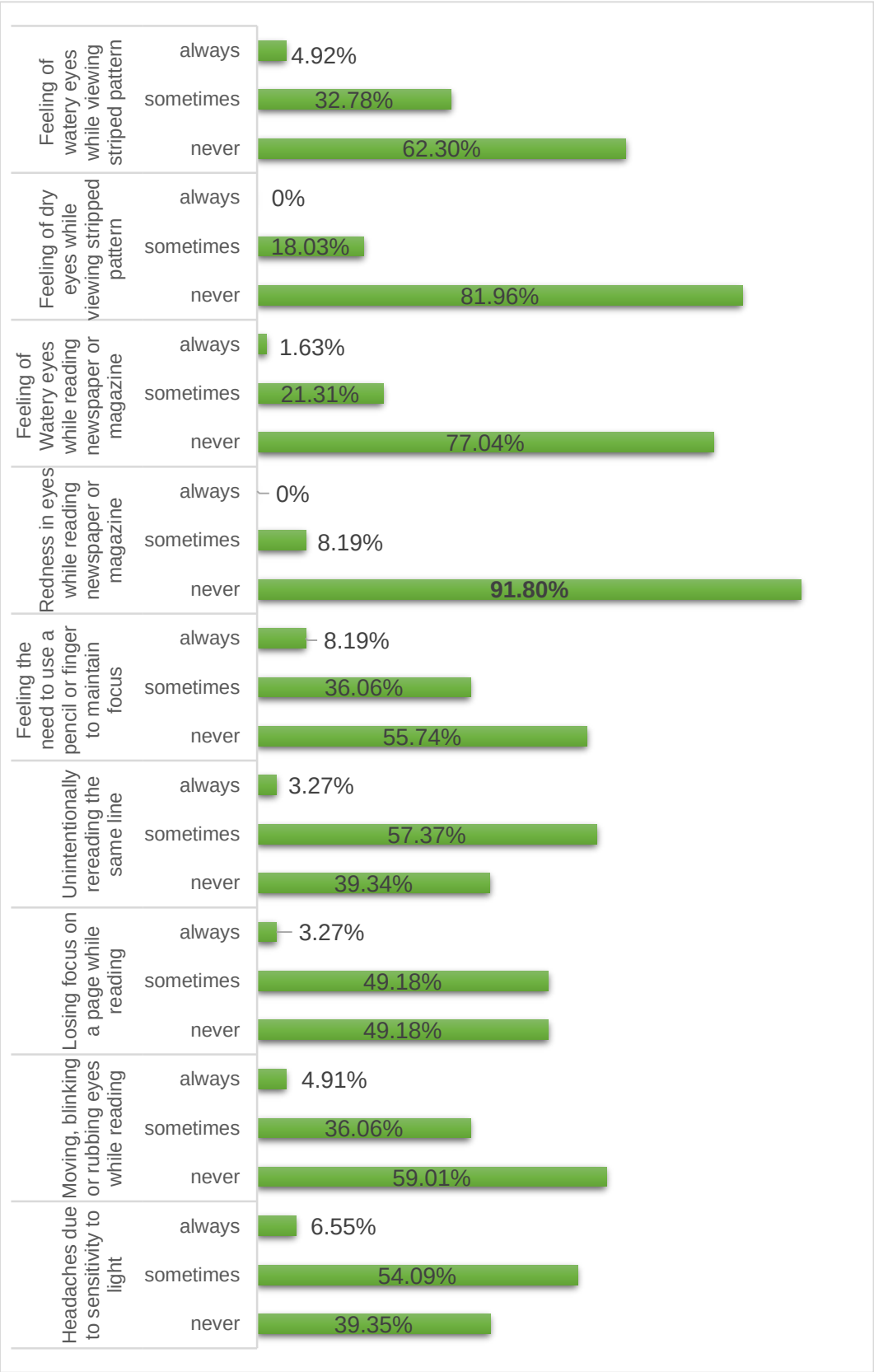

Figure 9: Percentage distribution of the respondents on the basis of their responses related to General Visual Discomfort while Reading

Very less than one-tenth (4.19%) of the respondents ‘Always’ felt the need to move their eyes around the page, or continually blink or rub their eyes to keep the text easy to see while reading. More than one-third (36.06%) of the respondents felt it ‘Sometimes’ and more than one-half (59.01%) of the respondents ‘Never’ felt the need to move their eyes around the page, or continually blink or rub their eyes to keep the text easy to see while reading

Less than one-tenth (6.55%) of the respondents ‘Always’ get headaches due to sensitivity to light. Slightly more than one-half (54.09%) of the respondents get headaches ‘Sometimes’ and more than one-third (39.35%) of the respondents ‘Never’ get headaches due to sensitivity to light.

Section:3

4.3 Extent of General Visual Discomfort while reading

The data presented in the **Table 16** and **fig 10** shows that a little less than one-fourth (24.59%) of the respondents experienced moderate extent of visual discomfort. Slightly less than three-fourth (75.40%) of the respondents experienced low extent of visual discomfort.

Table 16: Extent of general visual discomfort while reading

Extent of General visual discomfort while reading.	Range of scores	f	%
High Extent of Visual Discomfort	22-27	0	0
Moderate Extent of Visual Discomfort	15-21	15	24.59
Low Extent of Visual Discomfort	9-14	46	75.40

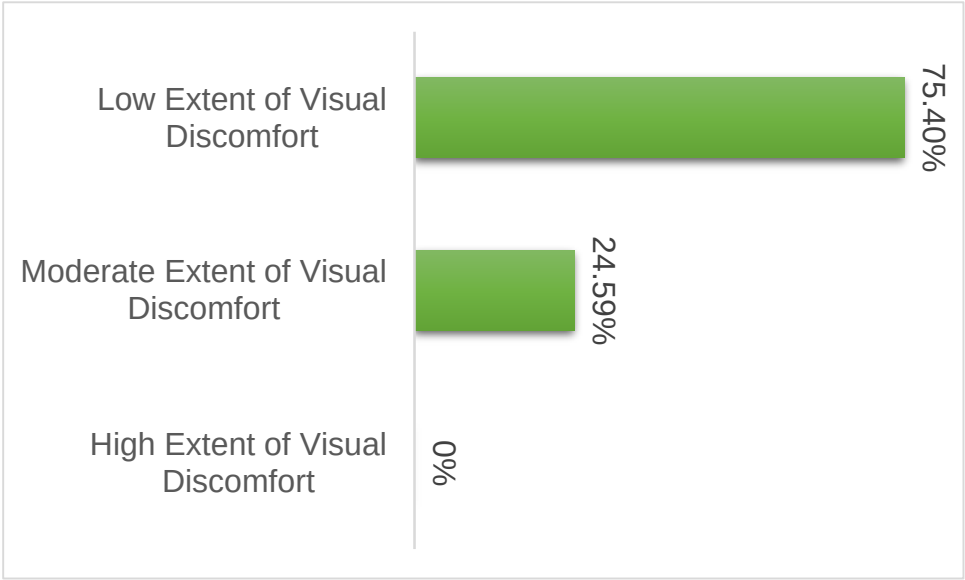

Figure 10: Extent of General Visual Discomfort related to Reading

Section:4

4.4 Respondent's perception of reading in simulated lighting condition -Warm white Light (3000k)

Plate 15: Warm white Light (3000k)

In order to find out respondent's perception of reading in simulated lighting condition -Warm white light (3000k), interview schedule was used. The scoring was computed using Likert rating scale where responses were 'Agree', 'Undecided' and 'Disagree' and scores of 3,2,1 were ascribed respectively.

The data presented in **Table 17 and Fig 11** shows that slightly more than three-fourth (72.13%) of the respondents 'Agreed' that the light was comfortable while reading. A little more than one-tenth (13.11%) of the respondents were 'Undecided' and less than one-tenth (14.75%) of the respondents 'Disagreed' that the light was comfortable.

Table 17: Distribution of the respondents according to their perception of reading in simulated lighting condition -Warm white Light (3000k)

(n=61)

Perception of the respondent while reading in warm white light (3000k)	Agree		Undecided		Disagree	
	f	%	f	%	f	%
Light was Comfortable	44	72.13	8	13.11	9	14.75
Eyes did not strained while reading	45	73.77	9	14.75	7	11.47
No Glare while reading	48	78.68	3	4.91	10	16.39
Eyes did not feel watery after reading	51	**83.60**	5	8.19	5	8.19
Satisfied with the colour of the light	35	57.37	12	19.67	14	22.95
No Visual distraction	32	52.45	19	31.14	10	16.39
Eyes did not feel tired while reading	40	65.57	11	18.03	10	16.39
Light did not hindered the reading task	38	62.29	10	16.39	13	21.31
No Difficulty in seeing letters clearly	40	65.57	15	24.59	6	9.83
No Anxiety due to the light	44	72.13	10	16.39	7	11.47
Light was pleasant	39	63.93	8	13.11	14	22.95

A little less than three-fourth (73.77%) of the respondents ‘Agreed’ that their eyes did not feel strained while reading. More than one-tenth (14.75%) of the respondents were ‘Undecided’ and a little more than one-tenth (11.47%) of the respondents ‘Disagreed’ that their eyes did not feel strained while reading.
Slightly more than three-fourth (78.68%) of the respondents ‘Agreed’ that they did not see glare while reading. Less than one-tenth (4.91%) of the respondents were ‘Undecided’ and more than one-tenth (16.39%) of the respondents ‘Disagreed’ that they did not see glare while reading.
Majority (83.60%) of the respondents ‘Agreed’ that they did not feel their eyes were watery after reading. A little less that (8.19%) of the respondents were ‘Undecided’ and a little less than one-tenth (8.19%) of the respondents were ‘disagreed’ that they did not feel their eyes were watery after reading.
More than one-half (57.37%) of the respondents ‘Agreed’ that they were satisfied with the colour of the light. More than one-tenth (19.67%) of the respondents were ‘Undecided’ and a little less than one-fourth (22.95%) of the respondents ‘Disagreed’ that they were satisfied with the colour of the light.

A little less than one-half (52.45%) of the respondents ‘Agreed’ that they did not feel visual distraction. A little less than one-third (31.14%) of the respondents were ‘Undecided’ and more than one-tenth (16.39%) of the respondents ‘Disagreed’ that they did not feel visual distraction.

More than two-third (65.57%) of the respondents ‘Agreed’ that their eyes did not feel tired while reading. More than one-tenth (18.03%) of the respondents were ‘Undecided’ and more than one-tenth (16.39%) of the respondents ‘Disagreed’ that their eyes did not feel tired while reading.

A little less than two-third (65.57%) of the respondents ‘Agreed’ that the light did not hindered their reading task. More than one-tenth (16.39%) of the respondents were ‘Undecided’ and a little less than one-fourth (21.31%) of the respondents ‘Disagreed’ that the light did not hindered their reading task.

