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THE EFFECT OF LIGHTING LEVELS ON LIGHTING PREFERENCES FOR OLDER
ADULTS USING A NON-IMMERSIVE VIRTUAL ENVIRONMENT OF THEIR RESIDENCES

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THE EFFECT OF LIGHTING LEVELS ON LIGHTING PREFERENCES FOR OLDER ADULTS USING A NON-IMMERSIVE VIRTUAL ENVIRONMENT OF THEIR RESIDENCES

A Master's Thesis

by
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Ankara
June 2023

To my dear parents

Dr. Esra Serpil Bayramlı and Dr. Sait Bayramlı



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OLDER ADULTS USING A NON-IMMERSIVE VIRTUAL ENVIRONMENT
OF THEIR RESIDENCES

The Graduate School of Economics and Social Science
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Ece Esin Ilgaz

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By Ece Esin Ilgaz

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design

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ABSTRACT

THE EFFECT OF LIGHTING LEVELS ON LIGHTING PREFERENCES FOR OLDER ADULTS USING A NON-IMMERSIVE VIRTUAL ENVIRONMENT OF THEIR RESIDENCES

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This study aims to examine the lighting preferences of older adults in home corridors. The effect of different lighting arrangements, and lighting levels in home corridors at night were investigated in a non-immersive virtual environment. Six different lighting scenarios were established for a virtual home corridor, and 200 lux and 60 lux lighting were used in the ceiling lighting and ground lighting in these scenarios. The effects of yellow-green neon tapes applied to door frames and lighting switches on lighting preferences were also examined. For this purpose, 90 participants (60 to 85 years old) were recruited for this study. Firstly, the participants were asked to explore and experience the environments, then they were expected to answer the questionnaire with a semantic differential scale.

The findings of this study demonstrated that there was a significant difference between 200 lux- 60 lux lighting. When there was ceiling lighting in the corridor, the participants mostly preferred 200 lux lighting. When there

was ground lighting in the corridor, they reported 60 lux lighting more positive than 200 lux. When yellow-green neon tapes were additionally applied to the corridor for 60 lux lighting, the lighting condition using neon tapes was most preferred.

Keywords: Lighting Level and Arrangement, Lighting Preferences, Older Adults, Yellow-green Neon Tapes, Non- Immersive Virtual Environment



ÖZET

SÜRÜKLEYİCİ OLMAYAN SANAL KONUT ORTAMINDAKİ AYDINLATMA SEVİYELERİNİN YAŞLI YETİŞKİMLERİN AYDINLATMA TERCİHLERİNE ETKİSİ

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Bu çalışmanın amacı yaşlıların ev koridorlarında aydınlatma tercihlerini incelemektir. Sürükleyici olmayan bir sanal ortamda ev koridorlarındaki gece aydınlatma düzeylerinin ve düzenlemelerinin etkisi araştırılmıştır. Bunun için altı farklı senaryo oluşturulmuş ve bu senaryolarda tavan ve zemin aydınlatmasında 200 lux ve 60 lux aydınlatma düzeyleri kullanılmıştır. Kapı kasalarına ve aydınlatma anahtarlarına uygulanan sarı-yeşil neon bantların aydınlatma tercihlerine etkisi de incelenmiştir. Bu amaçla, 90 katılımcı (60 ila 85 yaş arası) ile çalışılmıştır. Öncelikle, katılımcılardan ortamları keşfetmeleri ve deneyimlemeleri istenmiş, ardından anketi anlamsal farklılık ölçeği ile yanıtlamaları beklenmiştir.

Bu çalışmanın bulguları, 200 lux ile 60 lux aydınlatma arasında önemli bir fark olduğunu göstermiştir. Koridorda tavan aydınlatması varken katılımcılar en çok 200 lux aydınlatmayı tercih etmişlerdir. Koridorda zemin aydınlatması varken 60 lux aydınlatmayı 200 lux'ten daha çok tercih etmişlerdir. 60 lux

aydınlatma için koridora ek olarak sarı-yeşil neon bantlar uygulandığında ise en çok neon bantların kullanıldığı aydınlatma koşulu tercih edilmiştir.

Anahtar Kelimeler: Aydınlatma Düzeyi ve Düzeni, Aydınlatma Tercihleri, Yaşlı İnsanlar, Sarı-Yeşil Neon Bantlar, Sürekli Olmayan Sanal Ortam



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LIST OF ABBREVIATIONS

VE- Virtual Environment

niVE- Non-immersive Environment

IVE- Immersive Virtual Environment

VR- Virtual Reality

CL- Ceiling Lighting

GL- Ground Lighting

LED- Light Emitting Diode

DEMATEL- Decision-Making Trial and Evaluation Laboratory

ANP- Analytic Network Process

VIKOR- VlseKriterijumska Optimizacija I Kompromisno Resenje

SHSs- Smart Home Systems

GE- Glare Effect

GET- Glare Effect Test

CHAPTER I

INTRODUCTION

1.1 Problem Statement

People who are over 60 years old are referred to as older adults and 12,5% of the whole world population in 2015 are older adults. This quantity of population is still increasing rapidly. Given previous evidence that death is postponed among older adults, they are able to live 125 years by 2070 (de Beer, Bardoutsos, & Janssen, 2017). This predicted increase in maximum reported age at death shows that the human lifespan has no visible limit yet (Nations, World Population Ageing, 2015). Moreover, the population of older adults in the world is considered to have more than doubled in the next three decades (Nations, International Day of Older Persons, 2020). In other words, the population will increase to more than 1.5 billion older adults in 2050 (Nations, International Day of Older Persons, 2020). The older adults showing an increase in their population spend most of their time in their own houses (Fernandez-Portero, Alarcon, & Padura, 2017). Houses without a well-designed according to older adults' needs can be risky places for them (Evci, Ergin, & Beser, 2006). For example, 55 percent of the falls of older adults occur in their own homes and 23 percent occur near their houses because they cannot get very far from the surrounding of the house (Home Safety for Seniors - Statistics and Solutions - Age Safe America, 2017).

Basically, nighttime toilet usage is an issue to consider and generally, some older adults are forced to go to the toilet three times a night (Lee, Jeong, & Hirate, 2009). Corridors are the most commonly used circulation path at home to meet these needs (Sikder, Babun, Aksu, & Uluagac, 2019). The lighting of this circulation path is quite important to reduce accidents for the older adults (Osibona, Solomon, & Fecht, 2021; Van Bommel & Van den Beld, 2004; Boubekri, 2007; Christoffersen, 2011; Wurtman, 1968). It has been seen in the literature that studies have been carried out to increase the safety of older adults at home and to reduce accidents. However, a research gap has been observed, especially concerning corridor lighting, which is the most used circulation path. In addition, there is no significant evidence showing older adults' preference for lighting in corridors.

1.2. Aim of the Study

This study aims to examine the lighting preferences of older adults (over 60 years), and the effect of different lighting levels and arrangements in residential corridors, which are the most used space in a house (Sikder, Babun, Aksu, & Uluagac, 2019), at night, particularly when they wake up at night or want to meet a need at night. Another purpose of this study is to examine the effect of yellow-green neon color when applied in home corridors. The scope of this study does not include Kelvin's values and natural lighting.

1.3. Structure of the Thesis

There are six chapters in this study. The introduction describing the importance of the study is the first chapter. Then, the aim of the study, and the structure of the thesis are stated.

In Chapter II, there is a literature review on older adults in residential environments, previous studies on lighting preferences, and immersive virtual environments and non-immersive virtual environments. The lighting condition in the residential areas is examined and technical information related to light and vision is given on the part of older adults in a residential environment.

The methodology part of the study has the design of the study, research questions, sub-research questions, and hypotheses in Chapter III. Moreover, this part states the sample, experimental setup, and virtual corridor design. In addition to this, this chapter states the experimental procedure, instruments, data collection, questionnaires, and data analysis.

Then, Chapter IV covers the data analysis and quantitative results. It has three parts; comparison of lighting with 200 lux and 60 lux, effects of 200 lux and 60 lux in the ceiling, and ground on lighting preferences, and effects of the arrangement of lighting, and yellow-green neon tapes on lighting preferences. Chapter V is a discussion of the results.

Chapter VI represents the conclusion of the study and the suggestions for future studies.

CHAPTER II

LITERATURE REVIEW

2.1. Older Adults in Residential Environment

The most significant location in a person's life is their home (Feng, Chen, Zhu, & Xiong, 2018). Home permits a relationship between the resident and the broader environment on a mental and physical level (Shikder, Mourshed, & Price, 2012).

Shikder and his coworkers (2012) aim to present the current understanding of the physical and psychological effects of lighting and how they contribute to the promotion of an environment that is secure for older adults (Shikder, Mourshed, & Price, 2012). Their method was conducting a methodical review of the published literature on the physical and psychological effects of light on older adults (Shikder, Mourshed, & Price, 2012). As a result, older adults' physical, and emotional health have been promoted by lighting, which has been recognized as a major environmental trait, and visual performance data was determined to be well-supported (Shikder, Mourshed, & Price, 2012). However, it appears that recommendations and standards have largely concentrated on the illumination needs for particular activities and have

lacked in-depth instructions on vertical lighting and lighting design (Shikder, Mourshed, & Price, 2012).

Lee et. al., (2009) addressed the issue of older adults needing to get up at least twice or thrice throughout the night to use the restroom before attempting to get back to sleep in retirement homes (Lee, Jeong, & Hirate, 2009). This study examined various retirement homes in Tokyo to see how they handled the problem and how they used lighting to address it. Careful consideration was given to the variations in the living environments at each care facility as well as an analysis of the needs and concerns of the individuals using those facilities for this specific research (Lee, Jeong, & Hirate, 2009).

Especially, older adults are the individuals who spend most of their time at home, and an increasing proportion of older adults are living alone (Lee, Jeong, & Hirate, 2009). The population in the world is increasing rapidly day by day (Olmedo-Aguirre, et al., 2022), and it is expected to increase from 13% in 2008 to 24-25% by 2056 (Pfortmueller et. al., 2014). People whose population is fast growing are in a sensitive period of their lives because there are some situations in which they may be exposed to loneliness, isolation from society, increasing chronic illness, and physical and mental deterioration (Mahmoodabad, Zareipour, Askarishahi, & Beigomi, 2018). Their independence and health must be respected, and their living environment needs special care (Lee, Jeong, & Hirate, 2009). Navarro et. al. stated that partially dependent people can live independently or with a minimum level of care (Navarro, Vidana-Vila, Alsina-Pages, & Hervas, 2018).

The built environment should consider the different physical and psychological challenges that those 65 and older frequently face (Shikder, Mourshed, & Price, 2012). The main issues that have an impact on older adults' quality of life include limited mobility, chronic illness, mental

deterioration, and finally loss of independence (Shikder, Mourshed, & Price, 2012). In addition, they may also have visual disturbances, Alzheimer's disease sleep disorders, and depression (Shikder, Mourshed, & Price, 2012). In Figure 1, there is a summary of the impact of lighting on older adults. When determining the visibility and lighting system in homes designed for older adults, it should be carefully considered according to the needs of older adults (Shikder, Mourshed, & Price, 2012). For example, they have to wake up at night, go to the toilet, then come back to bed to continue to sleep (Lee, Jeong, & Hirate, 2009). There is an agreement on the creation of high-quality residential environments for older adults given the significant effects of living environments on their health, including their psychological and physical well-being (Hu, 2021; Parker, et al., 2004).

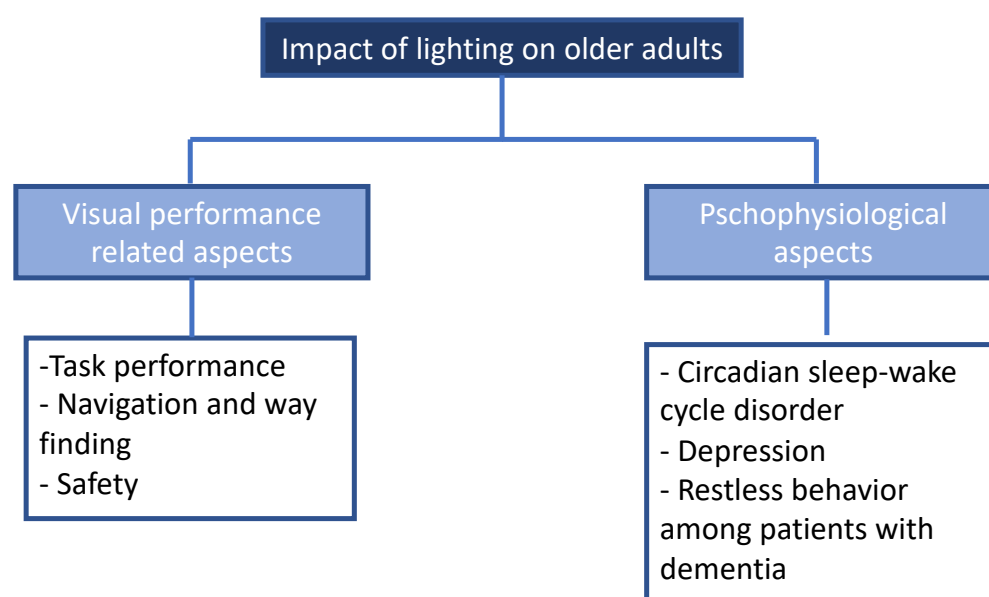


Figure 1. A summary of the impact of lighting on older adults (Shikder, Mourshed, & Price, 2012)

A crucial component of the quality of the indoor environment is lighting (Allan, Garcia-Hansen, Isoardi, & Smith, 2019). Allan et. al., (2019) suggests that according to the activity in the area, each piece of lighting needs to be

specially designed, and the relationship between lighting, place, and person determines the quality of the lighting (Allan, Garcia-Hansen, Isoardi, & Smith, 2019). Typically, lighting in residential environments is primarily focused on visual characteristics to promote energy efficiency, flexibility in multifunctional areas, and a feeling of aesthetics (Ticleanu, 2021).

2.1.1. Lighting Condition

Light is a form of electromagnetic radiation with wavelengths ranging from 380 nm to 770 nm, which activates the human eye and gives rise to the experience of vision (Boyce, 2022; International Lighting Vocabulary, 2019). Lighting is one of the most critical aspects to consider when designing a home (Rogers, Rogers, Takeshima, & Islam, 2004). It is one of the important aspects impacting the lives of older adults (Shikder, Mourshed, & Price, 2012). The population of older adults has been previously identified as one of the most significant housing concerns of the 21st century and adequate acceptable housing must be made available in the future (Shikder, Mourshed, & Price, 2012).

Osibona and his coworkers (2021) intended to combine current information on the relationship between house lighting and well-being and to suggest areas for further study (Osibona, Solomon, & Fecht, 2021). Using predetermined inclusion criteria, three different databases were investigated for pertinent literature, and The Newcastle Ottawa Scale was used to evaluate the quality of this study (Osibona, Solomon, & Fecht, 2021). The findings were qualitatively summarized according to lighting type (natural light, artificial light, and light at night) and classified by comprehensive health categories (sleep health, physical, and mental) (Osibona, Solomon, & Fecht, 2021). According to collected data, lighting in the residential environment can have a negative impact on health. However, the present database is restricted to a limited amount of research in many areas of light and well-

being (Osibona, Solomon, & Fecht, 2021). Therefore, more study on health effects is needed to better guide housing quality examinations and lighting regulations within the home (Osibona, Solomon, & Fecht, 2021). Studies on lighting and older adults have become widespread and published after 2012 (Lu, Park, & Ahrentzen, 2019). Light is critical for well-being and health since it regulates body systems, and adequate lighting is required for improved visual efficiency and safety, as well as to decrease falls and accidents (Osibona, Solomon, & Fecht, 2021; Van Bommel & Van den Beld, 2004; Boubekri, 2007; Christoffersen, 2011; Wurtman, 1968). However, lighting in a house is one of the less-examined aspects that affect housing quality (Osibona, Solomon, & Fecht, 2021).

Lu and his coworkers (2019) examined the scientific data on the effects of lighting on older adults in the following areas;

- activity level and instrumental activities of daily living
- circadian rhythm
- avoidance of falls and postural balance
- the quality of sleep.
-

They used a modified PRISMA systematic review approach, and an extensive review of lighting studies on older adults' visual and nonvisual performance was undertaken (Lu, Park, & Ahrentzen, 2019). According to collected data, some older adults found it difficult to use the restroom or any activities under lower lighting levels, brighter and blue illumination enhanced the circadian rhythms of older adults (Lu, Park, & Ahrentzen, 2019). In addition, LED (light emitting diode) lights which a lighting level is low mounted on door frames can assist older adults with keeping their balance and avoiding falls when moving at night, and some research showed that obtaining daylight while exercising was advantageous to the quality of sleep of older people (Lu, Park, & Ahrentzen, 2019).

Feng et. al., (2018) investigated evaluating and enhancing the housing environment of older adults to improve their quality of life, and it seeks to add to the field of improving older adults' housing using a framework for evaluation and data gathered from applicable literature (Feng, Chen, Zhu, & Xiong, 2018). This study suggested approaches and instructions enhance older adults dwelling using a mixed Multi-Criteria Decision Analysis model, a combination of the DEMATEL (Decision-Making Trial and Evaluation Laboratory)-based ANP (Analytic Network Process) (DANP) and the modified VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) methods, and the research findings and evaluations from the case study (Feng, Chen, Zhu, & Xiong, 2018). As a result, the proposed model demonstrated that improving ventilation and air quality, rather than adjusting temperature, is more important (Feng, Chen, Zhu, & Xiong, 2018). They also indicated that older adults' safety and quality of life are impacted by adequate daytime and nighttime illumination indoors and outside and lighting promotes increased alertness and attention in addition to a positive emotional and perceptual state (Feng, Chen, Zhu, & Xiong, 2018). Previously, a small number of systematic studies investigated the influence of lighting levels on older adults, as well as the impacts of daylight and artificial light at night on health in specific contexts such as nursing homes (Feng, Chen, Zhu, & Xiong, 2018; Lu, Park, & Ahrentzen, 2019; Aries, Aarts, & van Hoof, 2015; Cho, et al., 2015). It is crucial to provide specialized lighting design for older adult residents to meet their physical demands and improve their psychophysical health and well-being (Shikder, Mourshed, & Price, 2012).

Existing lighting guidelines and regulations apply to eyes that are healthy and young. However, a special lighting design is required for older adults (Kunduraci, 2017). For instance, the lighting needs of a person who is 80 years old are ten times more than those of a young person (on average) (Kunduraci, 2017).

Fernandez et. al., (2017) investigated the connection between older adults' life satisfaction and their reported pleasure with their residence (Fernandez-Portero, Alarcon, & Padura, 2017). Their method was that the set of tests consisted of three scales to measure the participants' degree of residential satisfaction and overall life satisfaction, and the living circumstances and habitability (Fernandez-Portero, Alarcon, & Padura, 2017). According to the findings, dwelling satisfaction was influenced by the physical aspects of the home as well as the amenities and standard of the residential surroundings, and the assessment of living circumstances indicated the level of home adaption and dwelling satisfaction of older adults. As a result, it was vital to encourage home rehabilitation to adapt them to the needs of the population of older adults (Fernandez-Portero, Alarcon, & Padura, 2017).

Sikder et. al., (2019) stated that our regular daily activities are rapidly becoming easier with the development of new Smart Home Systems (devices and applications) (SHSs) (Sikder, Babun, Aksu, & Uluagac, 2019). However, these systems also introduce a variety of security risks (Sikder, Babun, Aksu, & Uluagac, 2019). As a solution to these concerns, Sikder and his coworkers proposed Aegis, a unique context-sensitive security system to recognize unwanted activity in an SHS, in this study (Sikder, Babun, Aksu, & Uluagac, 2019). Aegis analyzes the current situation of connected smart home items (detectors and devices) in an SHS for various user actions and usage habits and constructs a situational framework to distinguish between dangerous and safe activities (Sikder, Babun, Aksu, & Uluagac, 2019). In this study, the reliability of Aegis was analyzed against five distinct hazardous activities (Sikder, Babun, Aksu, & Uluagac, 2019) As a result of this study, Aegis was able to identify inappropriate activity in SHS with high accuracy (over 95%) (Sikder, Babun, Aksu, & Uluagac, 2019).