Slightly less than two-third (65.57%) of the respondents ‘Agreed’ that they feel no difficulty in seeing the letters clearly. Slightly less than one-fourth (24.49%) of the respondents were ‘Undecided’ and slightly less than one-tenth (9.83%) of the respondents ‘Disagreed’ that they feel no difficulty in seeing the letters clearly.

A little less than three-fourth (72.13%) of the respondents ‘Agreed’ they did not feel anxiety due to the light. More than one-tenth (16.39%) of the respondents were ‘Undecided’ and a little more than one-tenth (11.47%) of the respondents ‘Disagreed’ they did not feel anxiety due to the light.

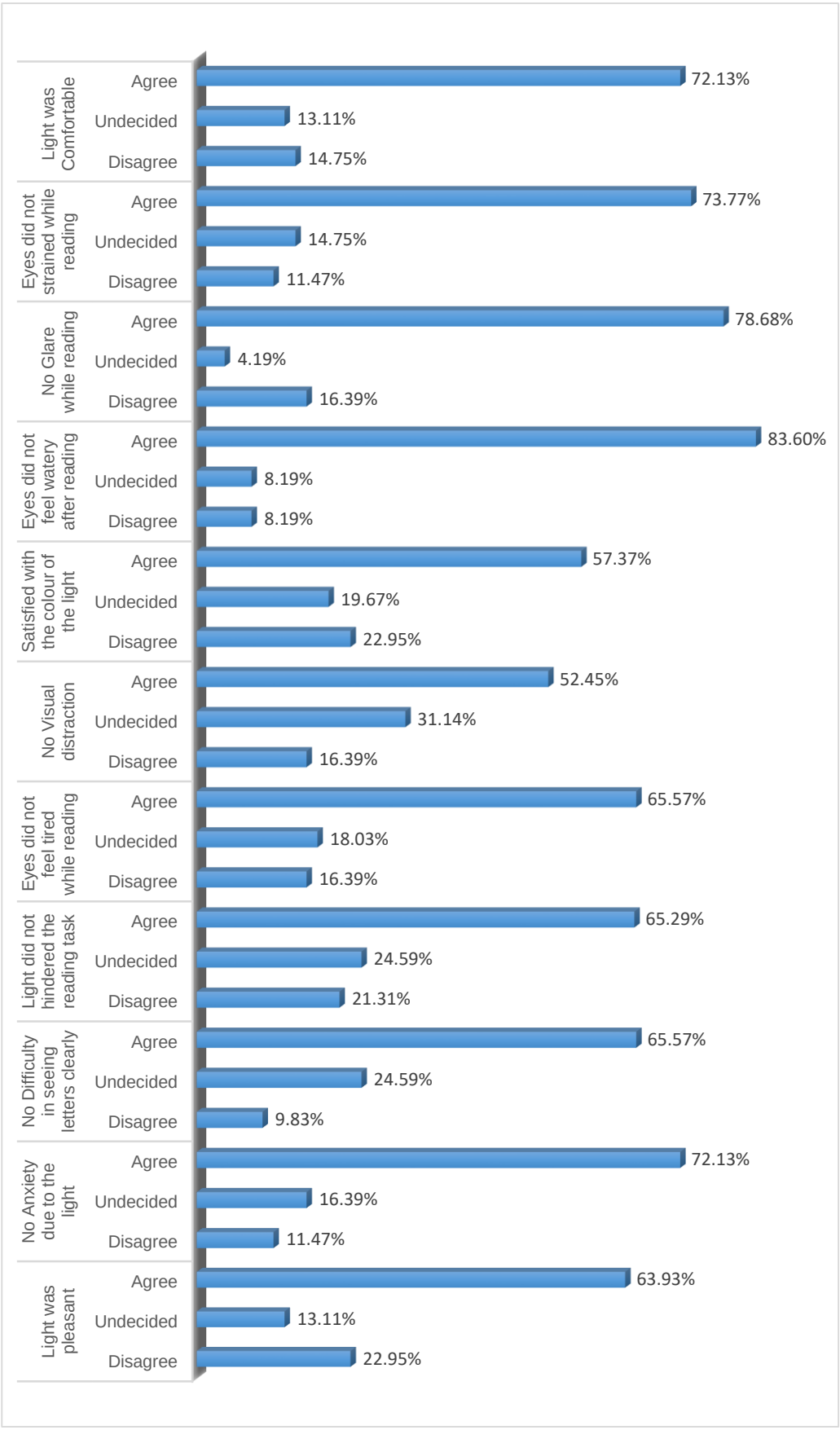

Figure 11: Percentage distribution of the respondents according to their perception of reading in simulated lighting condition- Warm white Light (3000k

Section:5

4.5 Respondent's perception of simulated lighting conditions while reading in Natural white light (4000k)

Plate 16: Natural white Light (4000k)

In order to find out respondent's perception of reading in simulated lighting condition- Natural white light (4000k), interview schedule was used. The scoring was computed using Likert rating scale where responses were 'Agree', 'Undecided' and 'Disagree' and scores of 3,2,1 were ascribed respectively. The data presented in **Table 18 and Fig 12** shows that Majority (86.88%) of the respondents 'Agreed' that the light was comfortable while reading. Less than one-tenth (3.27%) of the respondents were 'Undecided' and a little less than one-tenth (9.83%) of the respondents 'Disagreed' that the light was comfortable.

A little less than three-fourth (78.68%) of the respondents 'Agreed' that their eyes did not feel strained while reading. More than one-tenth (11.47%) of the respondents were 'Undecided' and a little more than one-tenth (9.83%) of the respondents 'Disagreed' that their eyes did not feel strained while reading.

Slightly more than three-fourth (67.21%) of the respondents 'Agreed' that they did not see glare while reading. Less than one-tenth (18.03%) of the

respondents were ‘Undecided’ and more than one-tenth (14.75%) of the respondents ‘Disagreed’ that they did not see glare while reading.

Majority (86.88%) of the respondents ‘Agreed’ that they did not feel their eyes were watery after reading. A little less than one-tenth (6.55%) of the respondents were ‘Undecided’ and less than one-tenth (6.55%) of the respondents were ‘Disagreed’ that they did not feel their eyes were watery after reading.

A little more than two-third (67.21%) of the respondents ‘Agreed’ that they were satisfied with the colour of the light. More than one-tenth (9.83%) of the respondents were ‘Undecided’ and a little less than one-fourth (22.95%) of the respondents ‘Disagreed’ that they were satisfied with the colour of the light.

More than one-half (57.37%) of the respondents ‘Agreed’ that they did not feel visual distraction. A little less than one-fourth (22.95%) of the respondents were ‘Undecided’ and more than one-tenth (19.67%) of the respondents ‘Disagreed’ that they did not feel visual distraction.

Less than three-fourth (70.49%) of the respondents ‘Agreed’ that their eyes did not feel tired while reading. More than one-tenth (18.03%) of the respondents were ‘Undecided’ and a little more than one-tenth (11.47%) of the respondents ‘Disagreed’ that their eyes did not feel tired while reading.

Less than three-fourth (70.49%) of the respondents ‘Agreed’ that the light did not hindered their reading task. More than one-tenth (18.03%) of the respondents were ‘Undecided’ and a little more than one-fourth (11.47%) of the respondents ‘Disagreed’ that the light did not hindered their reading task.

Table 18: Distribution of the respondents according to their perception of reading in simulated lighting condition -Natural white light (4000k)

(n=61)

Perception of the respondent while reading in natural white light (4000k)	Agree		Undecided		Disagree	
	f	%	f	%	f	%
Light was Comfortable	53	**86.88**	2	3.27	6	9.83
Eyes did not strained while reading	48	78.68	7	11.47	6	9.83
No Glare while reading	41	67.21	11	18.03	9	14.75
Eyes did not feel watery after reading	53	**86.88**	4	6.55	4	6.55
Satisfied with the colour of the light	41	67.21	6	9.83	14	22.95
No Visual distraction	35	57.37	14	22.95	12	19.67
Eyes did not feel tired while reading	43	70.49	11	18.03	7	11.47
Light did not hindered the reading task	43	70.49	10	16.39	8	13.11
No Difficulty in seeing letters clearly	48	78.68	6	9.83	7	11.47
No Anxiety due to the light	43	70.49	10	16.39	8	13.11
Light was pleasant	43	70.49	8	13.11	10	16.39

Slightly more than three-fourth (78.68%) of the respondents ‘Agreed’ that they feel no difficulty in seeing letters clearly. Slightly less than one-tenth (9.83%) of the respondents were ‘Undecided’ and slightly more than one-tenth (11.47%) of the respondents ‘Disagreed’ that they feel no difficulty in seeing letters clearly.

Less than three-fourth (70.49%) of the respondents ‘Agreed’ they did not feel anxiety due to the light. More than one-tenth (16.39%) of the respondents were ‘Undecided’ and a little more than one-tenth (13.11%) of the respondents ‘Disagreed’ they did not feel anxiety due to the light.

Less than three-fourth (70.49%) of the respondents ‘Agreed’ that the light was pleasant. A little more than one-tenth (13.11%) of the respondents were ‘Undecided’ and a little less than one-fourth (16.39%) of the respondents ‘Disagreed’ that the light was pleasant.

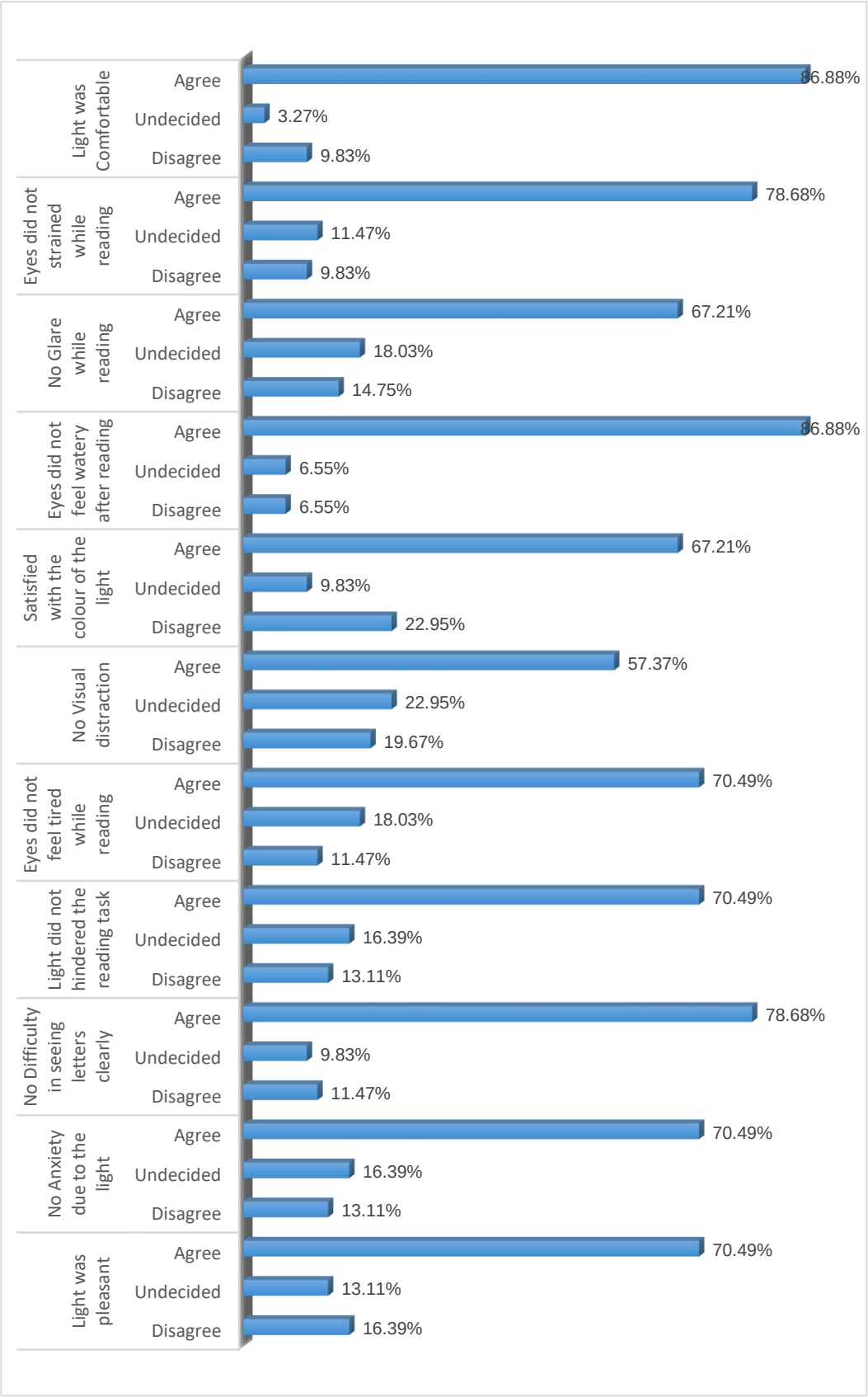

Figure 12: Percentage distribution of the respondents according to their perception of reading in simulated lighting condition -Natural white Light (4000k)

Section:6

4.6 Respondent's perception of simulated lighting conditions while reading in Cool white light (6500k)

Plate 17: Cool white Light (6500k)

In order to find out respondent's perception of reading in simulated lighting condition -Warm white light (3000k), interview schedule was used. The scoring was computed using Likert rating scale where responses were 'Agree', 'Undecided' and 'Disagree' and scores of 3,2,1 were ascribed respectively. The data presented in **Table 19 and Fig 13** shows that slightly more than three-fourth (75.40%) of the respondents 'Agreed' that the light was comfortable while reading. More than one-tenth (19.67%) of the respondents were 'Undecided' and less than one-tenth (4.91%) of the respondents 'Disagreed' that the light was comfortable.

Less than three-fourth (72.13%) of the respondents 'Agreed' that their eyes did not feel strained while reading. More than one-tenth (18.03%) of the respondents were 'Undecided' and a little less than one-tenth (9.83%) of the respondents 'Disagreed' that their eyes did not feel strained while reading.

Slightly less than two-third (65.57%) of the respondents 'Agreed' that they did not see glare while reading. A Less than one-fourth (21.31%) of the

respondents were ‘Undecided’ and More than one-tenth (13.11%) of the respondents ‘Disagreed’ that they did not see glare while reading.

A little less than tree-fourth (75.40%) of the respondents ‘Agreed’ that they did not feel their eyes were watery after reading. A little less than one-tenth (11.47%) of the respondents were ‘Undecided’ and more than one-tenth (13.11%) of the respondents were ‘Disagreed’ that they did not feel their eyes were watery after reading.

More than one-half (57.37%) of the respondents ‘Agreed’ that they were satisfied with the colour of the light. A little less than one-fourth (21.31%) of the respondents were ‘Undecided’ and slightly less than one-fourth (21.31%) of the respondents ‘Disagreed’ that they were satisfied with the colour of the light.

A little less than two-third (62.29%) of the respondents ‘Agreed’ that they did not feel visual distraction. More than one-tenth (18.03%) of the respondents were ‘Undecided’ and more than one-tenth (19.67%) of the respondents ‘Disagreed’ that they did not feel visual distraction.

Table 19:Distribution of the respondents according to their perception of reading in simulated lighting condition -Cool white light (6500k)

(n=61)

Perception of the respondent while reading in cool white light (6500k)	Agree		Undecided		Disagree	
	f	%	f	%	f	%
Light was Comfortable	46	**75.40**	12	19.67	3	4.91
Eyes did not strained while reading	44	72.13	11	18.03	6	9.83
No Glare while reading	40	65.57	13	21.31	8	13.11
Eyes did not feel watery after reading	46	**75.40**	7	11.47	8	13.11
Satisfied with the colour of the light	35	57.37	13	21.31	13	21.31
No Visual distraction	38	62.29	11	18.03	12	19.67
Eyes did not feel tired while reading	42	68.85	8	13.11	11	18.03
Light did not hindered the reading task	44	72.13	8	13.11	9	14.75
No Difficulty in seeing letters clearly	43	70.49	10	16.39	8	13.11
No Anxiety due to the light	42	68.85	8	13.11	11	18.03
Light was pleasant	37	60.65	11	18.03	13	21.31

More than two-third (68.85%) of the respondents ‘Agreed’ that their eyes did not feel tired while reading. More than one-tenth (13.11%) of the respondents were ‘Undecided’ and more than one-tenth (18.03%) of the respondents ‘Disagreed’ that their eyes did not feel tired while reading.

Less than three-fourth (72.13%) of the respondents ‘Agreed’ that the light did not hindered their reading task. More than one-tenth (13.11%) of the respondents were ‘Undecided’ and more than one-tenth (14.75%) of the respondents ‘Disagreed’ that the light did not hindered their reading task.

Less than three-fourth (70.49%) of the respondents ‘Agreed’ that they feel no difficulty in seeing the letters clearly. More than one-tenth (16.39%) of the respondents were ‘Undecided’ and more than one-tenth (13.11%) of the respondents ‘Disagreed’ that they feel no difficulty in seeing the letters clearly.

A little more than two-third (68.85%) of the respondents ‘Agreed’ that they did not feel anxiety due to the light. More than one-tenth (13.11%) of the respondents were ‘Undecided’ and more than one-tenth (18.03%) of the respondents ‘Disagreed’ that they did not feel anxiety due to the light.

Less than two-third (60.65%) of the respondents ‘Agreed’ that the light was pleasant. More than one-tenth (18.03%) of the respondents were ‘Undecided’ and a little less than one-fourth (21.31%) of the respondents ‘Disagreed’ that the light was pleasant.

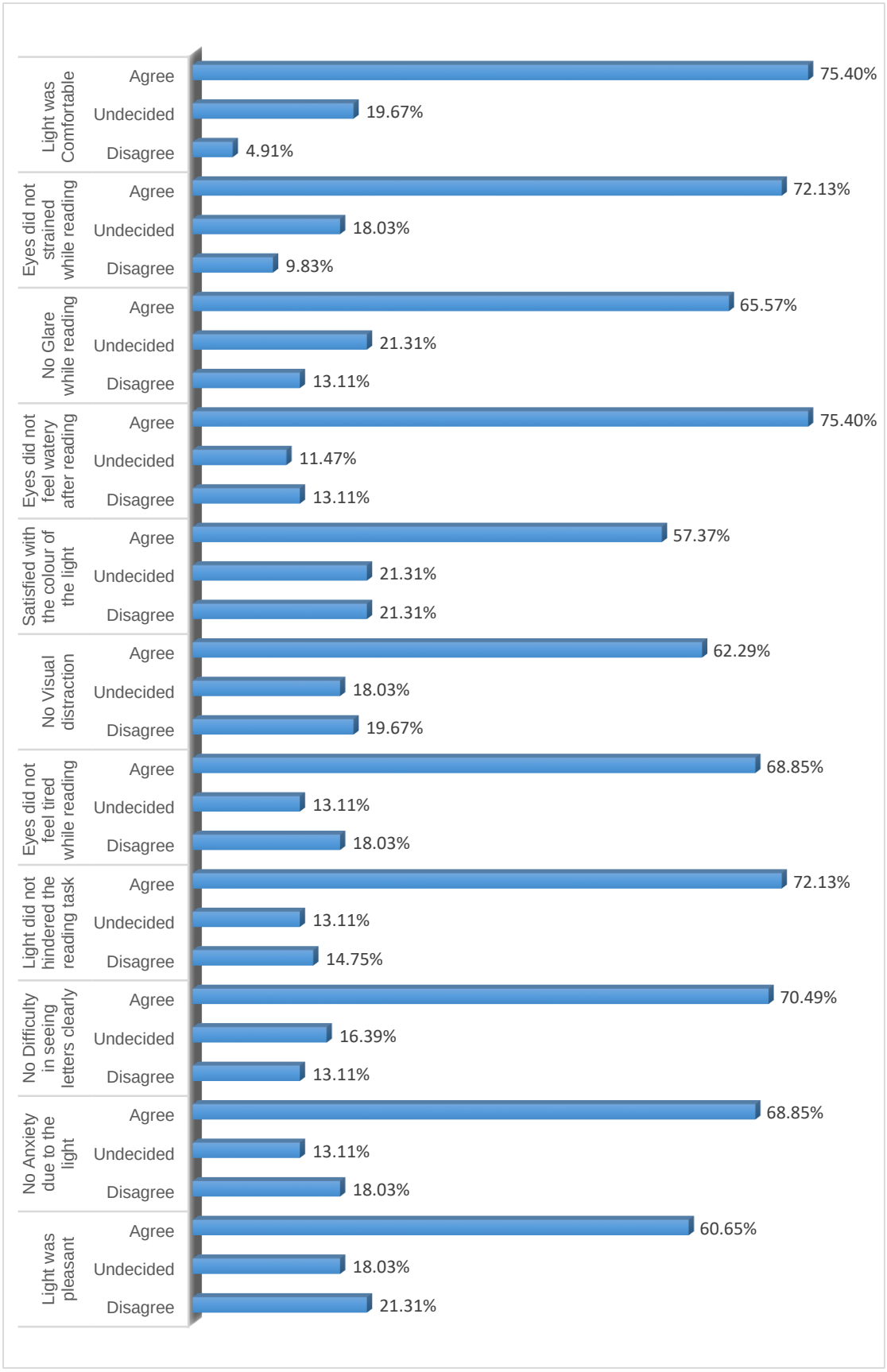

Figure 13: Percentage distribution of the respondents according to their perception of reading in simulated lighting condition -Cool white Light (6500k)

Section:7

4.7 Extent of Readability of the respondents while reading in three different CCTs of Direct Lighting- A probe was made to find out the extent of Readability while reading in different CCTs of Direct Light. The scores of each of the items of the scale were summated and the possible range of minimum and maximum scores were divided into three categories having equal intervals which were 'High Extent of Readability', 'Moderate Extent of Readability', and 'Low Extent of Readability'. The Minimum score was 11 and the Maximum score was 33 to study the Extent of Readability among respondents. Higher scores represented a high extent of readability among respondents.