There can be some factors that affect lighting design such as color and placement of elements (Fernandez-Portero, Alarcon, & Padura, 2017). Even when the lights are off, elements can assist in way-finding like being able to

see the way while walking down the corridor (Fernandez-Portero, Alarcon, & Padura, 2017). Therefore, they can reduce the risk of falls in corridors or other areas of the home (Fernandez-Portero, Alarcon, & Padura, 2017).

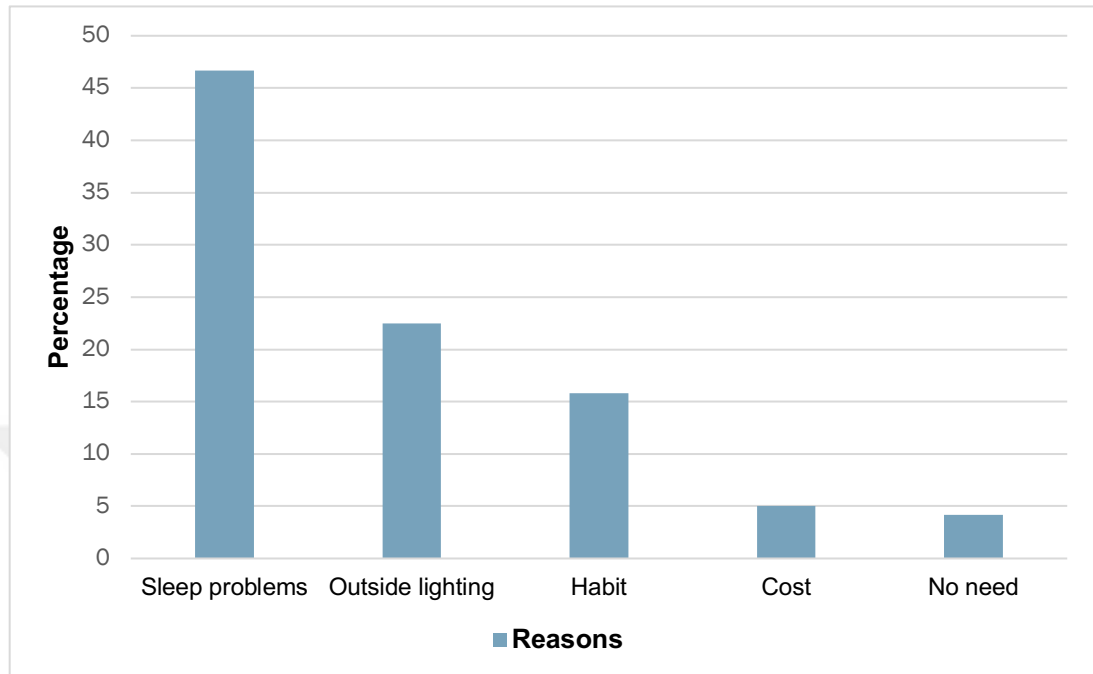


Figure 2. Reasons to turn off all the lights at night in a house (Lee, Jeong, & Hirate, 2009).

The corridor is the most circulation path in a residential environment (Sikder, Babun, Aksu, & Uluagac, 2019). Older adults need to walk down the corridor at night to use the facilities (Lee, Jeong, & Hirate, 2009). Therefore, it should be illuminated with appropriate lighting according to the person (Sikder, Babun, Aksu, & Uluagac, 2019). According to Lee's research, older adults find getting up to use the toilet by walking down the corridor to be quite frightening (Lee, Jeong, & Hirate, 2009). The proportion of those who turned off all the lights at night was found to be 53.4%, and the proportion of those who left some lights on was found to be 46.6%, and some of the reasons why some people turn off all the lights are old habit and the cost (Lee, Jeong, & Hirate, 2009) (see Figure 2).

Most older adults generally leave lights off, and it has been observed that they prefer night lighting to move around, especially in corridors (Lee, Jeong, & Hirate, 2009). In addition, when sufficient lighting is provided at night in the houses, the budget issue should be considered. According to the findings of Lu's research, older adults who have greater incomes had more lighting levels than those who have lower incomes, and older adults may not be conscious that low lux levels may affect their vision (Lu, Park, & Ahrentzen, 2019). Cain et. al., (2020) examined the influence of home lighting conditions on sleep and personal lighting level sensitivity (Cain, et al., 2020). The findings of the study were that almost half of the homes had intense sufficient light to reduce melatonin by 50% (Cain, et al., 2020). Therefore, house lighting has a big influence on sleep and the circadian rhythm, but how it will affect a particular person in their residence is rather undetermined (Cain, et al., 2020). Furthermore, lighting prevents older adults who get up to go to the toilet two or three times a night from sleeping when they return to their beds to sleep because of the too-bright light in the corridors (Lee, Jeong, & Hirate, 2009). Light is the primary factor influencing human circadian rhythms (Ticleanu, 2021).

Sander et. al., (2015) studied the impacts of blue-suppressed indoor light against strong blue-enriched interior light on sleep for older adults over 65 who were in great wellness (Sander, Markvart, Kessel, Argyraki, & Johnsen, 2015). Participants were exposed to two kinds of light for three weeks and as a result, blue-enriched settings resulted in a 7.44-hour sleep period, whereas blue-suppressed conditions resulted in a 7.31-hour sleep period (Sander, Markvart, Kessel, Argyraki, & Johnsen, 2015). A balance of bright light and darkness is necessary to obtain a normal daily sleep-wake cycle (Ticleanu, 2021). However, exposure to light at night can have a detrimental influence on circadian rhythms and sleep patterns, which may eventually result in health issues (Ticleanu, 2021).

Glare means that firstly light enters the eye and comes to the retina to form a distinct feeling, not all light energy; instead, some energy is dispersed and sometimes may cause the unpleasant problem (Facchin, Daini, & Zavagno, 2017). In the glare effect (GE), a white area seems to be self-luminous (Facchin, Daini, & Zavagno, 2017). It makes people uncomfortable without necessarily reducing their ability to see items (Fatios, 2015), and a visual image's sharpness might be reduced by the glare (Li, et al., 2016). Facchin and his coworkers indicated that two groups that were young and older adults (20-30 years old and 60-75 years old, respectively) were used to assess GE parameters, and the Glare Effect Test (GET) was conducted (Facchin, Daini, & Zavagno, 2017). Their prospective study's aim was to determine if the GET could be simply modified to detect parameters for brightness and uncomfortable glare (Facchin, Daini, & Zavagno, 2017). As a result of this study, there was a clear distinction between young adults and older adults, and the brightness parameters of GE for older adults were greater than those for young adults, pointing to a possible indirect link between brightness perception and uncomfortable glare (Facchin, Daini, & Zavagno, 2017).

Bright, glare-free lighting should be used to sufficiently illuminate the inside of the house (Rogers, Rogers, Takeshima, & Islam, 2004). In a room, a consistent lighting level is the safest option and dark parts should be illuminated and lightweight curtains can be used to prevent glare (Centers for Disease Control and Prevention, 2005). Older adults are severely affected by high-glare lighting (Leung, Wang, & Chan, 2019). It is advised to use bulbs with at least 100 watts and to lessen the amount of glare created, indirect lighting should be used (Rogers, Rogers, Takeshima, & Islam, 2004). In addition, there is a material called translucent wood, and it is found to effectively reduce glare when utilized for applications (Li, et al., 2016). Figure 3 shows the comparison of glass (glare) and transparent wood (anti-glare). Therefore, shiny materials should be eliminated to decrease the glare (Li, et al., 2016).

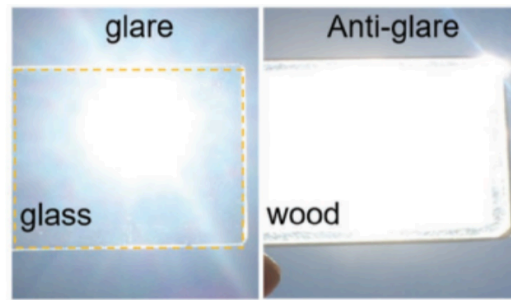


Figure 3. The comparison of glass (glare) and transparent wood (anti-glare)

Lighting switches that detect motion, sound, or sound that enable room lights to turn on can be preferred, and they should be easily accessible from the bed, and stairs should be well-lit and their light switches should be located at the top and bottom (Rogers, Rogers, Takeshima, & Islam, 2004). That is to say that all living areas at home should have sufficient lighting conditions and especially to illuminate the circulation ways, and night lighting should be preferred (Rogers, Rogers, Takeshima, & Islam, 2004). Affixed low-intensity LED lights can assist older adults in maintaining postural stability and reducing falls when moving around at night (Lu, Park, & Ahrentzen, 2019).

2.1.1.1. The Vision of the Aging Eye and Visual Perception

Three elements play a major role in how we see the world: light, how it interacts with surfaces, and how the human visual system interprets that light (Karmakar & Pant, 2017). Human physiology is impacted by the light entering the eyes in terms of vision (Boyce, 2022), and “lighting level” means the amount of light entering the eye (Gordon, 2015). The optical and neurological characteristics of the human visual system differ as people age, affecting people's visual abilities (Cheng, Ju, Sun, & Lin, 2016).

Boyce (2022) examined the information that is available about lighting effects on older adults (Boyce, 2022). Aspects of lighting that can lead to problems with headaches and tired eyes, raise the risk of falls, influence circadian rhythms problems, lessen the effects of depression and dementia, and be used to treat diseases through phototherapy are among the subjects covered (Boyce, 2022). In conclusion, it is believed that illumination affects human health. It is necessary to pay attention when assessing the veracity and appropriateness of general statements on the advantages and disadvantages of lighting for human health (Boyce, 2022). There is a connection between the chance of retinal injury and lifetime light exposure overall and the retina becomes affected negatively when exposed to light (Boyce, 2022). The further the age progresses, the effect of the treatments used to correct this negative effect decreases (Boyce, 2022).

Older adults are much more able to have low vision than young adults. They cannot see properly in low light conditions or at night, and when compared to younger generations, older adults require more time to adjust to gloomy situations, such as switching from the light outside to indoors (Lu, Park, & Ahrentzen, 2019; Owale, 2016). Most of visually handicapped people are over 50 years old (Vignesh, et al., 2019). The number of independent older adults with poor health and impairments is expected to rise over the next five decades, owing to predicted population growth (Rogers, Rogers, Takeshima, & Islam, 2004). Aging has an impact on the visual system and the eye undergoes natural age-related alterations (Shikder, Mourshed, & Price, 2012). For example, some people over the age of 60 may have age-related macular degeneration (AMD) in the United States and it is the main reason for significant irreversible visual loss (Jarrard, 2022). In addition, some of the other reasons why older adults have low vision are glaucoma, cataract, and diabetic retinopathy (Boyce, 2022). These impairments reduce visual performance such as adaptation in the dark, poor night vision, and inability to see color (Shikder, Mourshed, & Price, 2012). Advancing age also causes the maximum pupil size that the iris can provide to be reduced, and this effect of age is particularly pronounced at low levels of light (Boyce, 2022).

Visual perception is described as the act of gathering information about our surroundings and events by obtaining data from the light they emit or reflect (Karmakar & Pant, 2017). A variety of factors impact our visual perception, varying from differences in our capacity to see data to differences in how we interpret such data (Karmakar & Pant, 2017). It means that visual perception may change depending on whether there is visual impairment or not, age, and gender. Reduced object recognition and change-detection abilities that influence vision-related cognitive processes can be caused by age-related changes in the eye, and especially the perception of objects also becomes slow (Shikder, Mourshed, & Price, 2012).

Iancu and Iancu (2017) examined the theoretical viewpoint on technological assistance for older adults (Iancu & Iancu, 2017). This study is intended to conceptually illustrate how technology may be an instrument for meeting the requirements of older adults (Iancu & Iancu, 2017). As a result, technological assistance may be the only option for meeting the needs of older adults (Iancu & Iancu, 2017). According to Iancu and Iancu (2017), older adults perceive light and color differently, and lower light sensitivity, lower color perception, and tolerance for glare are all prone to be seen in older adults (Iancu & Iancu, 2017). Changing the location of household items can affect the reaction of older adults negatively (Shikder, Mourshed, & Price, 2012). According to Zielinska et al., fluorescent and neon colors help to perceive hazards, especially yellow-green neon colors (Zielinska, Wogalter, & Mayhorn, 2014). Ultraviolet (UV) radiation interacts with fluorescent colors, and they look brighter and more noticeable (Burns & Pavelka, 1995). In addition, Wogalter stated that as compared to other colors, the yellow-green neon color attracts the most attention and has the longest average look time (Wogalter & Vigilante, 2006). According to them, light comfort is a significant factor affecting older adults whose eye health is sensitive, and has an influence on their daily living, particularly when it comes to reducing the risk of falls in the home (Fernandez-Portero, Alarcon, & Padura, 2017).

Falling

Visual impairment is one of the most significant predictors of falling among older adults (Källstrand-Eriksson, Baigi, Buer, & Hildingh, 2013). A fall is described as falling to the floor (Gibson, 1990). It is a vital problem that affects older adults negatively whose population is increasing and they fall several times a year (Pfortmueller, Lindner, & Exadaktylos, 2014). Previous research on fall risk issues, older adults indicated that one in every four older adults had a high risk of falling (Yokoya, Demura, & Sato, 2008). Therefore, the "fear of falling" becomes one of the most significant anxieties among older adults, which might reduce their quality of life (Rogers, Rogers, Takeshima, & Islam, 2004; Walker & Howland, 1991). Almost half of all falls happen in their own homes (Rogers, Rogers, Takeshima, & Islam, 2004). In addition, an older adult who falls once tends to fall again (Tinetti & Speechley, 1989), and even it is probable that the majority of falls among older adults go undetected (Tideiksaar, 1988).

Most falls are caused by various risk factors (Elley, et al., 2008). In most studies, there are internal and external risk factors; age, female sex, history of old falls, posture, cognitive problems, neuromuscular diseases, body movements, balance disorders, and hearing problems are all internal risk factors for falls (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Tinetti, Doucette, Claus, & Marottoli, 1995; Tinetti, Speechley, & Ginter, 1988; Melton & Riggs, 1985; Gillespie, et al., 2012; Bergland, 2012). On the other hand, external risk factors include carpets, unbalanced flooring, low lighting level, electrical wires, seats, and armchairs without railings (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Tinetti, Doucette, Claus, & Marottoli, 1995; Tinetti, Speechley, & Ginter, 1988; Melton & Riggs, 1985; Gillespie, et al., 2012). Karlsson and his coworkers stated that falls were attributed to domestic dangers, and one of the most important reasons for falls is the lack of night lighting (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Davidson, Bond, Dawson, Steen, & Kenny, 2005). These

risk variables differ and interact with one another, and the chance of falling climbs fast as the number of risk factors grows (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Woolf & Akesson, 2003).

The consequences of falls are just as important as the reasons for falls, and injuries because of falls are a problem that should be considered. Each year, around 750,000 older adults get a devastating injury because of a fall (Rogers, Rogers, Takeshima, & Islam, 2004). Each year, more than 10,000 older adults die because of injuries sustained in a fall (Council, 2000). Many falls increase the risk of fractures, death, long-term pain, poor quality of life, soft tissue injuries, disability, and increased healthcare costs (Karlsson, Magnusson, Schewelov, & Rosengren, 2013). Around 5% of falls result in fractures, and 5-11% of all serious injuries in older adults are caused by falls (Rogers, Rogers, Takeshima, & Islam, 2004; Kannus, et. al., 1999; Henderson, White, & Eisman, 1998). In addition, the prevalence of osteoporosis in older adults increases their risk of breaking a bone in the event of a fall (Rogers, Rogers, Takeshima, & Islam, 2004). The majority of fractured bones occur indoors, and this is especially true for people over the age of 80 (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Bergström, Björnstig, Stenlund, Jonsson, & Svensson, 2008), and when people fall to the side, they're more likely to hit their head or the femur and break it (Rogers, Rogers, Takeshima, & Islam, 2004).

Falling is a resolvable problem (Elley, et al., 2008). Only modifiable risk factors which are home modifications can be targeted with prevention methods to reduce the future risk of falling such as lighting design, types of furniture, and the arrangement of elements at home (Karlsson, Magnusson, Schewelov, & Rosengren, 2013). Given these findings, it is reasonable that fall prevention strategies concentrate on the house (Rogers, Rogers, Takeshima, & Islam, 2004). Exercise is one-way older adults may do to reduce their personal risk of falling (Yokoya, Demura, & Sato, 2008). That is

to say that to reduce fall risk, older adults should do exercises regularly (Yokoya, Demura, & Sato, 2008).

Wang et. al., (2014) suggested an improved fall detection system observing the movements of older adults and it utilized data on smart body-worn sensors and works through home networks (Wang, Zhang, Li, Lee, & Sherrat, 2014). When older adults fall at home, help might be delayed and the situation can get worse. Therefore, fall detection systems are a solution to this problem (Wang, Zhang, Li, Lee, & Sherrat, 2014). These are electron devices that are actuators and smart sensors (Wang, Zhang, Li, Lee, & Sherrat, 2014). This suggested system has been implemented in a test system in this study and according to findings, both the sensitivity and particularity of the system are 96.8% and 98.1%, respectively, and it can identify falls with a high detection rate of 97.5% (Wang, Zhang, Li, Lee, & Sherrat, 2014).

Home Modifications for Older Adults

Focusing on home safety through home hazard modification is very crucial for older adults (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Lyons, John, & Brophy, 2006; Lin, Wolf, Hwang, Gong, & Chen, 2007; Thomas, et al., 1999; Ryan & Spellbring, 1996). Making home modifications reduces the chances of falling by 25% (Cumming, et al., 1999). The number of falls among this population can be reduced by modifying home risks (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Gillespie, et al., 2012; Hwang, Gong, & Chen, 2007; Thomas, et al., 1999; Stevens, Holman, & Bennett, 2001; Campbell, et al., 2005; Day, et al., 2002). Various studies have shown that making changes to one's lifestyle can enhance one's quality of life as they age (Rogers, Rogers, Takeshima, & Islam, 2004). Home is where most accidents occur (Bonney, Braubach, Moissonnier, Monolbaev, & Röbbel, 2003). In previous studies, the vast majority of accidents at home

are related to falls, and the more the dangers are reduced, the more the risk of falling will also decrease (Bonney et al., 2003).

Kamei et al., (2015) aim to assess a possible enhancement of fall prevention knowledge and home modification practices and to reduce domestic falls by implementing a home hazard modification program (HHMP) in older adults who were tracked for up to a year after the intervention (Kamei, et al., 2015). The HHMP intervention group or the control group was randomly allocated to 130 older adults residents in Tokyo, and all groups participated in four 2-hour multifaceted fall prevention programs, which included lessons on exercise, nutrition education, and fall-associated hazards education (Kamei, et al., 2015). Only the HHMP group got instruction and practice addressing the home safety (Kamei, et al., 2015). As a result, a 10.9% decrease in total falls was seen in the HHMP group, and in the HHMP group, fall prevention knowledge and house modifications both dramatically enhanced (Kamei, et al., 2015).

Recent research has found that multifactor interventions such as home hazards, safety analysis, and home modifications are effective in reducing the risk of falls among older adults in the community, highlighting the importance of reducing home hazards (Kamei, et al., 2015; Costello, & Edelstein, 2008; Gillespie, et al., 2012; Kamei, Kajii, Itoi, Kozakai, & Niino, 2010; Newton, 2006). Kamei and his coworkers indicated that it is critical for older adults to understand how to avoid injury in their own homes and to be able to change environmental hazards so as to preserve their daily residential safety (Kamei, et al., 2015). Assessment and adjustment of potential hazards in the home and professionally recommended fall prevention for older adults with a history of falling have resulted in fewer falls both inside and outside the house (Turner, et al., 2011). For older adults, multifactorial intervention programs have proven to be beneficial in avoiding falls (Kamei, et al., 2015; American Geriatrics Society, British Geriatrics Society, & American Academy of Orthopaedic Surgeons Panel on, 2001;

Costello, & Edelstein, 2008; Day L., et al., 2002; Gillespie, et al., 2012; Mahoney, et al., 2007; Tinetti, et al., 1994). It was found that there was a 30% reduction in falls when home modifications were implemented as part of a multifaced intervention (Tinetti, et al., 1994). Older adults who are at risk of falling benefit from fall prevention techniques (Elley, et al., 2008). Considering the complexity of total fall risk, every intervention program should cover and treat as many internal risk factors as feasible (Karlsson, Magnusson, Schewelov, & Rosengren, 2013). Moreover, fall prevention should include the identification of high-risk populations and these preventions can be appropriate calcium intake, exercises, functional ability improvement, health condition treatment, and avoidance of multi pharmacy (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Province, et al., 1995; Tinetti, McAvay, & Claus. 1996). The use of an in-home hazard reduction program has been shown to reduce the risk of falling among community-dwelling older adults (Karlsson, Magnusson, Schewelov, & Rosengren, 2013). Individualized multifactorial interventions should be explored for all older adults who have recurrent falls or are at risk of falling (Turner, et al., 2011).