Table 20: Extent of readability of the respondents while reading in three different CCTs of Direct Lighting

Extent of readability	Range of scores	f	%
Warm White Light (3000k)			
High Extent of Readability	26-33	43	**70.49**
Moderate Extent of Readability	19-25	13	21.31
Low Extent of Readability	11-18	5	8.19
Natural White Light (4000k)			
High Extent of Readability	26-33	50	**81.96**
Moderate Extent of Readability	19-25	4	6.55
Low Extent of Readability	11-18	7	11.47
Cool White Light (6500k)			
High Extent of Readability	26-33	41	**67.21**
Moderate Extent of Readability	19-25	13	21.31
Low Extent of Readability	11-18	7	11.47

The data presented in the **Table 20** and **Fig 14** shows that a little less than three-fourth (70.49%) of the respondents had 'High Extent of Readability' in Warm White Light (3000k). Slightly less than one-fourth (21.31%) of the respondents had 'Moderate Extent of Readability' in Warm White Light (3000k). A little less than one-tenth (8.19%) of the respondents had 'Low Extent of Readability' in Warm White Light (3000k).

Majority (81.96%) of the respondents had 'High Extent of Readability' in Natural white light (4000k). Less than one-tenth (6.55%) of the respondents

had ‘Moderate Extent of Readability’ in Natural white light (4000k). A little more than one-tenth (11.47%) of the respondents had ‘Low Extent of Readability’ in Natural white light (4000k).

A little more than two-third (67.21%) of the respondents had ‘High Extent of Readability’ in Cool white light (6500k). Slightly more than one-fourth (21.31%) of the respondents had ‘Moderate Extent of Readability’ in Cool white light (6500k). A little more than one-tenth (11.47%) of the respondents had ‘Low Extent of Readability’ in Cool white light (6500k)

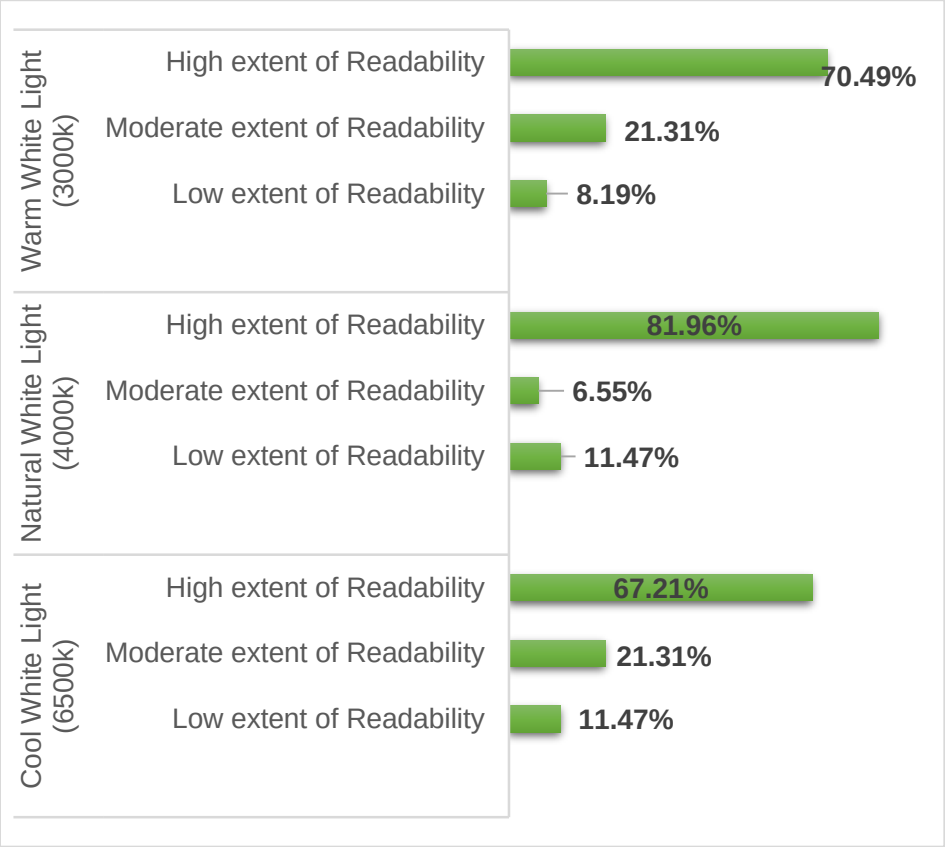

Figure 14: Extent of Readability of the respondents while reading in three different CCTs of Direct Lighting

Section: 8

4.8 Rate of readability among respondents while reading in three different CCTs of Direct Lighting

4.8.1 Time taken by each of the respondents under three different CCTs of Direct Lighting: The data presented in **Table 21** shows that more than one-half (59.01%) of the respondent's recorded time to read in warm white light (3000k) was between 60 seconds – 120 seconds. Less than one-half (40.99%) of the respondent's recorded time to read in warm white light (3000k) was between 121 seconds – 180 seconds.

Table 21: Time taken by each of the respondents under three different CCTs of Direct Lighting.

(n=61)

Recorded Time	Warm white light (3000k)		Natural white light (4000k)		Cool white light (6500k)	
	f	%	f	%	f	%
60 seconds – 120 seconds	36	**59.01**	44	**72.13**	40	**65.57**
121 seconds – 180 seconds	25	40.99	17	27.87	21	34.42

A little less than two-third (65.57%) of the respondent's recorded time to read in Cool white light (6500k) was between 60 seconds – 120 seconds. A little more than one-third (34.42%) of the respondent's recorded time to read in Cool white light (6500k) was between 121 seconds – 180 seconds. Less than three-fourth (72.13%) of the respondent's recorded time to read in Natural white light (4000k) was between 60 seconds – 120 seconds. Less than one-fourth (27.87%) of the respondent's recorded time to read in Natural white light (4000k) was between 121 seconds – 180 seconds.

Table 22: Words counts and average time taken in three different CCTs of direct light.

Page No.	CCT of Light	Words Count	Average Time
Page 1	Warm white light (3000k)	294 words count	119 seconds
Page 2	Natural white light (4000k)	286 words count	106 seconds
Page 3	Cool white light (6500k)	298 words count	115 seconds
Average words count: 293 words count			

The text that was given to read under three different CCTs was divided into 3 pages. The word count on page 1 was 294, on page 2 was 286 and on page 3 was 298. To calculate rate of readability the average of word count (293 words) was computed. The reading time was recorded for each of the respondents in each CCT of the light. The average time was computed to calculate the rate of readability. The average time to read in warm white light (3000k) was 119 seconds; in natural white light (4000k) was 106 seconds and in cool white light (6500k) was 115 seconds.

4.8.2 Rate of Readability: For the present study the Rate of Readability is total number of words per average time taken to read in each CCTs of Direct light. The rate of readability was calculated using this formula.

$$\textbf{Rate of readability} = \frac{\text{Total number of words (count)}}{\text{Average time taken (seconds)}}$$

The data presented in **Table 23** and **Fig 15** Shows that the rate of readability of the respondents in warm white light (3000k) was 2.46 words/ second; in Natural white light (4000k) was 2.76 words/ seconds and in Cool white light (6500k) was 2.54 words / seconds

Table 23: Rate of readability of the Respondents in three different CCTs of Direct light

CCTs of Light	Rate of Readability
Warm white light (3000k)	2.46 words /second
Natural white light (4000k)	2.76 words /second
Cool white light (6500k)	2.54 words /second

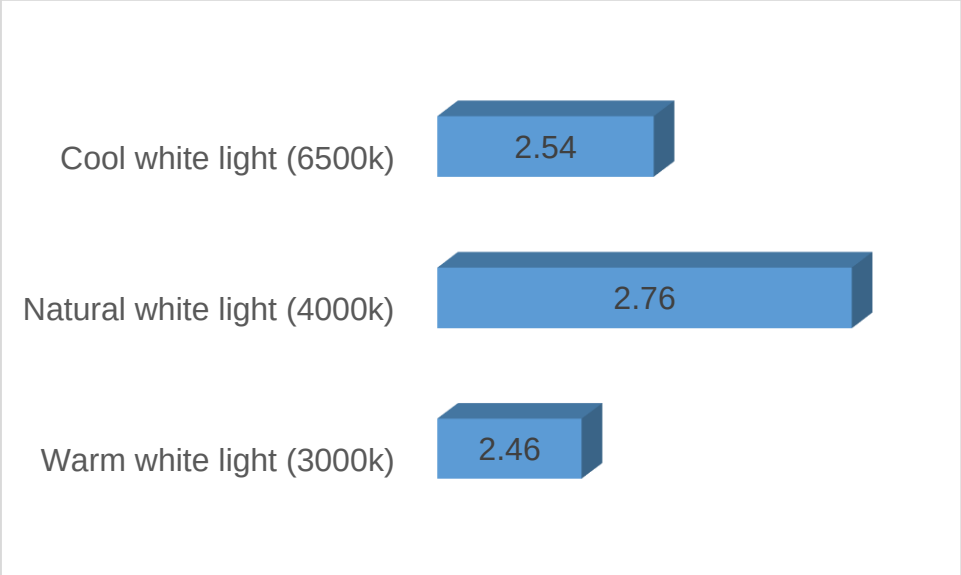

Figure 15: Rate of Readability of respondents in three different CCTS of Direct Light

Conclusion:

The data was collected from individuals who are in the age group of 18-28 years from Vadodara city through Interview schedule, in order to ascertain the Extent of Readability in three different CCTs of Direct Lighting. It was found that Slightly less than one-half of the respondents were in the age group of 21-24 years. A little less than two third of the respondents were female. Majority of the respondent's medium of language was English. Majority of the respondents were students. Less than two third of the respondents had normal vision. One-half of the respondents were having their power of eye sight of the right eye was between (-0.1) – (-2.4). A little less than two-third of the respondents were having their power of eye sight of the left eye was between (-0.1) – (-2.4). More than one-half of the respondents were not having their glasses/ lenses tinted. Majority of the respondents were having normal colour vision.

It was found that majority of the respondents never felt redness in their eyes after reading newspaper or magazine. Slightly more than three-fourth of the respondents were having low extent of general visual discomfort while reading. Majority of the respondents agreed that they did not feel their eyes

were watery after reading under warm white light (3000k). Majority of the respondents agreed that the light was comfortable and they also did not feel their eyes were watery after reading under natural white light (4000k). A little less than tree-fourth of the respondents agreed that the light was comfortable and they also did not feel their eyes were watery after reading under cool white light (6500). It was found that Majority of the respondent were having High Extent of Readability under Natural white light (4000k). It was found that Rate of Readability of the respondents was highest in the Natural white light (4000k) with 2.76 words/ second.

Section:9

4.9 Development of Recommended Guidelines with respect to General Lighting for Reading Spaces

The researcher reviewed available literature and web articles on Lighting, Reading, Ergonomics and Interior Design to select the content for recommendations to include in the Guidelines. The Guidelines, once developed was given to 1 expert of Interior design; 1 expert of Ergonomics of department of Family and Community Resource and an Eye specialist for content validation. Suggestion given by the experts were incorporated. The Guidelines included general Suggestions about lighting in Reading spaces concerning Ergonomics and Interior Design and things to be kept in mind while Reading. The Guidelines were then shared with the respondents via email and WhatsApp.

The content of Guidelines was presented under following sub-headings:

1. **Reading angle:** The Ideal reading angle is 60^{o} from horizontal reading surface. It can also differ from person to person.
2. **Focal distances:** The focal distance for reading and writing on paper is between 15" and 25" away from the eyes.

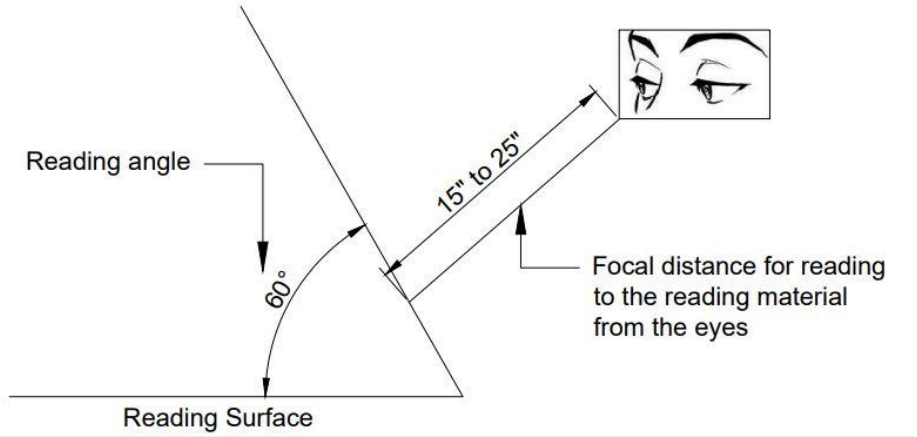

Plate 18: Reading angle and Focal distance

Table 24: Recommended Lighting levels in the Reading spaces: (in Lux)

Reading situation	Lux
Normal printed material, handwritten with ball-pen or with ink-pen.	200 to 500 lux
Poorly printed material and handwritten with medium dark pencil.	500 to 1000 lux
Handwritten with light pencil	1000 to 2000 lux

3. **CCT (Correlated Colour Temperature):** Based on the findings of the study the preferred CCT (Correlated Colour Temperature) of Lighting for reading is Natural white light (4000k) as perceived by the respondents.
4. **Position of reading lamp:** Correct position for reading lamp vary from person to person. The light source should never be in your direct line of sight.
5. **Glare:** For glass desk surface, be aware of glare from light reflected from the glass.
6. **Rest Period:** Follow the 20-20-20 rule. Every 20 minutes spent reading, try to look away at something that is 20 feet away for 20 seconds or close the for 20 seconds.
7. **Proper Posture to Read a Book at a Desk:**

- The back should be straight and supported.
- Leaning against the back of the chair is highly recommended in order to avoid putting strain on the back muscles, the chair should help to stay upright and not leaned back.
- The lumbar support is absolutely essential for extended reading sessions.
- Relaxing muscles and resting the feet firmly on the ground with the knees bent at a 90^{o} angle ensures that the legs do not feel numb. and that the joints are not going to suffer from sitting longer. Using foot rest will also be beneficial.

8. **Recommended exercises for better reading:**

1. **Palming**

Step 1: Make the palms of the hands warm by rubbing them vigorously together for a few seconds.

Step 2: Cup the hands over the closed eyes.

Step 3: Rest the cupped hands on the tissues surrounding the eyes and breathe in and out deeply.

Meditation during palming will help to relax even further. Palm for five-minute periods throughout the work day.

Plate 19: Palming exercise

Image Source: https://5minutecrafts.site/learn-tricks/how-to-exercise-your-eyes-2534/

2. Near and far focus

Step 1: Sit up straight and fully extend the right hand in the front. Then lift the thumb up and direct the eyes towards it.

Step 2: Slowly start moving the hand to the left side as much as one can while following the thumb with the eyes.

Step 3: Then move the hand back in the other direction as to continue to follow it with the eyes. Don't move the head and neck, but only the eyes.

Step 4: Repeat these movements several times.

Plate 20: **Near and far focus exercise**

Image Source: https://5minutecrafts.site/learn-tricks/how-to-exercise-your-eyes-2534/

3. **Eye Rolling**

   Step 1: Sit up straight, keep head still, look at left side

   Step 2: Then slowly roll the eyes upward

   Step 3: Then roll the eyes to the right side

   Step 4: Finish by rolling the eyes down to the floor.

   Step 5: Repeat several times before changing direction.

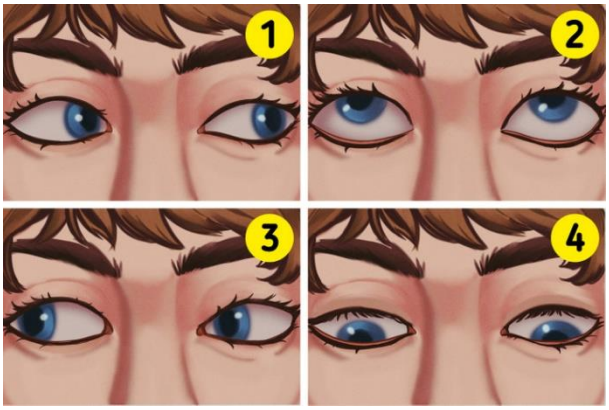

Plate 21: Eye rolling exercise

Image Source: https://5minutecrafts.site/learn-tricks/how-to-exercise-your-eyes-2534/

4. **Cover the Eyes** – Cover the eyes with an eye mask or some kind of soft material to block out all light for few minutes to provide rest
5. **Sunning**

   Step 1: Stand in front of a door or window that receives plenty of natural sunlight preferably early in the morning.

   Step 2: Close the eyes and allow the sunlight to gently warm the eyelids. Be sure to do this without the glasses or contacts lenses. Sunlight can help the retina release dopamine, which leads to healthy eye development. Make sure to this early in the morning.
6. **Warm & Cold Water Compresses**

   Step 1: Dip a soft and clean cloth into warm or cool water

   Step 2: Place it over the eyelids for a couple of minutes.

   Warm water will relax the eye muscles and cool water (or even ice cubes wrapped up in a cloth) will help reduce puffiness around the eyes caused by eye strain.

Section:10

4.10 Testing of Hypotheses

Several Hypothesis were formulated to find out the relationship between selected variables. In the present investigation, as per the nature of variables Analysis of the Variance (ANOVA), t-test and Coefficient of correlation was computed. For the purpose of statistical analysis, the hypothesis was formulated in null form. The results are presented in this section.

H_{O1}: There exists no variation in the Extent of Readability under Warm white light (3000k) CCT of Direct Lighting with selected personal variable viz. Age (in years), Medium of language and Glasses/ lenses tinted.

Analysis of Variance (ANOVA) was computed to show there exists variation in Extent of Readability under Warm white Light (3000k) CCT of Direct Light with Medium of Language and there exists no variation in Extent of Readability under Warm white light (3000k) CCT of Direct Lighting with selected personal variable viz. Age (in years and Glasses/ lenses tinted.

Table 25: Analysis of Variance showing variation in Extent of Readability under Warm white light (3000k) CCT of Direct Lighting with selected personal variable viz. Age (in years), Medium of language and Glasses/ lenses tinted.

Selected Variables	Sum of Squares	Mean Squares	df	F-value	Level of significance
Age (in years)					
Between Groups	7.491	3.746	2	0.289	N.S*
Within Groups	752.312	12.971	58		
Medium of language					
Between Groups	89.681	29.894	3	2.543	0.05
Within Groups	670.122	11.757	57		
Glasses/ lenses tinted					
Between Groups	6.947	2.316	3	0.175	N.S*
Within Groups	752.856	13.208	57		
Note: df =Degree of Freedom,*N.S. = Not Significant					

The computation of F- value showed that there exists variation in the Extent of Readability under Warm white light (3000k) CCT of Direct Lighting with Medium of language and there exist no variation in the Extent of Readability under Warm white light (3000k) CCT of Direct Lighting with selected personal variable viz. Age (in years) and Glasses/ lenses tinted.

$H_{O1.1}$: There exists no variation in the Extent of Readability under Natural white light (4000k) CCT of Direct Lighting with selected personal variable viz. Age (in years), Medium of language and Glasses/ lenses tinted.

Analysis of Variance (ANOVA) was computed to show there exists variation in Extent of Readability under Natural white light (4000k) CCT of Direct Lighting with Age (in years) and there exists no variation in Extent of Readability under Natural white light (4000k) CCT of Direct Lighting with selected personal variable viz. Medium of language and Glasses/ lenses tinted.

Table 26: Analysis of Variance showing variation in Extent of Readability under Natural white light (4000k) CCT of Direct Lighting with selected personal variable viz. Age (in years), Medium of language and Glasses/ lenses tinted.

Selected Variables	Sum of Squares	Mean Squares	df	F-value	Level of significance
Age (in years)					
Between Groups	49.605	24.803	2	2.759	0.05
Within Groups	521.379	8.989	58		
Medium of language					
Between Groups	35.331	11.777	3	1.253	N.S*
Within Groups	535.653	9.397	57		
Glasses/ lenses tinted					
Between Groups	28.619	9.540	3	1.003	N.S*
Within Groups	542.364	9.515	57		
Note: df =Degree of Freedom,*N.S. = Not Significant					

Table 27: Scheffe's test showing the mean significant in extent of Readability under Natural white light (4000k) CCT of Direct Lighting with Age.

Extent of Readability	Mean	df	Level of significance
Age (in years)			
18-20 years	21.89	58	0.05
21-24 years	20.10		
25-28 years	22.00		

The statistical analysis in scheffe's test on personal variable age of the respondents revealed that those who were in the age group of 25-28 years significantly differed from those who were in the age group of 18-20 and 21-24 years (Table 27).

$H_{O1.2}$: There exists no variation in the Extent of Readability under Cool white light (6500k) CCT of Direct Lighting with selected personal variable viz. Age (in years), Medium of language and Glasses/ lenses tinted.