Several hazardous areas in a person's house risk them falling (Rogers, Rogers, Takeshima, & Islam, 2004). Ramulu et. al., (2021) determined if home dangers and lighting conditions are linked to greater fall percentages in persons with various levels of glaucoma impairment to their visual fields (VF) (Ramulu, et al., 2021). Through monthly fall notebooks, participants with diagnosed or suspected glaucoma supplied three years' worth of potential fall statistics, and through an in-home evaluation, the lighting level and risks in seven different house regions were assessed (Ramulu, et al., 2021). The impact of fall risks and lighting level on the number of falls was assessed (Ramulu, et al., 2021). In conclusion, more effective lighting was found to cause fewer home falls, although there were fewer residential dangers (Ramulu, et al., 2021).

The circulation areas, bathroom, kitchen, bedroom, and staircases are some zones in a home where falls happen (Rogers, Rogers, Takeshima, & Islam, 2004; Lucht, 1971; Wild, Nayak, & Isaacs, 1981; Schelp & Svanström, 1986). Grab rails, stair doors, firemen, cabinet locks, heater tap adjustments, and lighting requirements are just a few of the things that need to be considered for home modification in terms of safety (Turner, et al., 2011). Implementing grab bars, stair gates, handrails, fireguards, blind cord wind-ups, smoke alarms, cupboard locks, corner cushions for sharp-edged furniture, electric outlet covers, lowering hot water temperatures, repairing damaged flooring, making improvements in lighting levels, and stabilizing floor surfaces are all examples of home environment modifications (Turner, et al., 2011). Furthermore, healthcare professionals, homecare workers, and older adults can collaborate with safety specialists and design engineers to enhance the home environment, therefore improving the long-term safety and well-being of older adults who want to live freely in their own homes (Rogers, Rogers, Takeshima, & Islam, 2004).

Campani and his coworkers (2021) aim to provide a method for home evaluations and modification treatments that are efficient, enduring, and transferrable to reduce falls and injuries caused by falls in older adults at home (Campani, et al., 2021). Their research questions were;

- Are the house assessments and modifications effective at decreasing fall rates?
- Which house design modifications are most successful in lowering fall rates?
- What should the format and delivery method of these modifications be for older adults?

The IPEST framework was used in this study (Campani, et al., 2021; Faggiano, 2018). It had two phases;

- Overview of the current scientific research

- To present the draft by hand so that clinical professionals might agree on it.

According to findings, the fall rates of older adults were effectively reduced by home modifications, and these are;

- Suitable floor coverings
- Sufficient lighting condition
- Proper furniture
- Designing the areas to obtain appropriate distance

2.1.1.2. Lighting Level

The lighting level refers to the amount of light that falls on a certain region of a surface, and its unit is lux (lx) (Boyce, 2014). In Figure 4, there is a Schematic illustration of lighting level (lux) (1 foot-candle = 1 lumen per square meter = 10.764 lux) (Tglights, 2019).

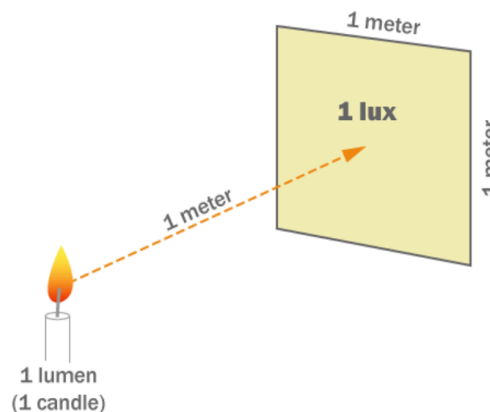


Figure 4. Schematic illustration of lighting level (lux) (Tglights, 2019)

The quality of life of older adults at home can be affected by lighting levels in both positive and negative ways (Phillips, Siu, Yeh, & Cheng, 2005). The positive side is that it provides a secure environment in the home for older

adults, while the bad side is that insufficient light can increase the risk of falls (Phillips, Siu, Yeh, & Cheng, 2005). The amount of light in the house of older adults should be frequently controlled for their quality of life to decrease and avoid accidents in residential situations (Phillips, Siu, Yeh, & Cheng, 2005). There are dangers in most houses because there is inadequate lighting (Pfortmueller, Lindner, & Exadaktylos, 2014). According to Noell-Waggoner, the built environment in many areas the absence of sufficient lighting conditions for older adults (Lu, Park, & Ahrentzen, 2019; Noell-Waggoner, 2006).

Kunduraci (2017) aims to make contributions to the literature and lead further studies on the interior comfort of older adults (Kunduraci, 2017). Previous studies provided technical lighting suggestions for dwellings to provide visual comfort for older adults, and Kunduraci stated that to enhance accessible design for older adults, the different visual needs of each area in the residential environment are stressed (Kunduraci, 2017). When the appropriate lighting is used for older adults, they can live an accident-free life (Kunduraci, 2017). The lux values in a residential environment need to be two times more than the standard values for older adults (Kunduraci, 2017). According to other studies, a 60-year-deteriorating old's eyes need up to three times lighter than a 20-year-old did for the same work (Gordon, 2015). Another especially damaging component is glare, and this sensitivity to brightness can be unpleasant for many older adults residents (Gordon, 2015). There are some residential areas and some guidelines for visual comfort and appropriate lighting level for older adults below (Kunduraci, 2017) (see Table 1).

Entrance and Corridor - A safe area at the entrance and the corridor are very important and it should be noted whether there are any level discrepancies between the two sides of the door (Kunduraci, 2017). Lighting fixtures in areas where conservation is vital should be positioned to highlight users'

faces without producing glare and they should have 200-300 lux at eye level (140-60 cm above the floor) (Kunduraci, 2017).

Kitchen – Task lighting glare and produces no shadows may be used to illuminate each task and above the countertop, 500 lux minimum is necessary (Kunduraci, 2017).

Bathroom – The sink area should be illuminated between 200 and 500 lux and avoid using glossy materials that might reflect unwanted light (Kunduraci, 2017). The lighting effect must be largely shadow-free to prevent poor vision and present a pleasing facial appearance (Karlen & Benya, 2017).

Bedroom – There are several usage areas (e.g. sleeping or reading). The layered lighting system can be used to illuminate each task (Kunduraci, 2017). Indirect and direct lighting should be provided with integrated care lighting that illuminates 85 cm above the floor by a minimum of 500 lux (Kunduraci, 2017). When getting out of bed at night, a night light can be placed so that the path to the bathroom can be visible easily (Centers for Disease Control and Prevention, 2005). Lighting switches should be designed close to the bed, and items that are frequently used, such as phones and telephones, should be kept within easy reach of the bed (Rogers, Rogers, Takeshima, & Islam, 2004). Moreover, the bed should be at the appropriate height, and to protect someone from falling out of bed at night, bars might be put on the side of the bed (Rogers, Rogers, Takeshima, & Islam, 2004). For individuals who use stools to get in and out of bed, the height of the bed should be reduced (Rogers, Rogers, Takeshima, & Islam, 2004). Rugs should not be used around the bed, on the contrary, it is recommended to use a non-slip floor material, and it is possible to install floors that activate the lighting system when they are touched (Rogers, Rogers, Takeshima, & Islam, 2004).

Table 1. The recommended lighting level in a residential area for older adults (Kunduraci, 2017)

Residential Areas	Recommended Lighting Level
Entrance/Corridor	200-300 lux
Kitchen	500 lux (Task lighting)
Bathroom	200-500 lux
Bedroom	500 lux

2.1.1.3. The Arrangement of Lighting

One of the issues that change visual perception is the arrangement of the lighting (Durak, Olguntürk, Yener, Güvenç, & Gürçınar, 2007). The arrangement of lighting is one of the most important factors affecting lighting distribution such as direct lighting, indirect lighting, and direct-indirect lighting (Wahab & Zuhardi, 2013). There are many architectural lighting fixtures. Some of them are cove lighting, wall washing, wall grazing, ambient lighting, and task lighting (Karlen & Benya, 2017). Each of these lighting has a different task and the type of lighting varies according to the needs in each area of a house (Karlen & Benya, 2017).

For instance, task lighting is used for visual tasks (reading) in a living room (Karlen & Benya, 2017). In a space that may already have some ambient light, task lighting increases the brightness for certain tasks (Lighting Patterns for Homes, 2015). Because the remainder of the living room's lighting is unwelcome and harmful for watching TV, viewing offers special lighting needs, and if watching TV is going to be a function, the lighting design should support it (Karlen & Benya, 2017). Therefore, the wall washers facing the south wall are the only luminaires that won't interfere with watching TV (Karlen & Benya, 2017). The lighting in the living room throughout the viewing period might be balanced by placing a floor lamp in the northeastern

corner (Karlen & Benya, 2017). There are two types of ambient lighting; direct and indirect ambient lighting (Gordon, 2015). Before application, it should be decided which type is appropriate for the area to use (Gordon, 2015). For a kitchen, indirect ambient lighting is recommended for general use, and task lighting is recommended for cabinets and sink areas (Karlen & Benya, 2017). Cove lighting is a well-known indirect lighting method that emits light from one or more sides of space up toward the ceiling to create a gentle ambient illumination (Mills, 2018). Owing to the increasing use of linear LED strips in indoor lighting, cove lighting is gradually becoming commonplace (Zagan, Skarzynski, & Tryzna, 2023). It can be used for general lighting or decoration (Zagan, Skarzynski, & Tryzna, 2023). It is quite important to decide on these lighting locations (Osibona, Solomon, & Fecht, 2021).

Lighting designers come into several challenging circumstances and scenarios when striving to provide appropriate lighting design such as direct glare, reflections in screens, and lamp color preference (Karlen & Benya, 2017). It is necessary to prefer the appropriate type of lighting and the arrangement of the lighting (Karlen & Benya, 2017).

Tuaycharoen (2020) investigated the impact of lighting and other environmental factors, such as color, furniture, and signs, on Thai older adults' interior navigation in the nursing home setting (Tuaycharoen, 2020). There were three different studies, and these are;

- investigating how the ability of older adults to find their way around in nursing homes is affected by the lighting conditions in the rooms,
- investigating the impact of the environment's color and substance on how older adults navigate the nursing home's three different rooms,

- an examination of how lighting, color, and signs affect navigation in nursing homes' corridors.

According to the results, older adults in nursing homes were encouraged to navigate inside spaces by using proper lighting and design elements including color, signs, and furniture (Tuaycharoen, 2020). Tuaycharoen (2020) stated that wayfinding design supports people in locating their destinations and comprehending their location (Tuaycharoen, 2020; Hamilton, 1979). Lighting and the arrangement of lighting are quite important for wayfinding, and the lighting in the corridors is very significant in terms of wayfinding (Tuaycharoen, 2020).

2.2. Previous Studies on Lighting Preferences

There are several studies examining lighting both in a real and virtual environment. Many of them have experiments to analyze the lighting condition. In addition, there are some studies related to lighting preferences in different areas in the literature.

Park and his colleagues investigated that North Americans and South Koreans had varied lighting preferences for hotel rooms in a virtual environment (Park, Pae, & Meneely, 2010). There were two cultural groups, two lighting intensities, and two light colors as independent variables, and there were pleasure, preference, and arousal as dependent variables in the study which had a between-within analysis (Park, Pae, & Meneely, 2010). They participated in a digital simulation and rated some images to collect data (Park, Pae, & Meneely, 2010). There was no daylight in the virtual hotel room, which affects the overall lighting condition inside, and a night view had added behind the window (Park, Pae, & Meneely, 2010). After the experiment, participants were asked to answer a questionnaire asking to rate

each scenario using the 5-Likert style and prefer their most and least preferred lighting setting (Park, Pae, & Meneely, 2010). The results showed that North American respondents preferred warm color lighting and low intensity in hotel rooms more than Korean respondents who preferred warm color lighting and high intensity, and participants from North America also reported that dim lighting was more stimulating than bright lighting, but those from Korea reported that bright lighting was more stimulating than dim lighting (Park, Pae, & Meneely, 2010).

Another study examines how the color of light affects older adults customers' capacity to read by figure to background color perception, value difference, and the total room lighting preferences in a retail store under an experimental environment, and the experiment was in a Lighting Laboratory (Park & Farr, 2007). There were four different lighting conditions, and the independent variables of the study were color-rendering properties, color temperature, and age (Park & Farr, 2007). There was a questionnaire that had an 8-point Likert scale, and adjectives pairs to examine the lighting such as comfortable-uncomfortable, like-dislike, and dim-bright (Park & Farr, 2007). Munsell grayscale was applied to analyze color perception for readability in different lighting conditions (Park & Farr, 2007). According to findings, older adults rated the higher color temperature light as less cool than younger people did, and in all lighting conditions, older adults gave themselves better marks for preference and comfort than younger participants (Park & Farr, 2007). When it comes to readability, stronger color-rendering light sources are preferable, and elders have greater trouble with warmer lighting when value contrasts are lessened (Park & Farr, 2007).

Yang et al., (2021) conducted research to enhance the illuminance in the activity room and bedroom in a nursing home for older adults in Beijing, and a Virtual environment and Integrated Environmental Solutions were used to simulate the daylight in the areas. Their contentment with daylight was examined by conducted questionnaires and lighting level measurements

(Yang, et al., 2021). As a result, the amount of sunlight that older adults need may depend on their physiological and psychological needs in addition to their visual needs, and more than older adult participants preferred daylighting over artificial lighting (Yang, et al., 2021). On the other hand, according to participants, daylighting is inadequate on cold days, and older adult participants preferred artificial lighting over daylighting (Yang, et al., 2021).

Zhong and his coworkers studied the effect of lighting level on the visual strain and lighting preference for both older adults and young adults in China (Zhong, et al., 2017). It was an experimental study that was a within-group in a dark office area, and there was a reading task to analyze the lighting preferences for 4 hours (Zhong, et al., 2017). There were three different lighting conditions. These are 300lx, 600lx, and 1200lx, and there were two questionnaires in the study (Zhong, et al., 2017). Participants first completed a questionnaire with a 7-point Likert scale to rate conditions such as visual strain, dry eye, and headache (Zhong, et al., 2017). The second questionnaire was conducted to examine the lighting preference, lighting comfort, and lighting level with a 7-point Likert scale again, and finally reading task was conducted (Zhong, et al., 2017). According to statistical analysis, older adults preferred 600lx, and young adults preferred ≤ 600 lx (Zhong, et al., 2017).

Cheng et. al., (2016) aim to better the lighting conditions for older adults by determining how LED lighting affects their ability to distinguish between colors, and their lighting preference (Cheng, Ju, Sun, & Lin, 2016). Studies were carried out under LED lighting with three distinct lighting levels (30lx, 100lx, and 1000lx) and two distinct color temperatures of 2800 K and 6000K (Cheng, Ju, Sun, & Lin, 2016). Farnsworth–Munsell 100-Hue Test which was a color identification test, and a six-item preference rating test were conducted (Cheng, Ju, Sun, & Lin, 2016). According to findings, the higher color temperature and the higher lighting level of LED lighting improve color

identification in older adults (Cheng, Ju, Sun, & Lin, 2016). Moreover, participants prefer the higher lighting level, creating an atmosphere more comfortable, pleasant, and ideal for reading, in contrast, although agreeing that a higher color temperature is preferable for reading, they still had differing preferences for the color temperature of lighting (Cheng, Ju, Sun, & Lin, 2016).

Hemalatha et. al., (2022) illustrated the impacts of correlated color temperature (CCT) and lighting level on physical perceptions and consumer preferences (Hemalatha, Chandramathy, Shanthi, & Dugar, 2022). Different shop profiles and users' ethnic backgrounds had different preferences for lighting settings (Hemalatha, Chandramathy, Shanthi, & Dugar, 2022). The moderate retail clothing store was created by utilizing modeling software 3Ds Max and V-ray, then the lighting analysis program DIALux Evo, and 16 scenarios were obtained (CCT: 2700K, 3000K, 4000K, 5700K; lighting level: 300lx, 500lx, 700lx) (Hemalatha, Chandramathy, Shanthi, & Dugar, 2022). The participants in the study preferred certain CCT and lighting levels for the store, and it was also discovered that the spatial perceptions of a retail setting are affected by both CCT and lighting levels (Hemalatha, Chandramathy, Shanthi, & Dugar, 2022). The results might help in formulating recommendations for properly arranging lighting settings unique to Indians (Hemalatha, Chandramathy, Shanthi, & Dugar, 2022).

Bogicevic et. al., (2018) determined what expectations individuals of different ages and genders have for hotel room design as well as how design preferences impact consumers' willingness to buy, and prefer to stay (Bogicevic, Bujisic, Cobanoglu, & Feinstein, 2018). This sort of experimental study involved 762 participants, and a 3D software program was used for creating the space color and design style modifications (Bogicevic, Bujisic, Cobanoglu, & Feinstein, 2018). According to the findings, the association between hotel guests' contentment and room design style were decreased by age and gender (Bogicevic, Bujisic, Cobanoglu, & Feinstein, 2018). While

older adults were equally satisfied with classic and modern design elements, younger guests preferred modern architectural elements, and males preferred spaces with masculine colors, whereas females are equally content with either (Bogicevic, Bujisic, Cobanoglu, & Feinstein, 2018).

Huang and his colleagues researched to understand the relationship between lighting color and lighting whiteness under four psychophysical experiments (Huang, et al., 2020). In this study, several testing items were illuminated using various sets of experimental light sources, two distinct CCTs, and two constant CCTs under 200 lx or 500 lx (Huang, et al., 2020). Participants were prompted to assess their impression of white and color preference when it came to illuminated items in the light booth (Huang, et al., 2020). In conclusion, it was discovered that participants mostly preferred whiter lighting for research with the constant CCT (Huang, et al., 2020).

2.3. Immersive Virtual Environment and Non-immersive Virtual Environment

Virtual reality system is to explore the environment by physically walking and rotating in a virtual environment, and within a constrained region, sensors and accelerometers monitor the user's motion, and the visuals on the head-mounted display (HMD) are changed in accordance with the observed motion (Cherep, et al., 2020).

Mahmoudzadeh and her coworkers (2021) investigated the lighting preferences of people, lighting satisfaction, and task performance in an office environment created in a virtual environment (VE) were affected by owning the ability to adjust the lighting condition (Mahmoudzadeh, Afacan, & Adi, 2021). This study was conducted in an immersive virtual environment (IVEs)

and there were three experiments to analyze the variables (Mahmoudzadeh, Afacan, & Adi, 2021). Various levels of lighting control were available for every step of the experiment, and personality attributes and lighting preferences were also investigated (Mahmoudzadeh, Afacan, & Adi, 2021). To deeper examine the participants' attitudes toward virtual reality (VR) technology, a technological acceptance model (TAM) was used (Mahmoudzadeh, Afacan, & Adi, 2021). According to the results, subjects were recommended to utilize more daylight by employing collaborative lighting that was just as effective as traditional lighting (Mahmoudzadeh, Afacan, & Adi, 2021). The cognitive load ratings for the subjects who used an automated lighting system to complete a reading task were much higher than those for the subjects who used collaborative lighting, which placed the same level of cognitive load on them as traditional lighting (Mahmoudzadeh, Afacan, & Adi, 2021). According to personality tests, those who scored well on openness had a variety of lighting preferences, including both traditional and collaborative lighting (Mahmoudzadeh, Afacan, & Adi, 2021). VE is a safe medium for older adults and also it allows for repeating scenarios and manipulating the task easily (Mahmoudzadeh, Afacan, & Adi, 2021) (Adi & Roberts, 2014) (Jansen-Osmann & Berendt, 2002). Moreover, participants' behavior in virtual environments matches the behavior in real environments (Mahmoudzadeh, Afacan, & Adi, 2021; Adi & Roberts, 2014; Jansen-Osmann & Berendt, 2002). Professionals in the construction business have used VR to analyze plans and compare alternatives (Mahmoudzadeh, Afacan, & Adi, 2021; Dunston, Arns, Mcglothlin, Lasker, & Kushner, 2011; Heydarian, Carnerio, Gerber, & Becerik-Gerber, 2015a; Leicht, Abdelkarim, & Messner, 2010; Majumdar, Fischer, & Schwegler, 2006; Moldovan, Messner, & Faddoul, 2006). Whatever form of representation is used (not only three-dimensional digital models), VR might be also characterized as the feeling of being present in a made-up architectural setting (Paes, Irizarry, & Pujoni, 2021). There are different types of VR systems and the main components are a computer-generated 3D model, navigational aids to control the virtual model, a display, and a software program that coordinates all the various parts (Paes, Irizarry, & Pujoni, 2021).

There are immersive virtual environments (IVEs) and non-immersive virtual environments (niVE) in VR platforms (Paes, Irizarry, & Pujoni, 2021). In IVEs, the display device presents stereoscopic images of a computer model while tracking sensors track the user's head and body motions, and one of the display systems used in head-mounted displays (HMDs) (Paes, Irizarry, & Pujoni, 2021). Non-immersive virtual environments display monoscopic images of a computer-generated model (Paes, Irizarry, & Pujoni, 2021). To interact, users can control the camera by moving the mouse and using a keyboard to move backward, forward, right, and left through the environment (Lombart, et al., 2020; Paes, Irizarry, & Pujoni, 2021).

There are some researches that HMDs used in IVE cause cybersickness. Cybersickness (CS) is also called virtual simulator or motion sickness (Caserman, Garcia-Agundez, Gamez-Zerban, & Göbel, 2021; Howarth & Costello, 1997; Kennedy, Drexler, & Kennedy, 2010). It means the negative effects that individuals may encounter while using VR (Caserman, Garcia-Agundez, Gamez-Zerban, & Göbel, 2021; Kim, Chung, Nakamura, Palmisano, & Khuu, 2015). According to experimental data, 6-12.9% of people stop their experience to a VE, whereas 60-95% of people experience some level of CS during that time (Caserman, Garcia-Agundez, Gamez-Zerban, & Göbel, 2021; Stanney, Hale, & Nahmens, 2003; Arns & Cerney, 2005; Roberts & Gallimore, 2005; Regan, 1995). Numerous symptoms of cybersickness can appear, including increased or decreased salivation, nausea, the feeling of body warmth, stomach awareness, disorientation, sweating, vertigo, eye pain, loss of vision, difficulty concentrating, tiredness, and occasionally even vomiting (Palmisano, Allison, & Kim, 2020; Ebenholtz, 1992; McCauley & Sharkey, 1992; Stanney & Salvendy, 1998; LaViola Jr, 2000; Lawson, 2014; Rebenitsch & Owen, 2016; Gavgani, Nesbitt, Blackmore, & Nalivaiko, 2017). In comparison to non-HMD VR, HMD VR also frequently results in greater nausea and fewer oculomotor symptoms (Palmisano, Allison, & Kim, 2020; Ebenholtz, 1992; Kennedy, Drexler, & Kennedy, 2010). According to Palmisano, compared to non-HMD, VR is more stimulating for cybersickness, and its main reason is VR causes some

virtual and physical head pose (DVP) during head movements (Palmisano, Allison, & Kim, 2020). In light of previous investigations, this study was conducted in a non-immersive virtual environment.

Theoretical Framework

Lighting studies have been carried out in a very wide scope. There are situations where light affects, the benefits of light on the human body, and how the light condition a residential environment should be in previous studies. In the literature review, there are experimental studies to examine the lighting condition for both young adults and older adults. These studies are in the real environment and virtual environment. In addition, some of them are related to cognitive performance, visual perception, and color temperature. Moreover, there are many studies examining the fall risk of older adults and home modification for reducing the fall risk. Although lighting has been investigated in the literature, there is a gap in the literature on the lighting preferences of older adults in a residential area, especially the corridor, which is the most commonly used circulation path (Sikder, Babun, Aksu, & Uluagac, 2019). This part is the theoretical framework of the study.

The population of older adults is increasing (Olmedo-Aguirre, et al., 2022). Considering their needs at home is quite crucial because they spend most of their time at home (Lee, Jeong, & Hirate, 2009). Studies on lighting for older adults are a common topic for researchers almost after 2012 (Lu, Park, & Ahrentzen, 2019). However, lighting is a broad topic and many issues need to be considered and researched, especially for older adults. A lighting system in the house that greatly affects their lives should be designed for older adults (Shikder, Mourshed, & Price, 2012). For instance, appropriate lighting is required for their visual efficiency and safety (Osibona, Solomon, & Fecht, 2021; Van Bommel & Van den Beld, 2004; Boubekri, 2007; Christoffersen, 2011; Wurtman, 1968). Bright, glare-free lighting should be

used to sufficiently illuminate the inside of the house (Rogers, Rogers, Takeshima, & Islam, 2004).

The vision of older adults is different from young adults (Shikder, Mourshed, & Price, 2012). They have low vision, especially at night (Lu, Park, & Ahrentzen, 2019; Owaley, 2016) because they have some impairments such as cataracts and diabetic retinopathy (Boyce P. R., 2022). Because of their low vision, they fall several times a year (Pfortmueller, Lindner, & Exadaktylos, 2014). There are other risk factors for falling at home such as furniture, slippery flooring, and the lack of railings (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Tinetti, Doucette, Claus, & Marottoli, 1995; Tinetti, Speechley, & Ginter, 1988; Melton & Riggs, 1985; Gillespie, et al., 2012).

Domestic dangers are among the issues that should be considered for older adults to live a healthy life, and making home modifications is significant to prevent domestic dangers (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Davidson, Bond, Dawson, Steen, & Kenny, 2005) such as corner cushions for sharp-edged furniture, grab bars, and repairing damaged flooring (Turner, et al., 2011).

According to the literature review, there are lighting preference studies for hotel rooms, stores, nursing homes, and office areas. However, most of them provide tasks to examine the lighting condition both in the real environment and virtual environment. For example, a reading task is generally given to analyze the lighting condition according to participants in the office lighting studies. However, there is a paucity of studies examining the lighting preferences of older adults in the home (as a subjective review), especially in

the corridor. Therefore, there is the theoretical framework of the study in Figure 5.

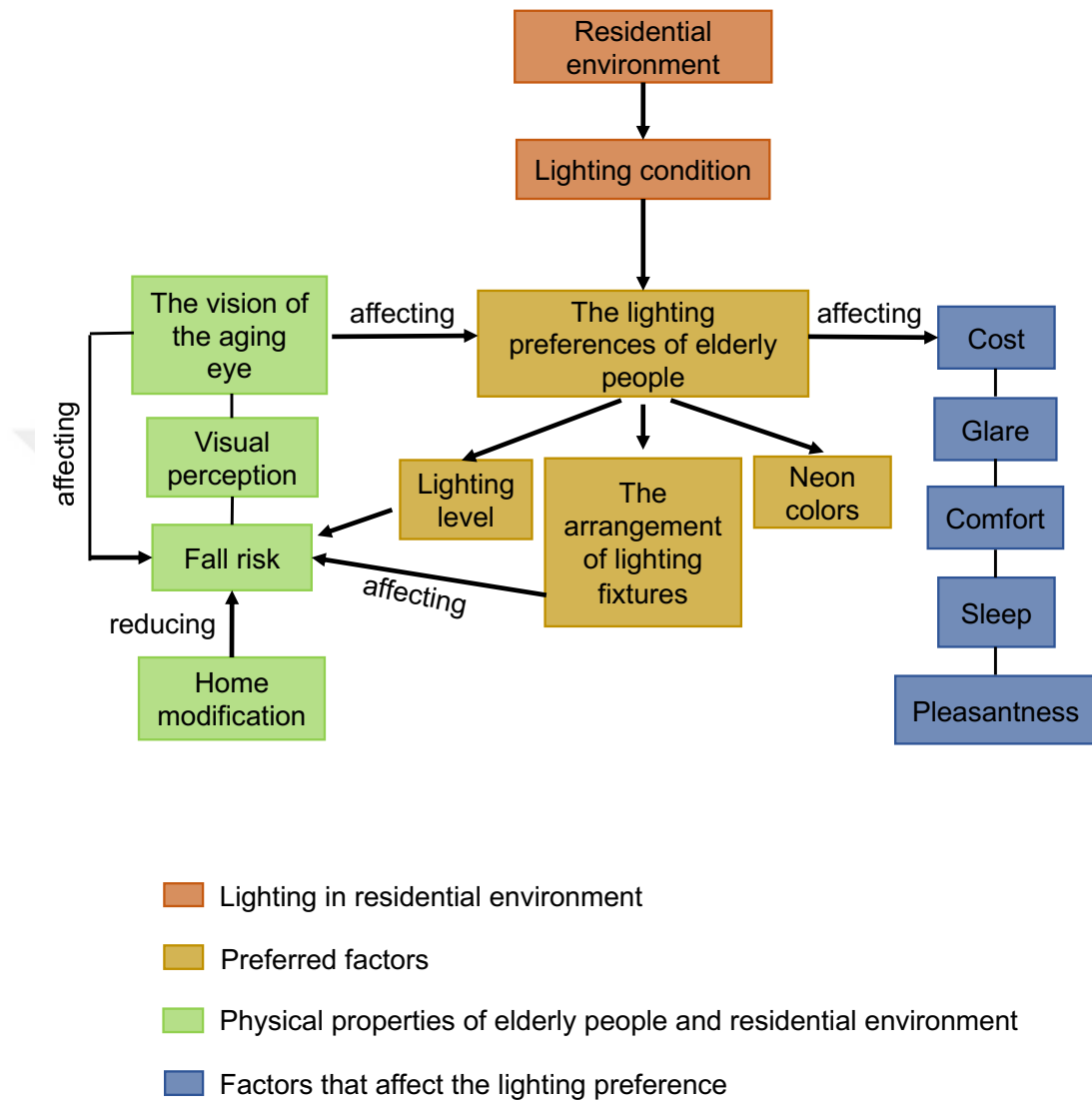


Figure 5. The theoretical framework of the literature part in this study

CHAPTER III

METHODOLOGY

3.1. Design of the Study

The objective of this experimental study is to understand the lighting preferences of older adults (over 60 years) in home corridors at night, which is the most used circulation path in the home, and to present them to designers. This research was conducted in the nIVE. VEs were chosen instead of real environments because under pandemic conditions, it could be dangerous to take the older adults to the real environment, and there is a research gap in the literature on lighting preferences in the home corridor for older adults at night conducted in the nIVE. In this quantitative study, it was investigated whether older adults prefer the lighting in the home corridors at night as ceiling lighting or ground lighting and whether they prefer the lighting level as 200 lux or 60 lux. In addition, the effect of yellow-green neon tapes applied to door frames and lighting switches in the corridor on lighting preferences was examined. The independent variables of the study were the arrangement of lighting, lighting level, and yellow-green neon tapes, and the dependent variable was older adults. This paper includes 3 questionnaires: Lighting Impression questionnaire (Kamali, 2020; Tifler, 1992), Lighting Survey (Eklund & Boyse, 1996; Mahmoudzadeh, Afacan, & Adi, 2021), and Scenario questionnaires.

3.1.1 Research Questions and Hypotheses

The main research question of the study is:

RQ: How would lighting in a residential corridor affect the lighting preferences of older adults at night?

There are also sub-research questions:

Sub-RQ1: Does the arrangement of lighting fixtures in the simulated home corridors of older adults positively affect their lighting preferences at night?

Sub-RQ2: Does the lighting level in simulated home corridors positively affect the lighting preferences of older adults at night?

Sub-RQ3: When night lighting is used in simulated home corridors, do the yellow-green neon tapes used in door frames and lighting switches have a positive effect on the lighting preferences of older adults at night?

The following hypotheses are put forward for this study:

H1: Older adults prefer ceiling lighting under 200 lux at night.

H2: Older adults prefer ground lighting under 60 lux at night.

H3: Older adults prefer yellow-green neon tapes used in door frames and lighting switches for ground lighting with 60 lux at night.

H4: Older adults prefer ground lighting at 200 lux without yellow-green neon tapes used in door frames and lighting switches at night.

3.2. Method

3.2.1. Participants

According to the G-power result, there must be a total of at least 66 subjects for this study. In this study, 90 participants (51 men and 39 women) who are between 60 and 85 years old were recruited (μ age = 69,86; SD age = 5,599). They were voluntary individuals coming to the audiologist. These participants were divided into three groups with 30 people disorderly and equally. One group is the control group (17 men and 13 women) and the others were Group 1 (17 men and 13 women) and Group 2 (17 men and 13 women). All participants were 56,7% men and 43,3% women. They live alone or with their husbands or wives in their own houses (Table 2).

Table 2. Gender and age distribution of the participants in experimental groups

Demographics	Frequency		Gender Percentage (%)	Mean Age	SD Age
	Woman	Man			
Control Group	13	17	56,7 (Man) 43,3 (Woman)	70,57	5,859
Group 1	13	17	56,7 (Man) 43,3 (Woman)	69,53	5,929
Group 2	13	17	56,7 (Man) 43,3 (Woman)	69,50	5,097
Total	39	51	56,7 (Man) 43,3 (Woman)	69,86	5,599

3.2.2. Preparation of Virtual Environment

3.2.2.1. Experimental Setup

A home corridor (room doors were visible in the corridor) was created in a virtual environment and this virtual corridor was designed to be similar to an older adult's house setting in Sahil Apartment in Caddebostan district, İstanbul. It has 3 rooms and 1 living room and the length of the corridor is 600 cm and the height of the corridor is 260 cm. This house was selected because an older adult is already living there. In addition to this, the created corridor was redesigned according to the standard dimensions given by the Türkiye Standards Institute and Türkiye Zoning Regulations for Planned Areas. According to these regulations, the width of this virtual corridor had been changed from 112 to 120 cm. In addition, it was designed in grayscale which means that the floor, wall, and ceiling were set in different shades of gray.

To understand the lighting preferences of occupants, two experiments were designed and six different virtual environments were created (see Table 3). Each experiment had three different scenarios, and there were three different lighting systems for the same virtual home corridor: (a) conventional ceiling lighting (CL) (control group), (b) ground lighting (GL) as night lighting, and (c) ground lighting as a night lighting with yellow-green neon tapes on door frames and lighting switches. In experiment 1, all scenarios had 200 lux. In the first scenario, there was conventional CL with 200 lux, in scenario 2, there was GL with 200 lux, and in scenario 3, there was GL with yellow-green neon tapes on door frames and lighting switches with 200 lux. Then, in experiment 2, all scenarios had 60 lux. In the first scenario, there was conventional CL with 60 lux, in scenario 2, there was GL with 60 lux, and in scenario 3, there was GL with yellow-green neon tapes on door frames and lighting switches with 60 lux. Table 3 shows the lighting system of these

different scenarios, and Tables 4 and 5 demonstrate the virtual corridors. In this context, it was investigated that the participants make a scenario preference according to the illuminations they perceived. Their general preferences with lighting in all scenarios were explored.

The virtual environment was set at night (11:00 pm, February 2nd, 2022 in İstanbul, Turkey). In the setting, there is only artificial lighting, and no daylight or outdoor lighting coming into the corridor. Additionally, the participants were informed before the experiment that there was no view to be seen from the windows.

This study was approved by I.D Bilkent University Ethical Committee and conducted following a protocol approved (No: 2022_04_07_02). All participants were informed before the experiment and they were asked to sign a consent form. This form has a brief of the study and states the possible risks. Additionally, it mentions that they have the right to give up participation at any time.

Table 3. The lighting systems of scenario

Lighting Systems	Scenario 1	Scenario 2	Scenario 3
Experiment 1	Ceiling lighting with 200 lux	Ground lighting with 200 lux	Ground lighting with yellow- green neon tapes on the door frames and lighting switches with 200 lux
Experiment 2	Ceiling lighting with 60 lux	Ground lighting with 60 lux	Ground lighting with yellow- green neon tapes on the door frames and lighting switches with 60 lux

Table 4. The virtual home corridor models in Experiment 1

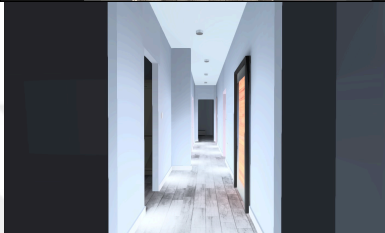
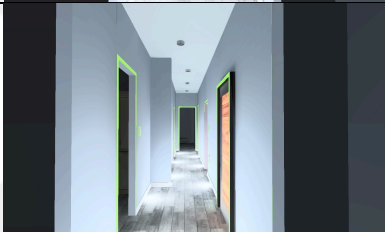
Experiment 1	
Virtual Corridor	Lighting System
	Ceiling Lighting with 200 lux
	Ground Lighting with 200 lux
	Ground lighting with yellow- green neon tapes on the door frames and lighting switches with 200 lux

Table 5. The virtual home corridor models in Experiment 2

Experiment 2	
Virtual Corridor	Lighting System
	Ceiling Lighting with 60 lux
	Ground Lighting with 60 lux
	Ground lighting with yellow- green neon tapes on the door frames and lighting switches with 60 lux

The virtual home corridor was modeled in 3DS Max 2020 including the walls, ceiling, windows, textures, and furniture (in the computer MacBook Pro, Retina, 15-inch, Mid 2015 at a resolution of 2880x1800 pixels). Textures were rendered by V-Ray in 3Ds Max, then it was imported into Dialux Evo. The artificial lighting level for each scenario was calculated in Dialux Evo to match both the lighting level in a physical environment and the lighting level in a virtual environment. Figure 6 and Figure 7 show the plan and section of the created corridor. In Figure 8, showing the reflected ceiling plan, the amount of ceiling LED spotlighting in the corridor is six and the amount of ground LED spotlighting in the corridor is nine. The lighting fixtures (see Table 6) are placed on the ceiling of the corridor by adjusting the appropriate distance, obtaining the required lux values (200 lux-60 lux).