Analysis of Variance (ANOVA) was computed to show there exists variation in Extent of Readability under Cool white light (6500k) CCT of Direct Lighting with Age (in years) and Glasses/ lenses tinted. There exists no variation in Extent of Readability under Cool white light (6500k) CCT of Direct Lighting with Medium of language.

Table 28: Analysis of Variance showing variation in Extent of Readability under Cool white light (6500k) CCT of Direct Lighting with selected personal variable viz. Age (in years), Medium of language and Glasses/ lenses tinted.

Selected Variables	Sum of Squares	Mean Squares	df	F-value	Level of significance
Age (in years)					
Between Groups	54.189	27.094	2	2.262	0.05
Within Groups	694.762	11.979	58		
Medium of language					
Between Groups	28.145	9.382	3	0.742	N.S*
Within Groups	720.806	12.646	57		
Glasses/ lenses tinted					
Between Groups	100.232	33.411	3	2.936	0.01
Within Groups	648.719	11.381	57		
Note: df =Degree of Freedom,*N.S. = Not Significant					

Table 29: Scheffe's test showing the mean significant in extent of Readability under Natural white light (4000k) CCT of Direct Lighting with Age and Glasses/lenses tinted.

Extent of Readability	Mean	df	Level of significance
Age (in years)			
18-20 years	22.14	58	0.05
21-24 years	20.33		
25-28 years	19.67		
Glasses/ lenses tinted			
No	19.00	57	0.05
Yes	22.06		
UV protected	23.44		

The statistical analysis in scheffe's test on personal variable age of the respondents revealed that those who were in the age group of 18-20 years significantly differed from those who were in the age group of 21-24 and 25-28 years (Table 29). The mean comparison shows that the UV protected Glasses/lenses significantly differed from tinted or non tinted glasses/lenses.

H_{O2}: There exist no difference between the Extent of Readability of the respondents under three different CCTs of Direct Light with their personal variable Gender.

To study the difference in the Extent of Readability of the respondents under three different CCTs of Direct Light with their personal variable- gender, t-test was computed.

Table 30:t-test showing difference in the Extent of Readability under three different CCTs of Direct Light respondents with their personal variable- gender.

Selected Variables	Mean score	t-value	df	Level of significance
Warm white light (3000k)				
Male	-1.126	0.243	59	N.S*
Female	-1.126			
Natural white light (4000k)				
Male	-0.243	0.773	59	N.S*
Female	-0.243			
Cool white light (6500k)				
Male	-1.217	0.204	59	N.S*
Female	-1.217			
Note: df =Degree of Freedom,*N.S. = Not Significant				

The computation of t-value depicted that there is no significant difference in the Extent of Readability of the respondents under three different CCTs of Direct Light with their personal variable- gender. Hence, the null hypotheses were accepted.

H_{O3}: There exist no difference between the Extent of Readability of the respondents with three different CCTs of Direct Light with Eye Sightedness.

To study the difference in the Extent of Readability of the respondents under three different CCTs of Direct Light with their personal variable- Eye Sightedness, t-test was computed

Table 31: t-test showing difference in the Extent of Readability under three different CCTs of Direct Light respondents with their personal variable- Eye Sightedness

Selected Variables	Mean score	t-value	df	Level of significance
Warm white light (3000k)				
Corrected vision	0.327	0.725	59	N.S*
Normal vision	0.327			
Natural white light (4000k)				
Corrected vision	0.702	0.382	59	N.S*
Normal vision	0.702			
Cool white light (6500k)				
Corrected vision	2.090	0.020	59	N.S*
Normal vision	2.090			
Note: df =Degree of Freedom,*N.S. = Not Significant				

The computation of t-value depicted that there is no significant difference in the Extent of Readability of the respondents under three different CCTs of Direct Light with their personal variable- Eye sightedness. Hence, the null hypotheses were accepted.

H_{O4}: There exist no relation between Extent of Readability and the three different CCTs of Direct Lighting.

Co-efficient of correlation was computed to find out relation between the Extent of Readability of the respondents and three CCTs of Direct Lighting.

Table 32: Co-efficient of correlation showing relationship between the Extent of Readability and the three different CCTs of Direct Lighting.

Sr.	Extent of Readability of the respondents	n	r-value	Level of significance
1.	Warm white light (3000k)	61	1	N.S*
2.	Natural white light (4000k)	61	0.296	0.01
3.	Cool white light (6500k)	61	0.347	N.S*

A significant relationship was found between Extent of Readability of respondents and 4000k CCT of Direct Lighting. Hence, the null hypothesis was rejected.

CHAPTER- 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

The sensory perception of sight is the light reflecting off of surfaces, objects, and shapes. The mind interprets these images through vision. Vision enables a person to comprehend the meaning of an event and make interpretations, while sight enables a person to observe an event. Although reading in low light won't harm the eyes permanently, it can create temporary issues including headaches and eye strain. One should be aware that reading in the right lighting can help to prevent eye strain whether they are reading a book, an e-reader, or on a tablet. Without light, which is a form of energy, there can be no vision. Depending on the object, light can reflect, absorb, or travel through it. It is also described as electromagnetic radiation that has the possibility of damaging eyesight. One of the various kinds of lighting schemes is direct light, which is the one that is most usually utilized. With a direct lighting scheme, more than 90 per cent of the total light flux is made to fall directly on the working plane with the use of deep reflectors. Colour temperature is a term used to describe how a lightbulb appears to be illuminated. It is measured on a scale from 1,000 to 10,000 in degrees Kelvin (K). The CCT (Correlated Colour Temperature) scale measures how warm or cool a light source's output is. To do tasks efficiently and securely in a professional or educational environment, good illumination is essential. The importance of lighting has been extensively studied and is thought to be crucial for occupant performance. Moreover, lighting contributes to the creation of a visually engaging environment that improves the interior space's appearance.

Studies have demonstrated the impact of illumination on human biological health, including heart rate, blood pressure, and circadian rhythm. Studies have shown that proper lighting settings have positive benefits on occupant worker efficiency and task completion speed and accuracy in addition to their emotional and biological effects.

The tasks to be accomplished and the comfort of all users must be taken into consideration when designing lighting in a human-centric manner. Additionally, it is asserted that poor lighting, flickering lights, and a lack of light controls in houses might contribute to health issues like eye strain and headaches.

Lighting in learning environments serves to provide a visually exciting environment so that learning can be done in the best possible way with the least amount of discomfort. Any intellectual learning place must have well planned artificial lighting as well as appropriate natural lighting. The reader's ability to understand a text clearly depends on the text's readability. It is crucial for students to have adequate illumination when reading because reading in low light or without the finest reading lamp can harm their eyes. In addition, headaches and eye strain may result.

After reviewing the available literature, the researcher found very less studies that focused on readability under Direct Lighting and even less on the CCTs of Direct lighting schemes. Hence, the present research aims to study the effects of direct lighting schemes under different CCTs on readability among the youth of Vadodara, Gujarat. The present study will be helpful in widening the data base and strengthening the curriculum on Interior designing, Lighting and Ergonomics courses that are offered by Department of Family and Community Resource Management, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda and various other institutes. In addition, this study will aid architects and interior designers in creating reading areas for students. The study will also provide guidelines on creating better reading spaces for educational institutes and residential spaces.

STATEMENT OF PROBLEM

The present research attempts to study the Effects of Direct Lighting on Readability among the youth of Vadodara city.

OBJECTIVES OF THE STUDY

1. To study General Visual Discomfort while reading as perceived by the respondents
2. To study and compare the Extent of Readability under three different CCTs Direct Lighting conditions.
3. To compare the Rate of Readability between different CCTs (Correlated Colour temperature) of Direct Lighting.

4. To develop guidelines for reading spaces concerning aspects of Direct Lighting.

DELIMITATION OF THE STUDY

1. The locale of the study will be limited to only Vadodara city.
2. The study will be limited to the age group of 18-28 years.
3. The source of Direct lighting for the present study will be limited to three types of CCTs (Correlated color temperature) of Direct Lighting namely warm white, natural white, and cool white.

HYPOTHESES OF THE STUDY

1. The Extent of Readability of the respondents will vary with their personal variables i.e. Gender, Age, Medium of language, Eye sightedness, tinted Glasses/ lenses and Color-blindness test results
2. The Extent of Readability of the respondents will vary with Experimental variable of the study i.e. Three different CCTs (Correlated color temperature) of Direct Light.

Methodology

The research design for the present study was experimental in nature. The sample for the present study was selected from Vadodara, Gujarat, India. After taking an informed consent from the respondents who were in the age group of between 18-28 years the data was collected from 61 respondents using purposive sampling technique for the selection of respondents. For the present study Interview schedule was used as a tool for data collection. The Interview schedule consisted of 5 sections: Section 1 consisted of background information of the respondents, section 2 consisted of statements regarding General information on visual discomfort and section 3 Includes statements concerning the effect of Warm white light (3000k) CCT of Direct lighting on their reading ability. section 4 Includes statements concerning the effect of Natural white light (4000k) CCT of Direct lighting on their reading ability. section 5 Includes statements concerning the effect of Cool white light (6500k) CCT of Direct lighting on their reading ability. To study the Extent of visual discomfort related to reading, the scoring was computed using Likert rating scale where responses were ‘Always’, ‘Sometimes’ and ‘Never’ and scores of 3, 2, and 1

were ascribed respectively. The scores of each of the items of the scale were summated and possible range of minimum and maximum scores were divided into three categories having equal interval which were “High”,” Moderate” and “Low”. To study the Extent of Readability under three different CCTs of Direct lighting, the scoring was computed using Likert rating scale where responses were ‘Agree’, ‘Undecided’ and ‘Disagree’ and scores of 3, 2, and 1 were ascribed respectively. The data was analysed by applying descriptive statistics (frequencies, percentage, mean and standard deviation) as well as relational statistics (Analysis of Variance [ANOVA], t-test and co-relation)

Major Findings

The major findings of the present study are presented here.

Section 1: Background Information

The data was collected from individuals who are in the age group of 18-28 years from Vadodara city through Interview schedule, in order to ascertain the Extent of Readability in three different CCTs of Direct Lighting. It was found that slightly less than one-half of the respondents were in the age group of 21-24 years. A little less than two third of the respondents were female. Majority of the respondent’s medium of language was English. Majority of the respondents were students. Less than two third of the respondents had normal vision. One-half of the respondents were having their power of eye sight of the right eye was between (-0.1) – (-2.4). A little less than two-third of the respondents were having their power of eye sight of the left eye was between (-0.1) – (-2.4). More than one-half of the respondents were not having their glasses/ lenses tinted. Majority of the respondents were having normal colour vision.

Section 2: General Visual Discomfort related to reading

Majority (91.80%) of the respondents ‘Never’ felt their eyes were red while reading. Majority (81.96%) of the respondents ‘Never’ felt that their eyes were dry while viewing striped pattern. Slightly more than three-fourth (77.04%) of the respondents ‘Never’ felt their eyes were watery while reading magazines or newspaper.

Section 2: Respondent's perception of reading in simulated lighting condition -Warm white light (3000k)

Majority (83.60%) of the respondents 'Agreed' that they did not feel their eyes were watery after reading under warm white light (3000k). Slightly more than three-fourth (78.68%) of the respondents 'Agreed' that they did not see glare while reading under warm white light (3000k). A little less than three-fourth (73.77%) of the respondents 'Agreed' that their eyes did not feel strained while reading.

Section 3: Respondent's perception of reading in simulated lighting condition -Natural white light (4000k)

Majority (86.88%) of the respondents 'Agreed' that the light was comfortable while reading under natural white light (4000k). Majority (86.88%) of the respondents 'Agreed' that they did not feel their eyes were watery after reading under natural white light (4000k). A little less than three-fourth (78.68%) of the respondents 'Agreed' that their eyes did not feel strained while reading under natural white light (4000k).

Section 4: Respondent's perception of reading in simulated lighting condition –Cool white light (6500k)

Slightly less than three-fourth (75.40%) of the respondents 'Agreed' that the light was comfortable while reading under cool white light (6500k). A little less than tree-fourth (75.40%) of the respondents 'Agreed' that they did not feel their eyes were watery after reading under cool white light (6500k). Less than three-fourth (72.13%) of the respondents 'Agreed' that their eyes did not feel strained while reading under cool white light (6500k). The findings further revealed that the 'High Extent of Readability' was found among respondents while reading under natural white light (4000k). The findings also revealed that the 'High Rate of Readability' was found among respondents while reading under natural white light (4000k).

Statistical Findings

The statistical findings revealed that that who were in the age group of 25-28 years significantly differed from those who were in the age group of 18-20 and 21-24 years while reading under Natural white light (4000k). The statistical analysis in scheffe's test on personal variable age of the respondents revealed that those who were in the age group of 18-20 years significantly differed from

those who were in the age group of 21-24 and 25-28 years. The mean comparison shows that the UV protected Glasses/lenses significantly differed from tinted or not tinted glasses/lenses while reading under Cool white light (6500k). A significant relationship was found between Extent of Readability of respondents and 4000k CCT of Direct Lighting.

Conclusion

A study was conducted on the effects of Direct Lighting on Readability among the youth of Vadodara, City. It was found that the mean age of the respondent was 21.09 years. Large number of the respondents belonged to the age group of 21-24 years 21 male and 20 female respondents were taken by snowball sampling for the present research. Majority of the respondents were students. Less than two third of the respondents had normal vision. More than one-half of the respondents were not having their glasses/ lenses tinted. Majority of the respondents were having normal colour vision. Further on analysing the data on General Visual Discomfort, it was found that majority of the respondents never felt redness in their eyes after reading newspaper or magazine. Slightly more than three-fourth of the respondents were having low extent of general visual discomfort while reading. On analysing the data of readability of the respondents under three different CCTs of direct lighting it was found that majority of the respondents agreed that they did not feel their eyes were watery after reading under warm white light (3000k). Majority of the respondents agreed that the light was comfortable and they also did not feel their eyes were watery after reading under natural white light (4000k). A little less than three-fourth of the respondents agreed that the light was comfortable and they also did not feel their eyes were watery after reading under cool white light (6500k). It was found that Majority of the respondent were having High Extent of Readability under Natural white light (4000k). It was found that Rate of Readability of the respondents was highest in the Natural white light (4000k). On analysing the data of Extent of Readability, Rate of Readability and hypotheses, it was found that Natural white light (4000k) CCT of the direct light suits best for reading.

Recommendations for the future studies

1. A similar kind of research can be carried out on wider scale.
2. A similar comparative study can be conducted between the individuals of different age group.
3. A study can be conducted on other activities with respect to lighting
4. Similar studies can be conducted focusing only on the readability aspects
5. Similar study can be conducted focusing on readability on electronic devices like smart phones, tablet and laptops.
6. An action project can be conducted to design a lamp specifically for reading purposes.

Implications of the study

The findings of the present study had the following implications:

For the field of Family and Community Resource Management

The field of Family and Community Resource Management has courses related to Interior designing, Lighting and Ergonomics offered to students at Under Graduate, Post Graduate and Doctorate level. The findings of the present study will help students in understanding Lighting with respect to ergonomics and interior designing for reading spaces.

For reading

The recommended guidelines and exercises for general reading spaces on the basis of the present study will help people to read in a better way.

For the Interior designers

The findings of the present study would help the interior designers to understand the concept of lighting for reading spaces for the residential as well public spaces like schools and libraries.

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APPENDIX – I

Interview schedule

Section I

Background Information

- **Name:**
- **Email ID:**

1. **Age (in years) _____**

2. **Gender**
    - Male
    - Female

3. **Medium of Language?**
    - English
    - Gujarati
    - Hindi
    - Other _____

4. **Occupation**
    - Student
    - Service
    - Business
    - Homemaker
    - Part-time job
    - Other _____
5. **Health Status**
    - Diabetes
    - Heart Problem
    - None
    - Other _____
6. **Will you be wearing glasses or contact lenses during the experiment?**
    - Yes
    - No

***If yes, then**

a. Are your glasses/lenses tinted?
    - Yes
    - No
    - UV protected

b. Power deficiency of eye sightedness?

+/-			
Right eye		Left eye	

7. **Result of Ishihara colour-blindness test _____**

SECTION-2

GENERAL INFORMATION ON VISUAL DISCOMFORT

RELATED TO READING

The following aspects are related to general visual discomfort related to reading. Please go through the following and put the [✓] tick mark in the appropriate column.

Sr. No.	Statements	Always	Sometimes	Never
1.	My eyes get watery while viewing a striped pattern			
2.	My eyes get dry when viewing a striped pattern			
3.	My eyes get watery while reading a newspaper or magazine			
4.	I get redness in my eyes while reading a newspaper or magazine			
5.	I feel the need to use a pencil or your finger to maintain focus when reading a page of text in a novel or magazine			
6.	I unintentionally reread the same line			

7.	When I read the letters on a page I lose focus			
8.	I feel the need to move my eyes around the page, or continually blink or rub my eyes to keep the text easy to see while reading			
9.	I get headaches due to sensitivity to light			

SECTION-3
RESPONDENT'S PERCEPTION OF SIMULATED LIGHTING CONDITIONS WHILE READING

The following aspects are related to respondents' perception of simulated lighting conditions. Please go through the following and put the [✓] tick mark in the appropriate column.

3A: Warm white light (3000k)

Lux meter reading: _____

Time Recorded: _____

Sr. No.	Statements	Agree	Undecided	Disagree
1.	The light was comfortable while, I was reading			
2.	My eyes did not feel strained while I was reading			
3.	I didn't see a glare while I was reading			
4.	I didn't feel that my eyes were watery after reading			

5.	I was satisfied with the colour of the light			
6.	I did not feel visual distraction			
7.	My eyes did not feel tired while reading in this light			
8.	This light did not hindered my reading task			
9.	It was not difficult to see the letters clearly because of the colour of light			
10.	I did not anxious due to the colour of light			
11.	The light was pleasing			

3B: Natural White Light (4000k)

Lux meter reading: _____

Time Recorded: _____

Sr. No.	Statements	Agree	Undecided	Disagree
1.	The light was comfortable while, I was reading			
2.	My eyes did not feel strained while I was reading			
3.	I didn't see a glare while I was reading			
4.	I didn't feel that my eyes were watery after reading			

5.	I was satisfied with the colour of the light			
6.	I did not feel visual distraction			
7.	My eyes did not feel tired while reading in this light			
8.	This light did not hindered my reading task			
9.	It was not difficult to see the letters clearly because of the colour of light			
10.	I did not anxious due to the colour of light			
11.	The light was pleasing			

3C: Cool White Light (6500k)

Lux meter reading: _____

Time Recorded: _____

Sr. No.	Statements	Agree	Undecided	Disagree
1.	The light was comfortable while, I was reading			
2.	My eyes did not feel strained while I was reading			
3.	I didn't see a glare while I was reading			
4.	I didn't feel that my eyes were watery after reading			

5.	I was satisfied with the colour of the light			
6.	I did not feel visual distraction			
7.	My eyes did not feel tired while reading in this light			
8.	This light did not hindered my reading task			
9.	It was not difficult to see the letters clearly because of the colour of light			
10.	I did not anxious due to the colour of light			
11.	The light was pleasing			

APENDIX-II

Ethical Compliance Certificate

Institutional Ethics Committee for Human Research (IECHR)

FACULTY OF FAMILY AND COMMUNITY SCIENCES
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

Ethical Compliance Certificate 2022-2023

This is to certify that **Ms. Jahnavi Luhar's** study titled, **Effects of Direct Lighting on Readability among Youth of Vadodara city** has been approved by the Institutional Ethics Committee for Human Research (IECHR), Faculty of Family and Community Science, The Maharaja Sayajirao University of Baroda. The study has been allotted the ethical approval number **IECHR/FCSc/M.Sc./2022/05.**

Prof Shagufa Kapadia
Chairperson
IECHR

Prof Mini Sheth
Member Secretary
IECHR

APENDIX-III

Consent form

Estd. 1949

NAAC Accredited "A" Grade

DEPARTMENT OF FAMILY AND COMMUNITY RESOURCE MANAGEMENT

FACULTY OF FAMILY & COMMUNITY SCIENCES

THE MAHARAJ SAYAJIRAO UNIVERSITY OF BARODA

VADODARA

INFORMED CONSENT FORM

The Department of Family and Community Resource Management, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda, Vadodara, supports the practice of protection of human participants in research. The following will provide you with information about the experiment that will help you decide whether or not you wish to participate. If you agree to participate, please be aware that you are free to withdraw at any point throughout the duration of the research without any penalty. In this study, you will be asked about your background information (Name, Age, Gender, Occupation, etc.), your health status, and your problems related to vision while reading.

All information you provide will remain confidential and will not be associated with your name. If for any reason during this study you do not feel comfortable, you may leave the study. Your participation in this study will require approximately 30-40 minutes. Please do not leave any response blank. If you have any further questions concerning this research, please feel free to contact us by Phone or email. (Ms. Jahnavi Luhar, +91 9712240089, jahnaviluhar18@gmail.com).

Please indicate with your signature in the space below that you understand what participation in the study involves and agree to give consent to participate. Your Participation is strictly voluntary. All information will be kept confidential and your name will not be associated with any research findings.

Jain.