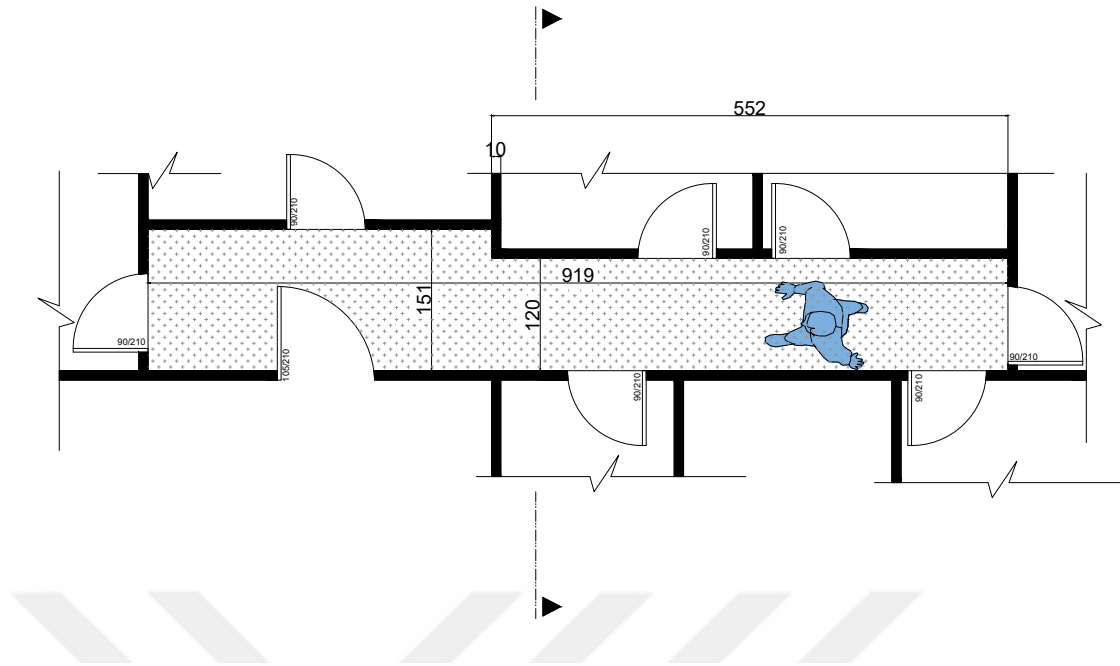


Figure 6. Plan of the virtual corridor (not to scale)

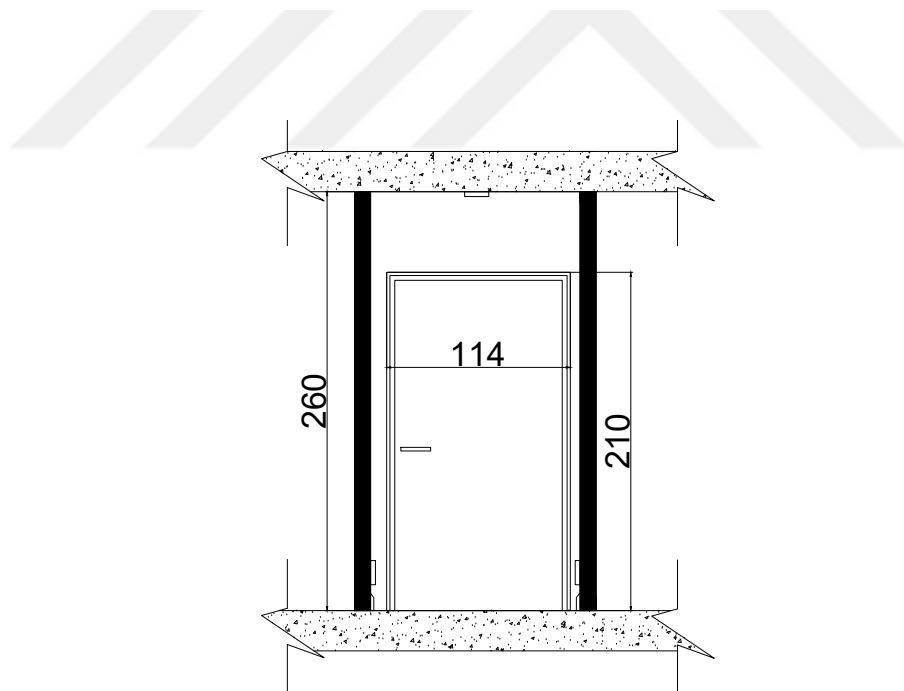


Figure 7. Section of the virtual corridor (not to scale)

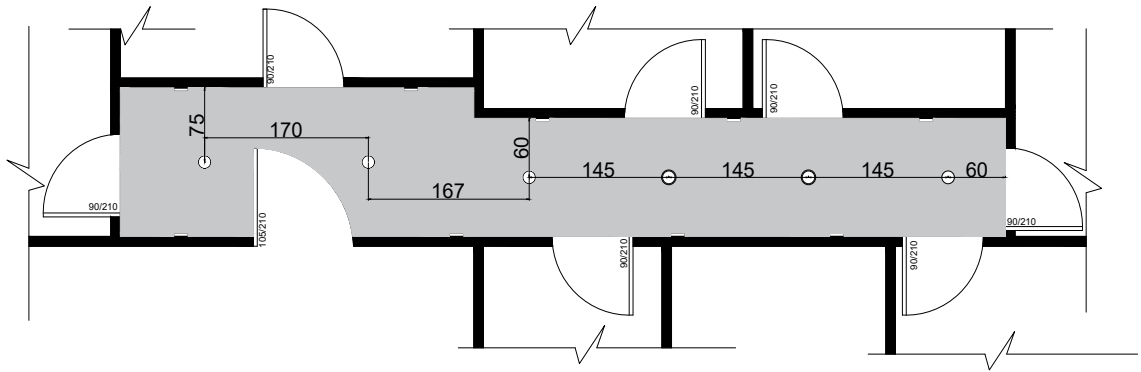
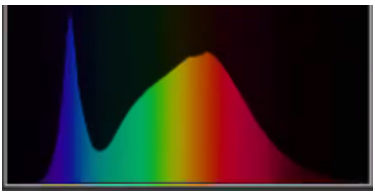
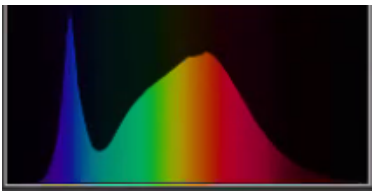


Figure 8. The reflected ceiling of the virtual corridor (not to scale)

Table 6. Specification of lighting fixtures

60 lux (Ceiling Lighting)		200 lux (Ceiling Lighting)
LIGHTMASTER	Light Name	LIGHTMASTER
LED	Light Type	LED
Downlight Zuma 6C16	Light Code	Downlight Zuma 6C16
≥80	CRI	≥80
9 Wattage	Nominal Wattage	16 Wattage
600	Luminous Flux	2800
	Color Spectra	

3.2.2.2. Virtual Environment

The experiment equipment was a computer screen which was MacBook Pro (Retina, 15-inch, Mid 2015) at a resolution of 2880x1800 pixels. All participants visualized the home corridor on this screen. A-Pro Head-Mounted Display was not preferred because this study was conducted on older adults in pandemic conditions and they are likely to feel dizzy or nauseous when using HMD (Palmisano, Allison, & Kim, 2020; Ebenholtz, 1992; Kennedy, Drexler, & Kennedy, 2010). Most studies stated that using HMDs causes some discomfort such as eye strain, dizziness, and nausea (Hirzle, Cordts, Rukzio, Gugenheimer, & Bulling, 2021). In the experiment, the study participants used a mouse and a keyboard to interact with the non-immersive home corridor and they were walking down the corridor by controlling the orientation of the camera. Moreover, the lighting preferences were documented in each scenario for further analysis of the arrangement of lighting, lighting level, and yellow-green neon tapes.

3.2.3. Experimental Procedure

This study was divided into four consecutive phases based on a systematic review as follows: phase I (definition of the experimental setting), phase II (modeling and simulation of the virtual environment), phase III (implementation), and Phase IV (data analysis) (see Figure 9). Figure 9 shows the process diagram of the study. There are six stages in these phases. In the first stage, the house of an older adult was found. In the second stage of phase II, this existing house in Caddebostan, İstanbul was designed and modeled in a virtual environment. The third phase of the study is implementation. It consisted of stages III, IV, and V. In stage III, data was collected through an experiment and questionnaires. Then, the experiment was revised by making a pilot study in stages IV, and V. A pilot study was conducted to validate the experimental environment and procedure. There was a task in the experiment,

in which the participants were asked about the painting on the wall. However, this task was not affected by lighting preferences and was removed from the experiment.

The final stage VI in phase IV is the results obtained by experiment and questionnaires. The data was analyzed by IBM SPSS Statistics 28 software, and Figure 10 shows the schematic illustration of the experimental procedure. The participants experienced six different scenarios and answered the related questionnaires. Three different groups of participants were randomly selected. These two experiments (experiment 1: 200 lux, experiment 2: 60 lux) in which each group of participants experienced only two scenarios lasted 3 weeks.

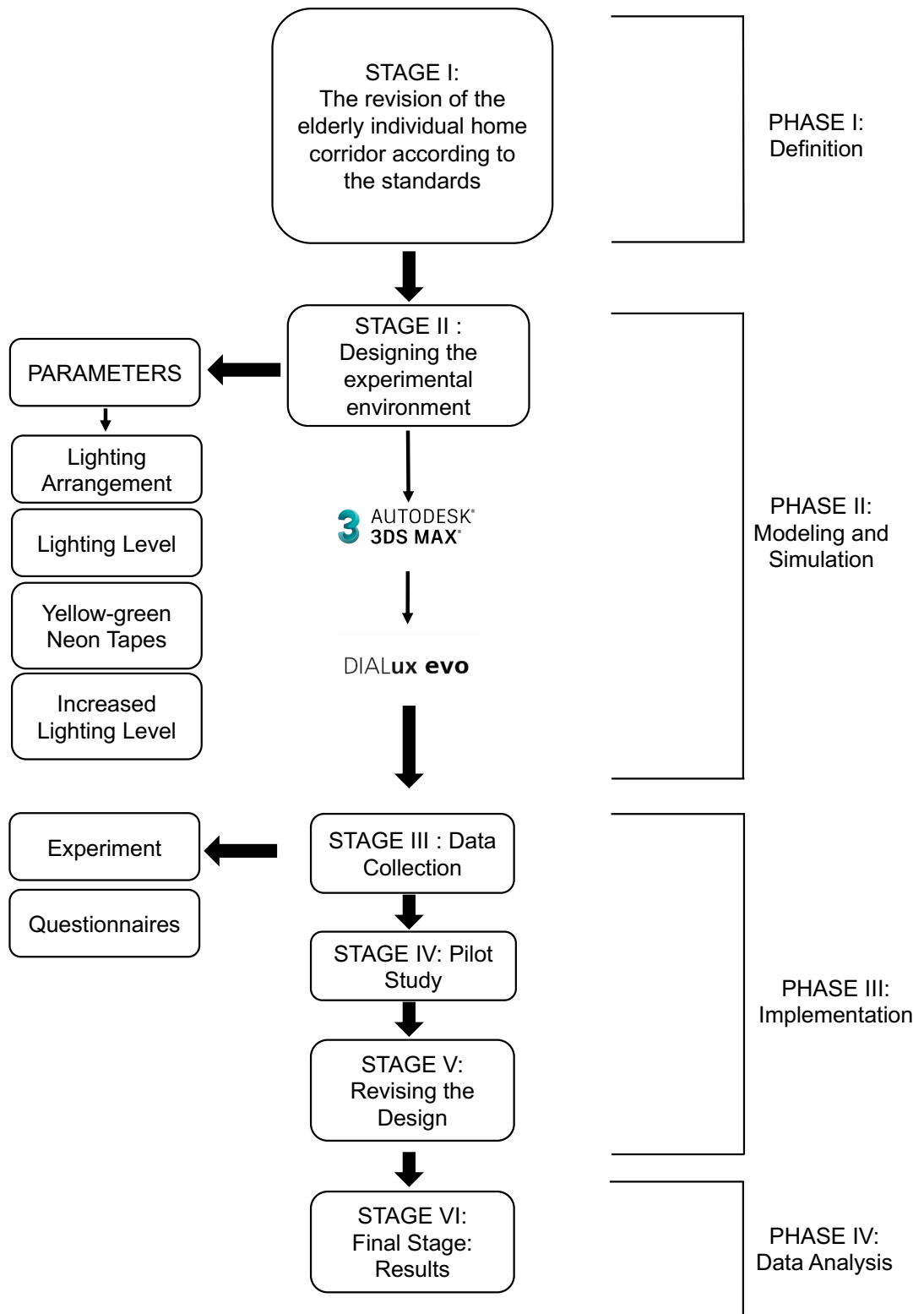


Figure 9. Process diagram of the study (drawn by the author, 2023)

Table 7 shows the groups of participants and the average lux values on eye level (140-160 cm above the floor) for the corridor in each lighting arrangement. The places other than the corridor are not illuminated. In the control group (30 participants), the corridor is illuminated by LED spotlighting from the ceiling. This lighting was considered to illuminate the corridor during the night, and the participants were informed in advance. In group 1 (30 participants), the corridor is illuminated by LED spot ground lighting. This lighting was designed as night lighting and it was considered to illuminate the corridor during the night, and the participants were informed about this before the experiment. In group 2 (30 participants), the corridor is illuminated by LED spot ground lighting as night lighting again and there are yellow-green neon tapes on the door frames and lighting switches.

Table 7. Average lux values on the corridor and groups of participants

Artificial Lighting	Experiment 1	Experiment 2
Control Group	200 lux (from the ceiling)	60 lux (from the ceiling)
Group 1	200 lux (from the ground)	60 lux (from the ground)
Group 2	200 lux (from the ground with yellow-green neon tapes)	60 lux (from the ground with yellow-green neon tapes)

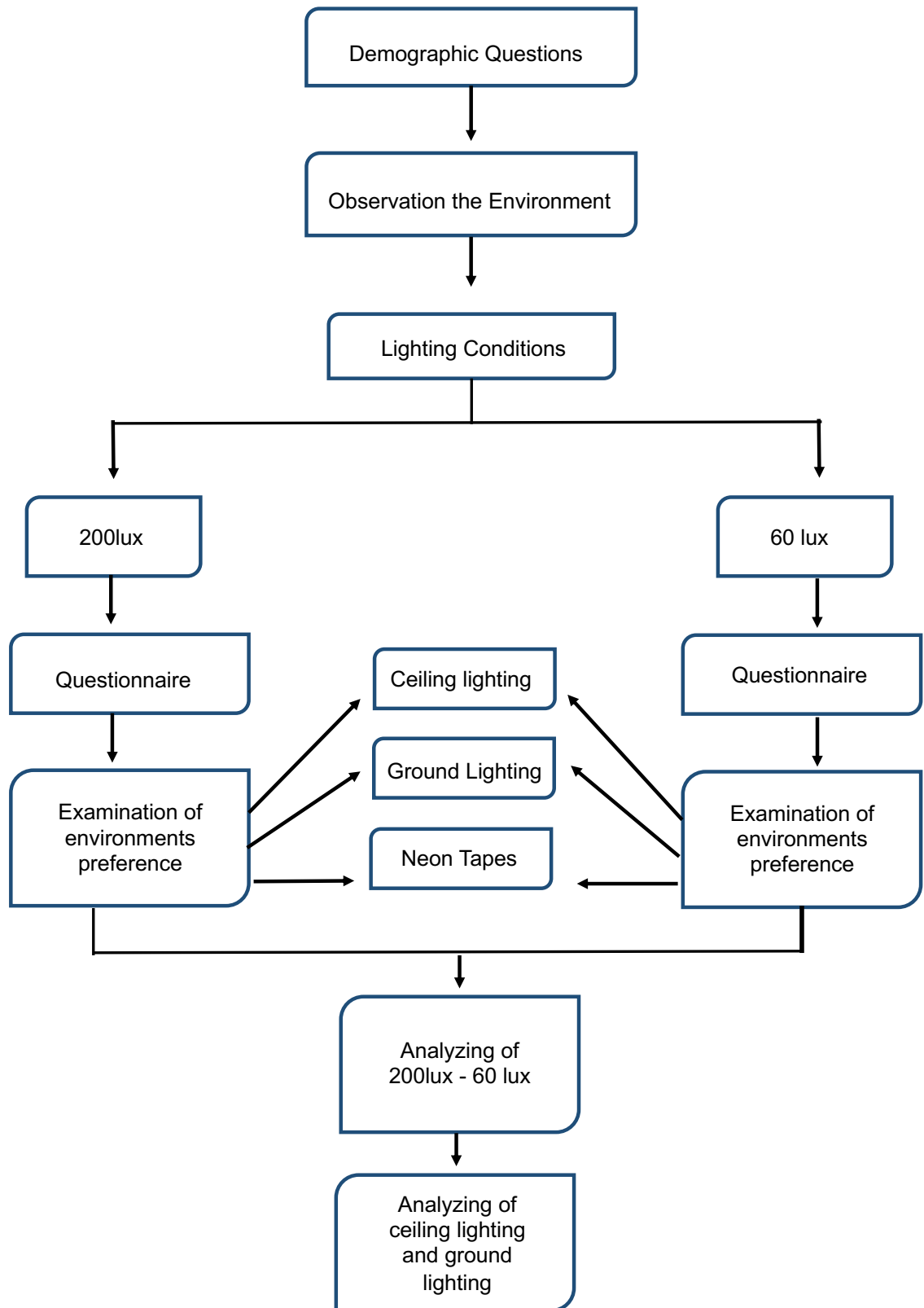


Figure 10. Schematic illustration of the experimental procedure (drawn by the author, 2023). Process diagram of the study (drawn by the author, 2023)

According to Zielinska's research, the color fluorescent (neon) yellow-green was helpful in perceiving hazards (Zielinska, Wogalter, & Mayhorn, 2014). Therefore, yellow-green neon tapes were added to the experiment to be considered as a recommendation for designers to consider integrating neon colors into their designs in this scenario.

According to Turkish Standards Institution, the corridor lighting in residential environments should be 100 lux and the night lighting is also considered 30 lux. Moreover, the lux values in the corridor need to be two times more than the standard values for older adults (Kunduraci, 2017). Therefore, the experiment was designed as 200 lux for general corridor lighting and 60 lux for corridor night lighting.

3.2.4 Instruments and Data Collection

This study was conducted through experimental research and questionnaires. Participants were randomly selected by paying attention to the order effect and the learning effect. Before the experiment, the participants were informed about the experiment. After that, they were asked to sign a consent form if they wished to participate in the experiment. All the participants were asked to fill out the questionnaires about lighting conditions after each scenario. The questionnaires comprise demographic information that they answered before the experiment, the Lighting Impression questionnaire, Lighting Survey, and the Scenario questionnaire that they answered after the experiment.

All participants entered the soundproof booth, sat in the same chair, and experienced six different conditions on the laptop at the table (see Figure 11). This audiologist is on Hoşdere Street in Ankara. Soundproof booths are scientific rooms that have acoustical control systems and they have standard

sizes (Shalool, Zainal, Gan, Umat, & Mukari, 2017). The display type is a laptop monitor (MacBook Pro (Retina, 15-inch, Mid 2015)) laptop, mouse, and keyboard. In this niVR setup, the mouse and keyboard are the interaction devices. Participants had the right for one minute to experience the environment. Figure 11 shows the participants during the experiment. To make it appear in the picture, the light in the room was switched on; however, the experiment was conducted with the light off.

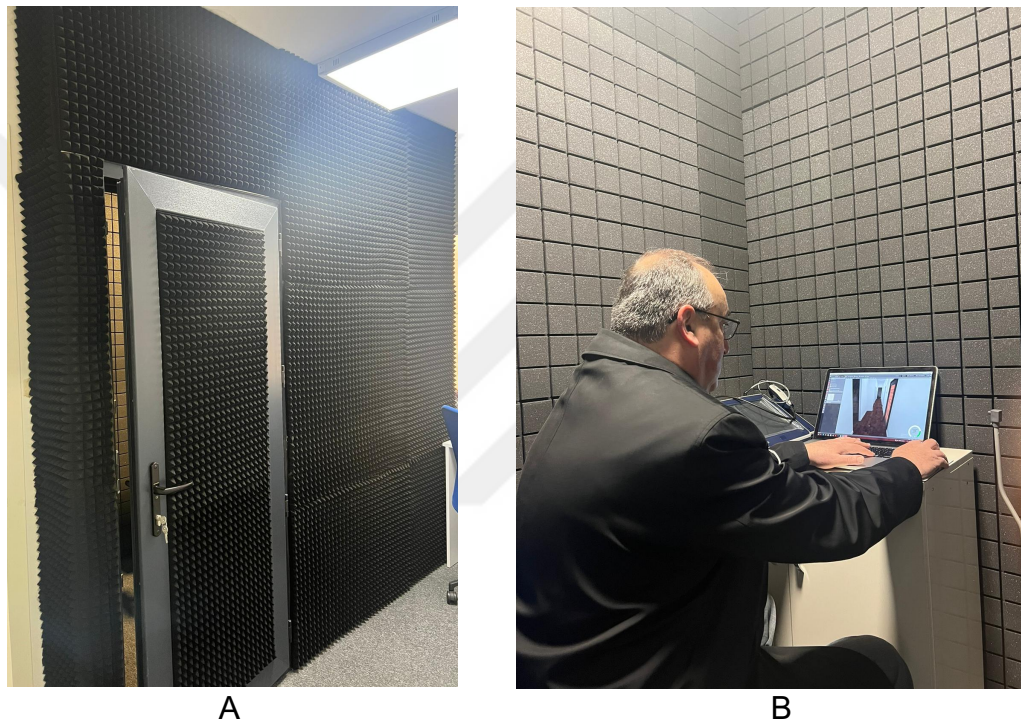


Figure 11. Soundproof audiologist booth (A) and participants during the experiment (B) (photo taken by the author, 2023)

3.2.5. Questionnaires

All the participants were asked to fill out the questionnaires about lighting after each scenario. The questionnaires comprised Part I Demographic Information that they answered before the experiment, Part II the Lighting

Impression Questionnaire (Kamali, 2020), (Tifler, 1992), Part III Lighting Survey (Eklund & Boyse, 1996), (Mahmoudzadeh, Afacan, & Adi, 2021), and Part IV Scenario Questionnaire that they answered after the experiment (Appendix A). The Turkish version of the questionnaires is in Appendix B. Part II, part III, and Part IV had a semantic differential scaling. Semantic differential scaling is used in lighting experiments to measure the psychological aspects of lighting and it helps to make experimental procedures more available and efficient (Tifler, 1992). It was to rate impressions and feelings created by the scenarios using a series of rating scales after watching the simulation. Answers were subjective judgments concerning the corridor's appearance under its present lighting system. They could use the intermediate categories of the scale to indicate intermediate judgments and they read both words at each end of a scale before they decide where to place their checkmark. In part II, participants put their checkmarks close to that word according to the feeling given by the lighting system in the scenario, and there were 14 semantic differential rating scales. In part III, the questionnaire is an agree-disagree format in a semantic differential scaling and seven questions had a seven-point Likert Scale Format. There were two copies of Part II and Part III for each scenario and one copy of Part IV which had four separate questions with an agree-disagree format in a semantic differential scaling (after experiencing both scenarios). Each participant rated each scenario once.

3.2.6. Data Analysis

The collected quantitative data were analyzed using IBM SPSS Statistics 28 software. In this study, both between-group results and within-group results were analyzed. Firstly, within groups results were examined. The paired sample t-test was conducted to make a comparison within groups. It is a dependent kind of test used when the samples are comprised of matched pairs of comparable units. It can be inferred that the data were not distributed

normally if the data set's P value is less than 0.05 by using paired sample t-test for analyzing the differences between 200 lux and 60 lux.

Factor Analysis was conducted to examine the differences between the two different lighting levels (200 lux-60 lux). Then, a one-way ANOVA test of unrelated samples was performed to examine the between-groups differences in lighting preferences (the effect of the arrangement of lighting and yellow-green neon tapes). A regression analysis was carried out to better understand how the adjective pairs affected the results. This analysis revealed which adjective predominates in each adjective pair.



CHAPTER IV

RESULTS

This chapter contains the results and statistical analysis of the findings. The data obtained from the experiment were analyzed using IBM SPSS Statistics 28 software. Experimental results were obtained from the uneventful participation of 90 participants. The data collected through experiments with 90 participants served as the basis for the examination of the data in all sections.

4.1. Comparison of Lighting with 200 lux and 60 lux

Several comparisons between scenarios were conducted to analyze the effect of the lighting arrangement and lighting level in the virtual home corridor on the lighting preferences. The sequence of the sample groups must be taken into consideration. Scenarios were examined separately in each lighting condition. The paired sample t-test was applied to these related samples because the sample group was the same (within groups). Wilcoxon Sign test was also applied. However, the paired sample t-test was preferred after the analysis. It analyzed the statistical significance of the preference of 200 lux and 60 lux in each scenario. In the value table, it is seen that there is a significant difference ($p < .05$) between Experiment 1 and Experiment 2 in all

items in the ceiling lighting for the control group. These adjective pairs are ugly-beautiful ($p<.001$), hazy-clear ($p<.001$), uncomfortable-comfortable ($p<.001$), unpleasant-pleasant ($p<.001$), dislike-like ($p<.001$), poorly arranged-well arranged ($p<.001$), dim-bright ($p<.001$), ordinary-special ($p<.001$), nonfunctional-functional ($p<.001$), frustrating-satisfying ($p<.001$), great eye discomfort-no eye discomfort ($p<.001$), depressing-stimulating ($p<.001$), visually cool-visually warm ($p<.001$), glare-nonglare ($p<.001$) (see Table 8). Participants in the control group found ceiling lighting (CL) with 200 lux more comfortable, pleasant, functional, and satisfying than CL with 60 lux, while CL with 60 lux was found more special and non-glare than CL with 200 lux. According to results and mean scores, the participants mostly preferred CL with 200 lux.

The paired sample test was applied for ground lighting. In Table 9, there are significant differences for adjective pairs that were demonstrated between 200 lux and 60 lux. When Table 9 is examined, it is seen that there is no significant difference between 200 lux and 60 lux for visually cool-visually warm ($p=0.354$) for the sample group ($p>.05$), and there is a significant difference between 200 lux and 60 lux for the other adjective pairs. These are ugly-beautiful ($p<.001$), hazy-clear ($p<.001$), uncomfortable-comfortable ($p<.001$), unpleasant-pleasant ($p<.001$), dislike-like ($p<.001$), poorly arranged-well arranged ($p<.001$), dim-bright ($p<.001$), ordinary-special ($p<.001$), nonfunctional-functional ($p=0.025$), frustrating-satisfying ($p<.001$), great eye discomfort-no eye discomfort ($p<.001$), depressing-stimulating ($p=.002$), glare-nonglare ($p<.001$). Participants found GL with 60 lux more comfortable, clear, pleasant, with no eye discomfort, non-glare, well-arranged, and satisfying than GL with 200 lux. On the other hand, they found 200 lux brighter and more glare than 60 lux. According to results and mean scores, the participants mostly preferred GL with 60 lux.

Table 8. Comparison between ceiling lighting with 200 lux (Experiment 1) and 60 lux (Experiment 2) for the control group (Paired sample t-test)

Ceiling Lighting	Adjectives	Mean		P
		200 lux	60 lux	200-60 lux
	Ugly - Beautiful	5.80	1.80	<.001
	Hazy - Clear	6.87	1.37	<.001
	Uncomfortable - Comfortable	6.17	1.50	<.001
	Unpleasant - Pleasant	3.67	1.57	<.001
	Dislike - Like	5.67	1.87	<.001
	Poorly arranged - Well arranged	4.73	1.83	<.001
	Dim - Bright	6.40	1.63	<.001
	Ordinary - Special	1.23	2.83	<.001
	Nonfunctional - Functional	6.37	1.60	<.001
	Frustrating - Satisfying	5.33	1.70	<.001
	Great Eye Discomfort - No Eye Discomfort	3.90	1.53	<.001
	Depressing - Stimulating	6.20	1.83	<.001
	Visually Cool - Visually warm	5.73	2.37	<.001
	Glare - Nonglare	2.77	6.60	<.001

The paired sample test was applied again for ground lighting with yellow-green tapes. When Table 10 is examined, it is seen that there is no significant difference between 200 lux and 60 lux for the adjective pairs of visually cool-visually warm ($p=0.455$) for the participants of group 2, and there is a significant difference between 200 lux and 60 lux for the other adjective pairs ($p < .001$). Participants perceived 60 lux with yellow-green neon tapes as more comfortable, pleasant, special, and functional than 200

lux with yellow-green neon tapes. In addition, they found 200 lux brighter than 60 lux. According to results and mean scores, the participants mostly preferred GL with yellow-green neon tapes at 60 lux.

Table 9. Comparison between ground lighting with 200 lux (Experiment 1) and 60 lux (Experiment 2) for group 1 (Paired sample t-test)

Ground Lighting	Adjectives	Mean		P
		200 lux	60 lux	200-60 lux
	Ugly - Beautiful	4.23	6.33	<.001
	Hazy - Clear	5.20	6.30	<.001
	Uncomfortable - Comfortable	3.83	5.66	<.001
	Unpleasant - Pleasant	4.33	5.13	<.001
	Dislike - Like	4.00	6.10	<.001
	Poorly arranged - Well arranged	4.40	6.77	<.001
	Dim - Bright	6.20	3.83	<.001
	Ordinary - Special	5.97	4.93	<.001
	Nonfunctional - Functional	5.53	5.17	.025
	Frustrating - Satisfying	3.90	5.47	<.001
	Great Eye Discomfort - No Eye Discomfort	2.47	6.63	<.001
	Depressing - Stimulating	4.33	5.57	.002
	Visually Cool - Visually warm	5.23	5.10	.354
	Glare - Nonglare	1.90	6.80	<.001

In conclusion, significant differences between 200 lux and 60 lux were observed for thirteen adjective pairs except visually cool-visually warm. Even though the sample group of GL and GL with yellow-green neon tapes were not the same, these differences were found to be almost the same for two different designed corridors.

Table 10. Comparison between 200 lux GL with yellow-green neon tapes (Experiment 1) and 60 lux GL with yellow-green neon tapes (Experiment 2) for group 2 (Paired sample t-test)

Ground Lighting with Yellow-green Neon Tapes	Adjectives	Mean		P
		200 lux	60 lux	200-60
	Ugly - Beautiful	1.53	6.83	<.001
	Hazy - Clear	4.40	6.87	<.001
	Uncomfortable - Comfortable	1.77	6.73	<.001
	Unpleasant - Pleasant	1.67	6.67	<.001
	Dislike - Like	1.47	6.70	<.001
	Poorly arranged - Well arranged	2.87	6.67	<.001
	Dim - Bright	6.47	4.60	<.001
	Ordinary - Special	4.27	6.90	<.001
	Nonfunctional - Functional	2.23	6.77	<.001
	Frustrating - Satisfying	1.77	6.37	<.001
	Great Eye Discomfort - No Eye Discomfort	1.60	6.87	<.001
	Depressing - Stimulating	3.20	6.73	<.001
	Visually Cool - Visually warm	5.93	5.77	.455
	Glare - Nonglare	1.10	6.80	<.001

The adjective pairs that did not exhibit similarity in differences were the adjective pairs of ordinary-special in-ground lighting and non-functional-functional in-ground lighting with yellow-green neon tapes. The participants found 200 lux brighter than 60 lux and they found 60 lux in GL with yellow-green neon tapes more special, functional, satisfying, clear, and pleasant than 200 lux (see Table 11).



Table 11. Summary of comparison between 200 lux and 60 lux for ground lighting and ground lighting with yellow-green neon tapes

Ground Lighting	ADJECTIVE PAIRS	Ground Lighting with Yellow-green Neon Tapes
There is a difference in favor of 60 lux (more beautiful)	Ugly - Beautiful	There is a difference in favor of 60 lux (more beautiful)
There is a difference in favor of 60 lux (clearer)	Hazy - Clear	There is a difference in favor of 60 lux (clearer)
There is a difference in favor of 60 lux (more comfortable)	Uncomfortable - Comfortable	There is a difference in favor of 60 lux (more comfortable)
There is a difference in favor of 60 lux (more pleasant)	Unpleasant - Pleasant	There is a difference in favor of 60 lux (more pleasant)
There is a difference in favor of 60 lux (liked more)	Dislike - Like	There is a difference in favor of 60 lux (liked more)
There is a difference in favor of 60 lux (more well-arranged)	Poorly arranged - Well arranged	There is a difference in favor of 60 lux (more well-arranged)
There is a difference in favor of 200 lux (brighter)	Dim - Bright	There is a difference in favor of 200 lux (brighter)
There is a difference in favor of 200 lux (more special)	Ordinary - Special	There is a difference in favor of 60 lux (more special)
There is a difference in favor of 200 lux (more functional)	Nonfunctional - Functional	There is a difference in favor of 60 lux (more functional)
There is a difference in favor of 60 lux (more satisfying)	Frustrating - Satisfying	There is a difference in favor of 60 lux (more satisfying)
There is a difference in favor of 60 lux (no-eye discomfort)	Great Eye Discomfort - No Eye Discomfort	There is a difference in favor of 60 lux (no-eye discomfort)
There is a difference in favor of 60 lux (more stimulating)	Depressing - Stimulating	There is a difference in favor of 60 lux (more stimulating)
No significant differences	Visually Cool - Visually warm	No significant differences
There is a difference in favor of 60 lux (no more glare)	Glare - Nonglare	There is a difference in favor of 60 lux (no more glare)

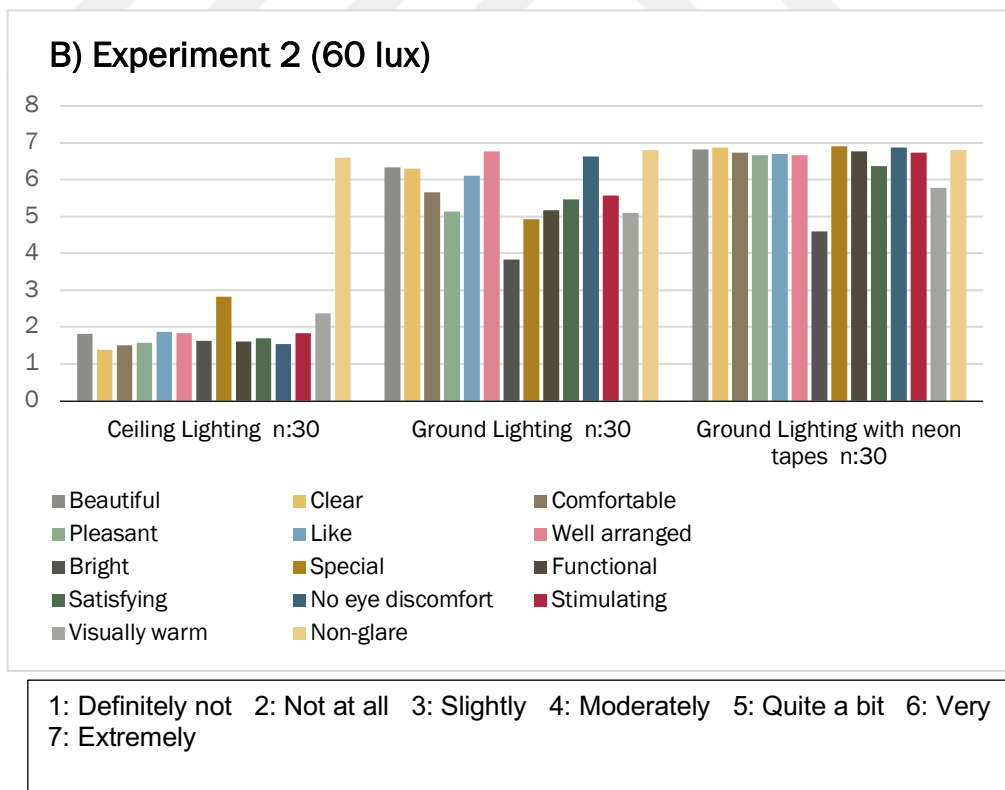
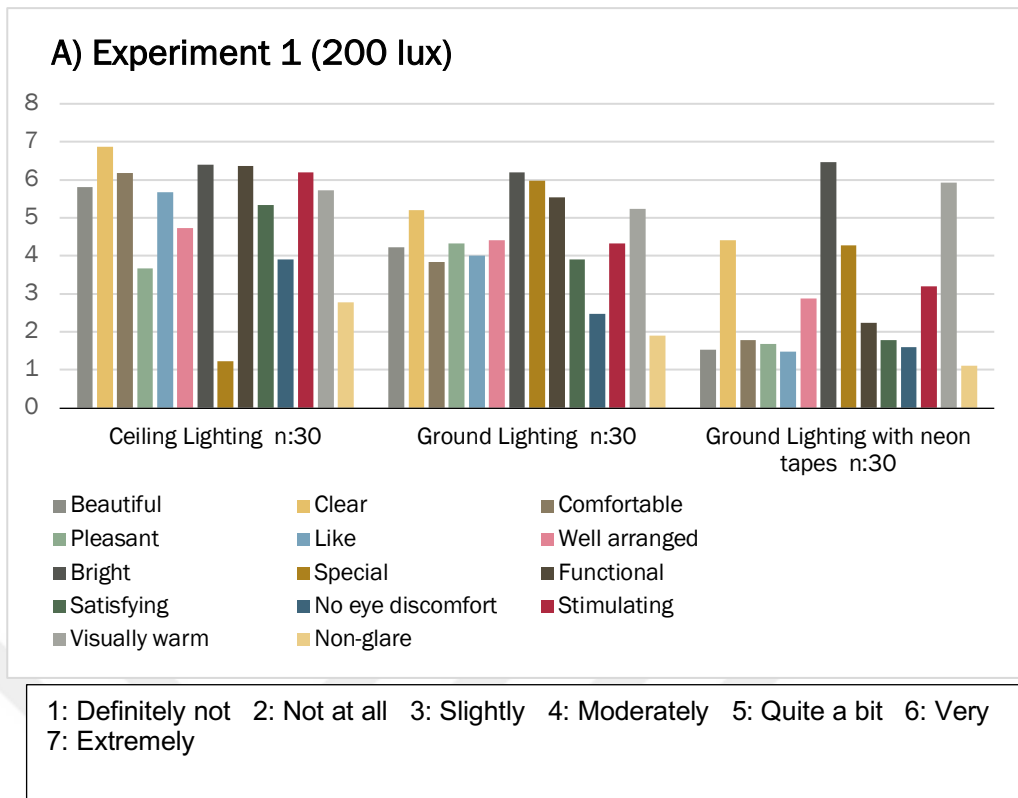


Figure 12. Mean values of the lighting condition under 200 lux (A) and 60 lux (B)

According to mean values, CL with 200 lux received much more favorable reviews than CL with 60 lux (see Figure 12). Then, GL with 60 lux was seen to be more positive than GL with 200 lux. In addition, GL with neon tapes at 60 lux was perceived more positively than GL with neon tapes at 200 lux. Figure 12 depicts the ratings of the subjects at 200 lux and 60 lux.

After the analysis of the second data of the preference of 200 lux and 60 lux, the results were not used because this analysis was not reliable and useful for this study.

4.2. Effects of 200 lux and 60 lux in the Ceiling and Ground Lighting on Lighting Preferences

Factor analysis was used to understand the potential effects of 200 lux and 60 lux on the corridor. The impacts of lighting level were investigated using factor analysis.

Table 12. KMO for 200 lux and 60 lux

KMO and Barlett's Test		200 lux	60 lux
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,902	,951
Bartlett's Test of Sphericity	Approx. Chi-Square	1046,537	2088,405
	Sig.	<,001	<,001

Table 13. Factor Analysis of 200 LUX; Total Variance

200 lux (Total Variance Explained)						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7,674	54,816	54,816	7,674	54,816	54,816
2	1,655	11,823	66,639	1,655	11,823	66,639
3	,963	6,881	73,521			
4	,866	6,184	79,705			
5	,687	4,904	84,609			
6	,564	4,030	88,640			
7	,349	2,491	91,130			
8	,329	2,350	93,480			
9	,282	2,015	95,495			
10	,183	1,304	96,799			
11	,145	1,038	97,837			
12	,108	,772	98,609			
13	,102	,727	99,335			
14	,093	,665	100,000			

When Table 12 is examined, it is seen that the KMO values for 200 lux and 60 lux can be expressed as excellent and excellent, respectively. It is seen that KMO values of lighting level (200 lux=0.902, 60 lux=0.951) were greater than 0.60 and Bartlett's test of Sphericity shows that multivariate normality is achieved ($p < .01$). Therefore, factor analysis can be done.

Table 14. Factor Load Values for 200 lux

200 lux		
Rotated Component Matrix ^a	Component	
	1	2
Uncomfortable-comfortable	,930	
Dislike-like	,913	
Ugly-beautiful	,906	
Frustrating-Satisfying	,881	
Nonfunctional-functional	,845	
Depressing-stimulating	,841	
Hazy-clear	,823	
Great eye discomfort-no eye discomfort	,805	
Glare-nonglare	,696	
Poorly arranged-well arranged	,520	
Ordinary-special		,611
Unpleasant-pleasant		,637
Visually cool-visually warm		-,605
Dim-bright		-,436

In the total variance table, the KMO value is 0.90, and Barlett's test of sphericity shows that multivariate normality is achieved ($p < .01$) (see Table 12). The Cronbach's alpha coefficient was calculated for 200 lux as 0.869, and 0.70 is an acceptable value. According to Eigenvalues, the variables were collected under 2 different components at 200 lux (see Table 13). The name of component 1 was comfort level, and the name of component 2 was visuality. In component 1, there were uncomfortable-comfortable, dislike-like, ugly-beautiful, frustrating-satisfying, nonfunctional-functional, depressing-stimulating, hazy-clear, great eye discomfort-no eye discomfort, glare-nonglare, and poorly arranged-well arranged adjective pairs with the 54% of the total variance. In component 2, ordinary-special, unpleasant-pleasant, visually cool-visually warm, and dim-bright adjective pairs with 11% of the total variance. The adjective pairs together explain 66.64% of the variance.

The factor load values of the adjective pairs vary between 0.436 and 0.930 (see Table 14).