Name & Signature of Respondent: Kaushik · S. Jain

Date: 15/12/22

Ms. Neha Rathore
Research guide &
Assistant Professor
Department of FCRM
FFCSc , MSU

Ms. Jahnavi Luhar
Researcher
M.Sc. (F.C.Sc.)Department of FCRM
FFCSc, MSU

APENDIX-III

Consent form

Estd. 1949

NAAC Accredited "A" Grade

DEPARTMENT OF FAMILY AND COMMUNITY RESOURCE MANAGEMENT

FACULTY OF FAMILY & COMMUNITY SCIENCES

THE MAHARAJ SAYAJIRAO UNIVERSITY OF BARODA

VADODARA

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All information you provide will remain confidential and will not be associated with your name. If for any reason during this study you do not feel comfortable, you may leave the study. Your participation in this study will require approximately 30-40 minutes. Please do not leave any response blank. If you have any further questions concerning this research, please feel free to contact us by Phone or email. (Ms. Jahnavi Luhar, +91 9712240089, jahnaviluhar18@gmail.com).

Please indicate with your signature in the space below that you understand what participation in the study involves and agree to give consent to participate. Your Participation is strictly voluntary. All information will be kept confidential and your name will not be associated with any research findings.

Haya Sheth

Name & Signature of Respondent:

Date: 16/12/22

Ms. Neha Rathore
Research guide &
Assistant Professor
Department of FCRM
FFCSc., MSU

Ms. Jahnavi Luhar
Researcher
M.Sc. (F.C.Sc.)Department of FCRM
FFCSc, MSU

APENDIX-III

Consent form

Estd. 1949

NAAC Accredited "A" Grade

DEPARTMENT OF FAMILY AND COMMUNITY RESOURCE MANAGEMENT

FACULTY OF FAMILY & COMMUNITY SCIENCES

THE MAHARAJ SAYAJIRAO UNIVERSITY OF BARODA

VADODARA

INFORMED CONSENT FORM

The Department of Family and Community Resource Management, Faculty of Family and Community Sciences, The Maharaja Sayajirao University of Baroda, Vadodara, supports the practice of protection of human participants in research. The following will provide you with information about the experiment that will help you decide whether or not you wish to participate. If you agree to participate, please be aware that you are free to withdraw at any point throughout the duration of the research without any penalty. In this study, you will be asked about your background information (Name, Age, Gender, Occupation, etc.), your health status, and your problems related to vision while reading.

All information you provide will remain confidential and will not be associated with your name. If for any reason during this study you do not feel comfortable, you may leave the study. Your participation in this study will require approximately 30-40 minutes. Please do not leave any response blank. If you have any further questions concerning this research, please feel free to contact us by Phone or email. (Ms. Jahnavi Luhar, +91 9712240089, jahnaviluhar18@gmail.com)

Please indicate with your signature in the space below that you understand what participation in the study involves and agree to give consent to participate. Your Participation is strictly voluntary. All information will be kept confidential and your name will not be associated with any research findings.

Name & Signature of Respondent: Garima Rajput

Date: 16/12/22

Ms. Neha Rathore
Research guide &
Assistant Professor
Department of FCRM
FFCSc., MSU

Ms. Jahnavi Luhar
Researcher
M.Sc. (F.C.Sc.)Department of FCRM
FFCSc, MSU

APENDIX-IV

Invitation Poster for Experiment

Hi,

I am Jahnavi Luhar, M.Sc. student from Maharaja Sayajirao University of Baroda

I am conducting an Experimental research on "Effects of Direct Lighting on Readability among Youth of Vadodara city"

The criteria for participating in this experiment are as follows:

- The age should be between 18-28 years.
- A person who has medium fluency in English can participate in this experimental research.

If you fit these criteria, I request you to participate in this experiment.

If you wear glasses, I request you to bring your power deficiency number.

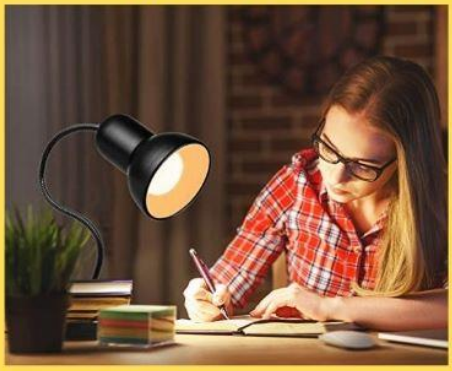
Date: **12/12/22 to 17/12/22**

Time: **10:00 am to 05:00 pm**

This experiment will only take half an hour of your time.

Venue: Hospitality management laboratory, Faculty of family and community sciences, Maharaja Sayajirao University.

Interested individuals who are willing to participate give their consent and confirmation of their time slot on **WhatsApp No. 9712240089** or Mail it to **jahnaviluhar18@gmail.com**



APENDIX-V

Reading material for experiment

Page 1

BOOK FOR ATLEAST ONE LIBRARY

I come from a middle-class teacher's family. In my family, as with many other families of teachers, books and knowledge were considered to be more important than money. In our village, I still remember the way people respected my grandfather. He was certainly not the richest man. He used to sit in front of our house, on a mat below a shady banyan tree. He always held a book in his hand. In the evening people would come to him for his advice. Even the richest man, when passing by, would greet him respectfully. I asked him once. "Why should the teacher be respected?" He smiled and told me a story. It seems, some friends of Arjun, the mighty warrior in Mahabharata, asked him why he gave so much respect to his teacher Dronacharya. Drona was old, not as rich as Arjun, and never ruled any kingdom. But Arjun would always sit at his feet respectfully. When asked why, it seems Arjun replied, "In this life, everything perishes over a period of time. Whether it be diamond, beauty, gold, or even land Only one thing withstands this destruction. It is knowledge The more you give the more you get." A teacher gives knowledge to students and I consider him the richest person. That is the reason a teacher is respected; not for his riches but because he is the source of knowledge.' As a child, the first expedition I ever made outside my home was to the village library building with my grandfather. The library was situated in a small two-storied structure. There was a shop on the ground floor and on the first floor was the library. A big banyan tree stood next to the building. There was a cement platform under it.

APENDIX-V

Reading material for experiment

Page 2

In Kannada, we call it katte. In the evening, all the elders of the village would sit here. My grandfather was one of them. I would accompany him and he would go and sit on the platform after dropping me at the first floor. It was the first of the many libraries I was to enter. There were cupboards with glass panes so that one could read the titles of the books easily. Newspapers and weeklies were piled up neatly. Tables and chairs were laid for people to sit and read. There was absolute silence. I started reading children's books there and used to be absorbed in them until my grandfather would call me to go home. Years passed and I became a girl of twelve years, I had finished reading almost all the books in that little village library. At times I used to feel bored going to the library as there were not many new books. But still, I accompanied my old grandfather to the banyan tree. One such evening, we were coming back after our outing. I was feeling particularly bored with the library that day. It was dark and the streetlights were blinking. My grandfather could not see too well so I was leading him by his hand. Suddenly he asked me,' I will recite half a poem, will you complete it? This is a well-known poem.' I said I would try. We often played this game and I had learnt many poems like this. He said, 'If I have wings... I immediately answered without blinking my eyes, 'I will go to the neighbouring village library and read many more books. My grandfather stopped in surprise. He said, "Will you repeat it?"

APENDIX-V

Reading material for experiment

Page 3

I repeated, 'I will go to the neighbouring village library and read many more books. "He laughed and said, 'What an unusual way to complete the poem! Do you know what the original poem is?" 'Yes, I know. 'If I have wings I will fly in the vast blue sky. I will see beautiful places I will meet great people. I will search for hidden treasures." My grandfather kept quiet. When we reached home he sat down on a mat and called me. He was tired but looked very happy. He took my little hand into his and said, "Do you know, there was a great man called Andrew Carnegie in USA. He was a billionaire who lived a century back. He willed all his wealth, not to his children, but to build library buildings in as many villages as possible. I have not seen America, but it seems any library you see in any village was invariably built using Andrew Carnegie's money. I do not know how long I will live, but today I realized how much you love books from the way you completed the poem. Promise me, when you grow up, if you have more money than you need, you will buy books for at least one library." It was a cold winter night. I still remember the warmth of his large hand in mine. He was old, and his hands had become hard and wrinkled writing thousands of lines on the blackboard with chalk every day. We were not rich like Carnegie, but certainly, my grandfather had a richness of experience and knowledge. Later in my life, I became well off. I remembered my promise of buying books for the library. Today, through Infosys Foundation, we have given books to ten thousand such libraries.

Abstract

In a study room, work or school setting, adequate lighting is crucial for performing tasks like reading and writing effectively. The importance of lighting has been extensively studied and is thought to be crucial for occupant's performance. Moreover, lighting contributes to the creation of a visually engaging environment that improves the interior space's appearance. The tasks to be accomplished and the comfort of all users must be taken into consideration when designing lighting in a human-centric manner. Additionally, it is asserted that poor lighting, flickering lights, and a lack of light controls in reading spaces might contribute to health issues like eye strain and headaches. Lighting in learning environments serves to provide a visually exciting environment so that learning can be done in the best possible way with the least amount of Visual discomfort. Any intellectual learning place must have well planned artificial lighting as well as appropriate natural lighting. Thus, a study was undertaken to know the Extent of Readability under different CCTs of Direct Lighting among the youth of Vadodara City. The research design for the present study was Experimental in nature. The data was collected from 61 respondents who were in the age group of 18-28 years, using purposive sampling technique. An interview schedule used as a tool for data collection consisting of 5 sections. The first section comprised of Background Information of the respondents. The second section consisted of statements regarding General information on visual discomfort experiencing while reading. The third section includes statements concerning the effect of Warm white light (3000k) CCT of Direct lighting on their reading ability. The fourth section includes statements concerning the effect of Natural white light (4000k) CCT of Direct lighting on their reading ability. The fifth section includes statements concerning the effect of Cool white light (6500k) CCT of Direct lighting on their reading ability. The data was analysed by applying descriptive statistics (frequencies, percentages, means and standard deviations) as well as relational statistics (Analysis of Variance (ANOVA), t-test and Co-relation). The findings revealed that the mean age of the respondent was 21.09 years. 21 males and 40 female respondents were taken for the present study. It was found that large number of respondents were Students (91.80%). It was found

that less than two-third (60.66%) of the respondents had normal vision. Majority (91.80%) of the respondents never felt redness in their eyes after reading newspaper or magazine. Slightly less than three-fourth (75.40%) of the respondents experienced ‘Low extent of visual discomfort’ while reading. Majority (83.60%) of the respondents agreed that they did not feel their eyes were watery after reading under warm white light (3000k). Majority (86.88%) of the respondents agreed that the light was comfortable and they also did not feel their eyes were watery after reading under natural white light (4000k). A little less than tree-fourth (75.40%) of the respondents agreed that the light was comfortable and they also did not feel their eyes were watery after reading under cool white light (6500k). It was found that Majority of the respondent were having ‘High Extent of Readability’ under Natural white light (4000k). It was found that Rate of Readability of the respondents was highest under Natural white light (4000k). The findings of the study will help students in understanding Lighting with respect to ergonomics and interior designing for reading spaces. It would also help the interior designers to understand the concept of lighting for reading spaces for the residential as well public spaces like schools and libraries. On the basis of the conducted study, guidelines were developed and shared through Email and WhatsApp to make their reading experience better.