According to the results of the analysis, the KMO value is 0.95 for 60 lux, and Barlett's test of sphericity shows that multivariate normality is achieved ($p < .01$) (see Table 12). The Cronbach's alpha coefficient was calculated for 60 lux as 0.981. According to Eigenvalues, the variables were collected under 1 component at 60 lux (see Table 15). The name of component 1 was comfort level. In component 1, there were all the adjectives pair with 80% of the total variance. Therefore, the adjective pairs together explain 80.51% of the variance. The factor load values of the adjective pairs vary between 0.200 and 0.975 (see Table 16).

Table 15. Factor Analysis of 60 LUX; Total Variance

60 lux (Total Variance Explained)						
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11,271	80,508	80,508	11,271	80,508	80,508
2	1,012	7,230	87,738			
3	,430	3,070	90,808			
4	,373	2,662	93,470			
5	,218	1,557	95,027			
6	,167	1,192	96,219			
7	,119	,850	97,069			
8	,090	,644	97,713			
9	,082	,587	98,300			
10	,072	,512	98,812			
11	,064	,454	99,267			
12	,043	,308	99,574			
13	,032	,232	99,806			
14	,027	,194	100,000			

Table 16. Factor Load Values for 60 lux

60 lux	
Rotated Component Matrix ^a	Component
	1
Hazy-clear	,975
Uncomfortable-comfortable	,969
Ugly-beautiful	,962
Great eye discomfort-no eye discomfort	,959
Dislike-like	,955
Poorly arranged-well arranged	,949
Nonfunctional-functional	,949
Unpleasant-pleasant	,947
Frustrating-Satisfying	,940
Depressing-stimulating	,916
Ordinary-special	,855
Visually cool-visually warm	,849
Dim-bright	,843
Glare-nonglare	,200

4.3. Effect of the Arrangement of Lighting and Yellow-green Neon Tapes on Lighting Preferences

To analyze the ratings of the arrangements of lighting and yellow-green neon tape preference, the mean rating scores of the three different scenarios were compared. To analyze the statistical significance between different lighting conditions, the One-way ANOVA test was used. Table 17 is examined, the mean scores given by the participants to the adjective pairs ugly–beautiful ($p<.001$), hazy–clear ($p<.001$), uncomfortable-comfortable ($p<.001$), unpleasant-pleasant ($p<.001$), dislike-like ($p<.001$), poorly-arranged-well arranged ($p<.001$), ordinary-special ($p<.001$), non-functional-functional ($p<.001$), frustrating-satisfying ($p<.001$), great eye discomfort-no eye

discomfort ($p < .001$), depressing-stimulating ($p < .001$), visually cool-visually warm ($p = 0.012$), glare-non-glare ($p < .001$) differ significantly between different lighting. To understand which groups, there is a difference, a post-hoc test was performed. The adjective pair that is dim-bright mean scores of the participants did not differ significantly between three different lighting conditions ($p = 0.303$). In other words, all lighting conditions at 200 lux do not affect dim-bright scores. The mean scores of ten adjective pairs out of fourteen were high in ceiling lighting. Therefore, one can say that CL with 200 lux was found more positive than GL and GL with neon tapes. For example, the mean score of uncomfortable-comfortable in-ground lighting with neon tapes ($\bar{X} = 1.77$) is lower than the ground lighting ($\bar{X} = 3.83$) and ceiling lighting means score ($\bar{X} = 6.17$). The mean score of ceiling lighting ($\bar{X} = 6.17$) is higher than the mean score of ground lighting ($\bar{X} = 3.83$). It means that according to participants, the mean values of the uncomfortable-comfortable variable were greater positively in CL. The means score of unpleasant-pleasant and ordinary-special in GL were higher than CL and GL with neon tapes. The pair of visually cool-visually warm showed a high mean score in GL with neon tapes. In Figure 13, there is a bar chart of the results. Even though there was no significant difference in dim-bright, the mean values of dim-bright were positively higher in CL, GL, and GL with neon tapes. According to results and mean scores, the participants mostly preferred CL with 200 lux. In the 200 lux lighting, GL was mostly preferred among GL and GL with neon tapes.

Table 17. Descriptive statistics of the scores of the participants at 200 lux (experiment 1) group by group (One-way ANOVA results)

200 lux	Lighting Condition	n	Mean	S	p
Ugly - Beautiful	CL	30	5.80	0.805	<.001
	GL	30	4.23	0.626	
	GL+neon	30	1.53	0.571	
Hazy - Clear	CL	30	6.87	0.346	<.001
	GL	30	5.20	0.805	
	GL+neon	30	4.40	0.894	
Uncomfortable-Comfortable	CL	30	6.17	0.699	<.001
	GL	30	3.83	0.699	
	GL+neon	30	1.77	0.858	
Unpleasant-Pleasant	CL	30	3.67	0.802	<.001
	GL	30	4.33	0.758	
	GL+neon	30	1.67	0.661	
Dislike-Like	CL	30	5.67	1.028	<.001
	GL	30	4.00	0.695	
	GL+neon	30	1.47	0.507	
Poorly-arranged-Well arranged	CL	30	4.73	1.048	<.001
	GL	30	4.40	1.133	
	GL+neon	30	2.87	1.008	
Dim-Bright	CL	30	6.40	0.675	.303
	GL	30	6.20	0.761	
	GL+neon	30	6.47	0.629	
Ordinary-Special	CL	30	1.23	0.430	<.001
	GL	30	5.97	0.615	
	GL+neon	30	4.27	0.691	
Non-functional-Functional	CL	30	6.37	0.615	<.001
	GL	30	5.53	0.819	
	GL+neon	30	2.23	0.935	
Frustrating-Satisfying	CL	30	5.33	0.959	<.001
	GL	30	3.90	0.960	
	GL+neon	30	1.77	0.626	
Great Eye Discomfort-No Eye Discomfort	CL	30	3.90	1.242	<.001
	GL	30	2.47	0.629	
	GL+neon	30	1.60	0.621	
Depressing-Stimulating	CL	30	6.20	0.714	<.001
	GL	30	4.33	0.994	
	GL+neon	30	3.20	0.847	
Visually Cool-Visually Warm	CL	30	5.73	1.337	.012
	GL	30	5.23	0.568	
	GL+neon	30	5.93	0.640	
Glare-Non-glare	CL	30	2.77	1.040	<.001
	GL	30	1.90	0.662	
	GL+neon	30	1.10	0.305	

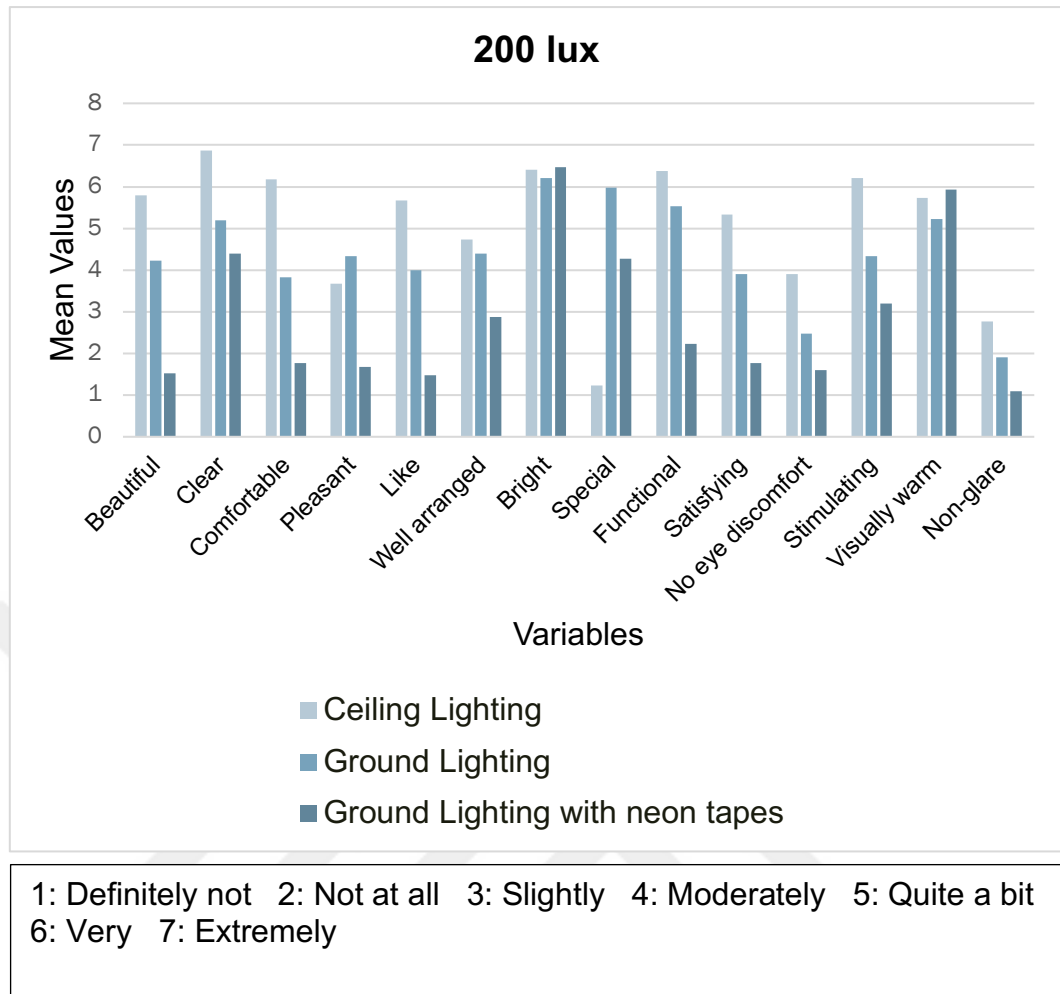


Figure 13. Mean values of the adjectives in three different scenarios at 200 lux

To analyze the results of the arrangements of lighting and yellow-green neon tape preference, the mean values of CL, GL, and GL with neon tapes at 60 lux were compared. The One-way ANOVA test was conducted for this data set. In the Table 18, the mean ratings of ugly–beautiful ($p < .001$), hazy–clear ($p < .001$), uncomfortable–comfortable ($p < .001$), unpleasant–pleasant ($p < .001$), dislike–like ($p < .001$), poorly–arranged–well arranged ($p < .001$), dim–bright ($p < .001$), ordinary–special ($p < .001$), non–functional–functional ($p < .001$), frustrating–satisfying ($p < .001$), great eye discomfort–no eye discomfort ($p < .001$), depressing–stimulating ($p < .001$), visually cool–visually warm ($p < .001$) differ significantly between three lighting condition ($p < .05$). To understand which groups, there is a difference was, a post-hoc test was performed.

Table 18. Descriptive statistics of the scores of the participants at 60 lux (experiment 2) group by group (One-way ANOVA results)

60 lux	Lighting Condition	n	Mean	S	p
Ugly - Beautiful	CL	30	1.80	0.664	<.001
	GL	30	6.33	0.661	
	GL+neon	30	6.83	0.379	
Hazy - Clear	CL	30	1.37	0.615	<.001
	GL	30	6.30	0.596	
	GL+neon	30	6.87	0.434	
Uncomfortable-Comfortable	CL	30	1.50	0.630	<.001
	GL	30	5.66	0.670	
	GL+neon	30	6.73	0.521	
Unpleasant-Pleasant	CL	30	1.57	0.568	<.001
	GL	30	5.13	0.900	
	GL+neon	30	6.67	0.606	
Dislike-Like	CL	30	1.87	0.681	<.001
	GL	30	6.10	0.803	
	GL+neon	30	6.70	0.466	
Poorly-arranged-Well arranged	CL	30	1.83	0.747	<.001
	GL	30	6.77	0.504	
	GL+neon	30	6.67	0.606	
Dim-Bright	CL	30	1.63	0.669	<.001
	GL	30	3.83	0.986	
	GL+neon	30	4.60	1.003	
Ordinary-Special	CL	30	2.83	1.117	<.001
	GL	30	4.93	1.015	
	GL+neon	30	6.90	0.305	
Non-functional-Functional	CL	30	1.60	0.621	<.001
	GL	30	5.17	1.117	
	GL+neon	30	6.77	0.430	
Frustrating-Satisfying	CL	30	1.70	0.651	<.001
	GL	30	5.47	1.008	
	GL+neon	30	6.37	0.718	
Great Eye Discomfort-No Eye Discomfort	CL	30	1.53	0.681	<.001
	GL	30	6.63	0.615	
	GL+neon	30	6.87	0.346	
Depressing-Stimulating	CL	30	1.83	0.834	<.001
	GL	30	5.57	1.278	
	GL+neon	30	6.73	0.450	
Visually Cool-Visually Warm	CL	30	2.37	1.217	<.001
	GL	30	5.10	0.759	
	GL+neon	30	5.77	1.073	
Glare-Non-glare	CL	30	6.60	0.621	.194
	GL	30	6.80	0.407	
	GL+neon	30	6.80	0.407	

According to the post-hoc test results, the p-value of glare-nonglare was higher than the significant level (0.05). Therefore, there is no significant difference in the glare-non-glare variable according to participants ($p = 0.194$). In other words, all lighting conditions at 60 lux do not affect glare-nonglare scores. The mean values of thirteen adjective pairs out of fourteen were high in GL with neon tapes. Thus, one can say that GL with yellow-green neon tapes at 60 lux was perceived more positively than CL and GL. For example, the mean score of nonfunctional-functional in GL with neon tapes ($\bar{X} = 6.77$) is higher than CL ($\bar{X} = 5.17$), and GL mean score ($\bar{X} = 1.60$). The mean score of GL ($\bar{X} = 5.17$) is higher than the mean score of CL ($\bar{X} = 1.60$) group. It means that according to participants, the mean values of the nonfunctional-functional variable for GL with neon tapes were higher in a positive manner. The means score of glare-nonglare for GL, and GL with neon tapes are the same ($\bar{X} = 6.80$). According to results and mean scores, the participants mostly preferred GL with yellow-green neon tapes at 60 lux.

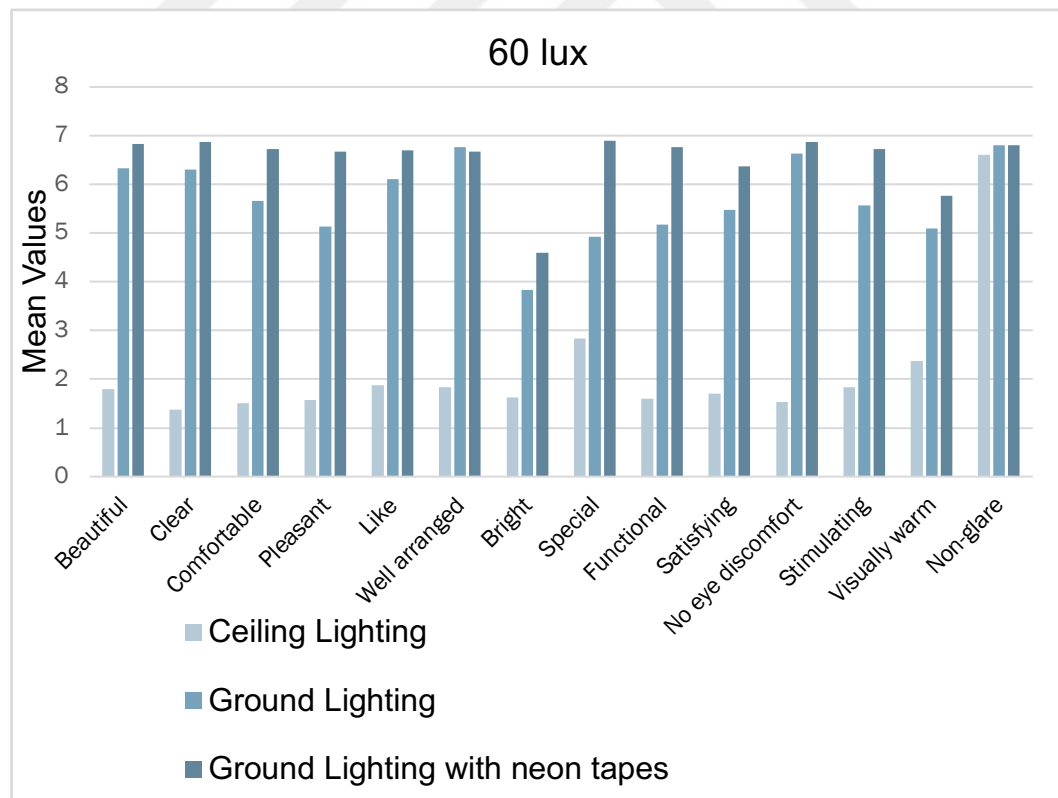


Figure 14. Mean values of the adjectives in three different scenarios at 60 lux

In Figure 14, even though there was no significant difference in glare-nonglare, the mean values of glare-nonglare were positively higher in CL, GL, and GL with neon tapes in the bar chart which demonstrates the mean values of the adjectives in three different scenarios at 60 lux.

Table 19. Descriptive statics of the total mean scores obtained by the participants according to lighting conditions (One-way ANOVA)

200-60	Lighting Condition	n	Mean	S	p
Adjective pairs at 200 lux	CL	30	70.83	3.15	<.001
	GL	30	61.53	2.87	
	GL+neon	30	40.27	2.41	
Adjective pairs at 60 lux	CL	30	30.03	2.85	<.001
	GL	30	79.60	3.08	
	GL+neon	30	91.27	3.17	

Table 19 shows the total mean scores of all adjective pairs under 200 lux and 60 lux. When this table is examined, the mean score of the total adjective pairs at 200 lux and 60 lux differ significantly according to different lighting conditions ($p < .001$). To understand between which groups, there is a difference was, a post-hoc test was performed. According to the post-hoc test results, for adjective pairs at 200 lux, the mean score of GL with neon tapes ($\bar{X} = 40.27$) is lower than GL ($\bar{X} = 61.53$) and CL's mean score ($\bar{X} = 70.83$). The mean score of GL ($\bar{X} = 61.53$) is lower than the mean score of CL ($\bar{X} = 70.83$). One can say that CL under 200 lux was found more positive than CL under 60 lux and GL under 60 lux was perceived more positive than GL under 200 lux. In addition, GL with neon tapes under 60 lux was found more positive than GL with neon tapes under 200 lux. Among all of them, GL with neon tapes under 60 lux was found to be more positive than the others.

The last data were the data of CL, GL, and GL with neon tapes (A) preferences at 60 lux. In addition, there were the comfort and pleasantness

level data (B and C respectively) at 200 lux. Finally, participants were asked to make a preference for whether the lighting with 60 lux could stay on all night (C). The questions for each group were organized according to the experiment. Therefore, the questionnaire answered by each group is classified as A-B-C because they were different surveys in themselves.

Table 20. Descriptive statistics of the scores of the participants at 200 lux and 60 lux group by group (One-way ANOVA results)

200-60		Lighting Condition	n	Mean	S	p
1	A	CL	30	2.67	0.922	<.001
	B	GL	30	6.60	0.621	
	C	GL+neon	30	6.93	0.254	
2	A	CL	30	4,63	1.098	<.001
	B	GL	30	3.33	0.606	
	C	GL+neon	30	5.23	1.135	
3	A	CL	30	2.77	0.971	<.001
	B	GL	30	4.23	1.165	
	C	GL+neon	30	5.07	0.640	
4	A	CL	30	1.17	0.379	<.001
	B	GL	30	6.67	0.547	
	C	GL+neon	30	6.93	0.254	

A: Control group questionnaire (ceiling lighting)

B: Group 1 questionnaire (ground lighting)

C: Group 2 questionnaire (ground lighting with yellow-green neon tapes)

The One-way ANOVA test was conducted for this data. In Table 20, there are significant differences for all the statements ($p < .001$). To understand which groups, there is a difference, a post-hoc test was performed.

According to post-hoc test results, the mean score of GL with neon tapes ($\bar{X} = 6.93$) for statement 1 is higher than GL ($\bar{X} = 6.60$) and CL mean score ($\bar{X} = 2.67$). The mean score of GL ($\bar{X} = 6.60$) is higher than the mean score of CL ($\bar{X} = 2.67$). One can say that GL with neon tapes at 60 lux was found more positive than CL and GL. For statement 2, the mean score of GL ($\bar{X} = 3.33$) is lower than the mean score of CL ($\bar{X} = 4.63$), and GL with neon tapes ($\bar{X} = 5.23$). For statement 3, the mean score of GL with neon tapes ($\bar{X} = 5.07$) is higher than GL ($\bar{X} = 4.23$) and CL ($\bar{X} = 2.77$). The mean score of GL ($\bar{X} = 4.23$) is higher than the mean score of CL ($\bar{X} = 2.77$). For statement 4, the mean score of CL ($\bar{X} = 1.17$) is lower than the mean score of GL ($\bar{X} = 6.67$) and GL with neon tapes ($\bar{X} = 6.93$) (see Figure 15). One can say that GL with neon tapes at 200 lux was found more positive than CL and GL for statements 2 and 3. The participants mostly preferred the lighting with 60 lux to stay on all night in GL with neon tapes.

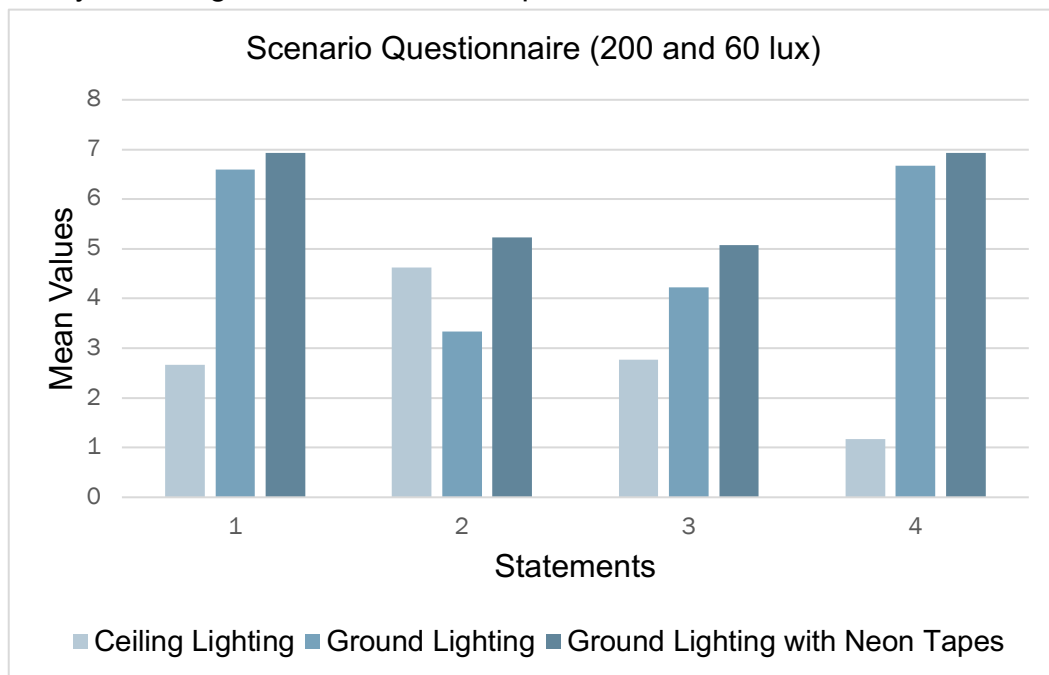


Figure 15. Mean values of the adjectives in three different scenarios at 200 and 60 lux.

Older adults mostly preferred 200 lux lighting when there was ceiling lighting, confirming H1. Another result of the study was that older adults mostly preferred 60 lux when there was ground lighting, which confirms H2. Participants preferred yellow-green neon tapes which were the independent variables in the study for ground lighting when there was 60 lux lighting. The finding approves H3. The last finding of the study is that yellow-green neon tapes were not preferred in GL with 200 lux, which confirms H4.

The results of One-way ANOVA showed that the arrangement of the lighting and yellow-green neon tapes used in door frames and lighting switches significantly affected lighting preferences. To get a better understanding of the effect of the adjective pairs, a Regression Analysis was conducted. The correlation tables are in Appendix C. This analysis shows us which adjective is more predominant in each adjective pair for 200 lux and 60 lux. In other words, regression analysis demonstrates the proportion of the variance in the dependent variable (lighting preferences) that can be explained by the independent variables. In this study, the effect of the arrangement of lighting, and yellow-green neon tapes were examined for both 200 lux and 60 lux lighting conditions. Firstly, multilinear regression was applied for 200 lux. In Table 21, in the first model, there was a positive relationship between the arrangement of lighting and the lighting preferences. The significance level was less than 0.05 ($p < .001$). It means that the arrangement of lighting had a significant impact on the lighting preferences of older adults. According to Table 21, the R square of 0,784 means that 78.4% of the variance is explained. Adjusted R Square shows the variable percentage of the Total Variance. The arrangement of lighting had a 76% effect on the lighting preferences of older adults from the total variance, according to the adjusted R square, which has a value of 0,769. In the second model (see Table 21), both the arrangement of lighting and yellow-green neon tapes had a positive, strong relationship with lighting preferences. The significance level was less than 0.05 ($p < .001$). It means that the arrangement of lighting, and yellow-green neon tapes had a significant impact on the lighting preferences of older adults. In Table 21, the R square of 0,824 means that 82.4% of the variance

is explained. According to the adjusted R square, the arrangement of lighting had an 80% effect on the lighting preferences of older adults from the total variance (see Table 21). R squares in model1 and 2 were different from each other. Therefore, perceived yellow-green neon tapes added a change to the study model. Since the arrangement of lighting and neon tapes were included separately, it is seen that it explains both the total variance and how much for each dimension separately in the hierarchical regression analysis result (see Table 22). Then, as adjective pairs were investigated, their contribution to the total variable could be seen by examining the significance levels in Table 23.

Table 21. Summary regression table for 200 lux

Model	R	R Square	Adjusted R Square	Std. The error of the Estimate	F Change	Sig.
1	,886 ^a	,784	,769	,941	50,301	<,001
2	,908 ^b	,824	,806	,861	9,067	<,001

a. Predictors: (Constant), The Arrangement of Lighting

b. Predictors: (Constant), The Arrangement of Lighting, Yellow-green Neon Tapes

c. Dependent Variable: The Lighting Preferences

Table 22. Hierarchical regression analysis results (ANOVA) for 200 lux

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	267,022	6	44,504	50,301	<,001 ^b
	Residual	73,434	83	,885		
	Total	340,456	89			
2	Regression	280,454	8	35,057	47,326	<,001 ^c
	Residual	60,001	81	,741		
	Total	340,456	89			

a. Dependent Variable: The Lighting Preferences

b. Predictors: (Constant), The Arrangement of Lighting

c. Predictors: (Constant), The Arrangement of Lighting, Yellow-green Neon Tapes

Table 23. Table of coefficients for 200 lux

Model		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	1,049	,691	1,519	,133
	Unpleasant-Pleasant	,470	,128	3,665	<,001
	Poorly Arranged-Well Arranged	,163	,091	1,781	,079
	Ordinary-Special	-,342	,083	-4,121	<,001
	Great Eye Discomfort- No Eye Discomfort	,311	,125	2,482	,015
	Depressing-Stimulating	,057	,110	,516	,608
	Glare-Non-glare	,483	,125	3,869	<,001
2	(Constant)	4,372	1,006	4,348	<,001
	Unpleasant-Pleasant	,434	,118	3,662	<,001
	Poorly Arranged-Well Arranged	,061	,087	,706	,482
	Ordinary-Special	-,123	,100	-1,235	,220
	Great Eye Discomfort- No Eye Discomfort	,299	,115	2,610	,011
	Depressing-Stimulating	-,090	,107	-,838	,405
	Glare-Non-glare	,325	,120	2,697	,009
	Preference of 60 lux (neon tapes)	-,293	,105	-2,797	,006
	Preference of 200 lux (neon tapes)	-,261	,094	-2,763	,007

In model 1, the values of all adjective pairs were less than 0.05 except poorly arranged- well arranged, and depressing-stimulating (see Table 23).

Therefore, there was a significant effect of these adjective pairs on lighting preferences. In model 2, the values of all adjective pairs were less than 0.05 except poorly arranged- well arranged, ordinary-special, and depressing-stimulating. Therefore, there was a significant effect of these adjective pairs

on lighting preferences. Additionally, the values in column B showed what proportion of the dependent variable's value came from the adjectives.

Multilinear regression was also applied for 60 lux. According to Table 24, in the first model, there was a positive relationship between the arrangement of lighting and the lighting preferences. The significance level was less than 0.05 ($p < .001$). It means that the arrangement of lighting (independent variable) had a significant impact on the lighting preferences of older adults (dependent variable). the R square of 0,778 means that 77.8% of the variance is explained in Table 24. The arrangement of lighting had a 60% effect on the lighting preferences of older adults from the total variance, according to the adjusted R square, which has a value of 0,601. In model 2, both the arrangement of lighting and yellow-green neon tapes had a positive, strong relationship with lighting preferences. The significance level was less than 0.05 ($p < .001$). It can be said that the arrangement of lighting, and yellow-green neon tapes had a significant impact on the lighting preferences of older adults. In Table 24, the R square of 0,820 means that 82 % of the variance is explained. According to the adjusted R square, the arrangement of lighting had a 66% effect on the lighting preferences of older adults from the total variance (see Table 21). R squares in model1 and 2 were also different from each other for 60 lux lighting conditions. Therefore, perceived yellow-green neon tapes added a change to the study model. The hierarchical regression analysis results were shown in Table 25.

Table 24. Summary regression table for 60 lux

Model	R	R Square	Adjusted R Square	Std. The error of the Estimate	F Change	Sig.
1	,778 ^a	,606	,601	1,489	133,573	<,001
2	,820 ^b	,672	,664	1,366	17,317	<,001

a. Predictors: (Constant), The Arrangement of Lighting

b. Predictors: (Constant), The Arrangement of Lighting, Yellow-green Neon Tapes

c. Dependent Variable: The Lighting Preferences

Table 25. Hierarchical regression analysis results (ANOVA) for 60 lux

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	296,132	1	296,132	133,573	<,001 ^b
	Residual	192,879	87	2,217		
	Total	489,011	88			
2	Regression	328,461	2	164,231	87,971	<,001 ^c
	Residual	160,550	86	1,867		
	Total	489,011	88			

a. Dependent Variable: The Lighting Preferences

b. Predictors: (Constant), The Arrangement of Lighting

c. Predictors: (Constant), The Arrangement of Lighting, Yellow-green Neon Tapes

Table 26. Table of coefficients for 60 lux

Model		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	,147	,418	,353	,725
	Visually cool-Visually warm	1,015	,088	11,557	<,001
2	(Constant)	-,997	,472	-2,113	,037
	Visually cool-Visually warm	,741	,104	7,119	<,001
	Preference of 200 lux (neon tapes)	,588	,141	4,161	<,001

In model 1, the value of visually cool-visually warm was less than 0.05 (see Table 26). Therefore, there was a significant effect of this adjective pair on lighting preferences at 60 lux. In model 2, the values of visually cool-visually warm, and preference of 200 lux (neon tapes) were less than 0.05. Therefore, there was a significant effect of these items on lighting preferences.

CHAPTER V

DISCUSSION

In this study, the effect of the arrangement of lighting, lighting level, and yellow-green neon tapes on lighting preferences at night in home corridors was investigated. First, the needs and preferences of older adults in the residential environment were examined. To better understand the differences in the vision and perception between older adults and young adults, the vision of the aging eye and visual perception were studied in depth. Then, an experimental study in a non-immersive virtual environment was conducted to compare the arrangement of lighting, and lighting level to determine the lighting preferences of older adults.

5.1. 200 lux and 60 lux Lighting Levels

The same sample groups of participants experienced two experiments with different lighting levels (200 lux – 60 lux). The paired-sample t-test was used to analyze the results and to compare two different lighting levels (see Table 8). Then, the mean values of the results were illustrated in graphics (see Figure 12). The findings indicated that 200 lux in CL was found more comfortable, pleasant, functional, and satisfying than 60 lux in GL, while CL with 60 lux was found more special and non-glare than 200 lux in CL. There

was a significant difference between 200 lux and 60 lux in all adjective pairs for CL. This result is consistent with the literature indicating that older adults require and prefer higher lighting levels than younger adults (Kunduraci, 2017; Lu, Park, & Ahrentzen, 2019; Karlsson, Magnusson, Schewelov, & Rosengren, 2013). In addition, the area was seen more favorably as being better for navigation as the lighting level increased (Turner, et al., 2011). This contrasts with previous research that demonstrated that older adults are negatively affected by high-glare lighting (Leung, Wang, & Chan, 2019). However, Wahab and Zuhardi stated that the lighting distribution is significantly influenced by the location of the lighting (Wahab & Zuhardi, 2013). These results are for ceiling lighting preferences, and this could be the reasonable factor for mostly preferring CL with 200 lux.

The other findings indicated that 60 lux in GL was perceived as more comfortable, clear, pleasant, with no eye discomfort, non-glare, well-arranged, and satisfying than 200 lux in GL. On the contrary, 200 lux in GL was found brighter and had more glare than 60 lux. There was no significant difference between 200 lux and 60 lux for the adjective pair of visually cool-visually warm, and the rest of the adjective pairs; ugly-beautiful, hazy-clear, uncomfortable-comfortable, unpleasant-pleasant, dislike-like, poorly arranged-well arranged, dim-bright, ordinary-special, nonfunctional-functional, frustrating-satisfying, great eye discomfort-no eye discomfort, depressing-stimulating, glare-nonglare were found differently. It can be said that there was a significant difference between 200 lux and 60 lux in the preferences. These results are aligned with the literature that contends that night lighting is essential in the circulation areas (corridors) for older adults to perceive the environment and move comfortably at night (Karlsson, Magnusson, Schewelov, & Rosengren, 2013; Davidson, Bond, Dawson, Steen, & Kenny, 2005; Centers for Disease Control and Prevention, 2005; Rogers, Rogers, Takeshima, & Islam, 2004; Lee, Jeong, & Hirate, 2009), and Kunduraci stated that older adults need two times more lighting level than young adults (Kunduraci, 2017). Therefore, the night lighting scenario was established, and the experiment was carried out by making night lighting 60

lux, the standard of which is 30 lux, and it was presented to the preference of the older adults. According to the results, they mostly preferred GL with 60 lux. The final finding in the lighting level preference research indicated that older adults found 60 lux GL with yellow-green neon tapes as more comfortable, pleasant, special, and functional than 200 lux. Furthermore, they perceived 200 lux brighter than 60 lux. According to Lu (2019), lighting with a low lighting level mounted on door frames protects older adults from falls and allows them to find their balance (Lu, Park, & Ahrentzen, 2019). According to collected data from that research, older adults mostly preferred GL with yellow-green neon tapes at 60 lux. These findings are also consistent with the literature stating that high-glare lighting has an unfavorable impact on older adults (Leung, Wang, & Chan, 2019).

5.2. Effects of 200 lux and 60 lux in the Ceiling and Ground Lighting on Lighting Preferences

Lighting is a factor that affects human health, and if it is used appropriately, it can have a positive impact on health (Ticleanu, 2021; Feng, Chen, Zhu, & Xiong, 2018; Osibona, Solomon, & Fecht, 2021; Hu, 2021; Lee, Jeong, & Hirate, 2009; Shikder, Mourshed, & Price, 2012). One of the crucial and effective issues was the arrangement of lighting. In this study, factor analysis, one-way ANOVA, and multilinear regression were used to analyze the differences between ceiling lighting and ground lighting (CL and GL). The effectiveness level of 200 lux and 60 lux were expressed as excellent. In the regression test, the effect of lighting arrangements and yellow-green neon tapes on lighting preferences at 200 lux was 83% while at 60 lux it decreased slightly to 74% (see Table 21-24).

In 2020, an experiment was conducted by Tuaycharoen. This study examined the effect of lighting, color, and signs on the wayfinding of older adults in nursing homes (Tuaycharoen, 2020). Finding their way with the help

of light was investigated. He indicated that a wayfinding design aids in helping people understand their location and perception of their destination (Tuaycharoen, 2020). It can be said that instead of traditional ceiling lighting, lighting designs can be made on wayfinding in the corridors, especially at night. There are studies about the effect of lighting on sleep health. Ticleanu (2021) indicated that finding the balance between bright light and dark is very important for maintaining sleep patterns (Ticleanu, 2021). Moreover, he stated that being under the influence of light at night affects circadian rhythm negatively (Ticleanu, 2021). For this reason, it may be appropriate to use night lighting so that lighting with a high lighting level does not come from the corridor while older adults are sleeping. According to the study by Lee and his coworkers (2009), older adults who go to the restroom a few times have sleep problems when they return to their rooms because of the lighting in the circulation areas (Lee, Jeong, & Hirate, 2009). In 2012, Shikder and his team presented the physical and psychological effects of lighting on older adults (Shikder, Mourshed, & Price, 2012). According to them, depression and sleep problems are seen in older adults exposed to poorly designed lighting systems (Shikder, Mourshed, & Price, 2012). In addition, Cain and his team (2020) investigated the effect of residential lighting conditions on sleep (Cain, et al., 2020). He indicated that lighting affects sleep and circadian rhythm (Cain, et al., 2020). Osibona and his team (2021) examined the effect of natural lighting, artificial lighting, and night lighting on sleep health (Osibona, Solomon, & Fecht, 2021). Osibona stated that lighting can have a negative effect on sleep health. However, there are few studies investigating the relationship between health and light (Osibona, Solomon, & Fecht, 2021). Facchin and his team (2017) had a study on glare (Facchin, Daini, & Zavagno, 2017). Facchin stated that older adults are more susceptible to glare than young adults (Facchin, Daini, & Zavagno, 2017). According to the literature review, it can be said that the absence of light from the corridors to the bedrooms or the low lighting level of light they are exposed to when they use the corridor positively affects the health of older adults.

In this study, when the results and mean values of 200 lux were examined, ceiling lighting with 200 lux was mostly preferred (see Table 17) instead of ground lighting with 200 lux and ground lighting with yellow-green neon tapes at 200 lux. The findings are in line with the literature suggesting that lighting arrangement affects lighting distribution and changes visual perception as discussed above. Moreover, when the results and mean values of 60 lux were examined, ground lighting with yellow-green neon tapes at 60 lux was mostly preferred (see Table 18) instead of CL with 60 lux and GL with 60 lux. The results are consistent with the literature indicating that the color fluorescent (neon) yellow-green was helpful in perceiving hazards (Zielinska, Wogalter, & Mayhorn, 2014). Zielinska and her coworkers (2014) investigated the effect of colors (Zielinska, Wogalter, & Mayhorn, 2014). According to their experimental study, it was seen that the yellow-green neon color was a warning against hazards and makes it easier to detect an item (Zielinska, Wogalter, & Mayhorn, 2014). In this study, analyses of the effect of yellow-green neon tapes demonstrated that older adults preferred to apply yellow-green neon tapes on door frames and light switches in the home corridor at night, and the use of this color could be considered appropriate for older adults.

The findings of the analysis examining whether the lighting in the corridor stays on all night is that GL 60 lux with neon tapes stays on. Therefore, if the lighting in the corridor stayed on all night, the participants preferred 60 lux night lighting. Lee and his coworkers indicated that older adults are afraid because there is no appropriate lighting when using the corridor to meet their needs at night (Lee, Jeong, & Hirate, 2009). According to their study, the rate of older adults keeping the light off was high. One of the reasons for this was the cost (Lee, Jeong, & Hirate, 2009). Another study stated that older adults may have glare problems from lights in areas with high lighting levels (Leung, Wang, & Chan, 2019). Because of the cost and glare, older adults may have selected GL with 60 lux (with the addition of neon tapes), which is why the study's findings are consistent with the literature.

There are many studies conducted in a virtual environment (VE). A few of the reasons for choosing a VE in these studies are to be able to repeat the scenarios as many times as desired, to easily manipulate the task, and to have a safe environment (Mahmoudzadeh, Afacan, & Adi, 2021) (Adi & Roberts, 2014) (Jansen-Osmann & Berendt, 2002). In addition, head-mounted display (HMD) used in immersive virtual environments (nIVEs) is used in some studies to explore the experiments. However, there some studies concentrated on the disadvantages of HMDs. HMDs cause cybersickness (CS), and some of the symptoms are nausea, sweating and loss of vision (Palmisano, Allison, & Kim, 2020; Ebenholtz, 1992; McCauley & Sharkey, 1992; Stanney & Salvendy, 1998; LaViola Jr, 2000; Lawson, 2014; Rebenitsch & Owen, 2016; Gavgani, Nesbitt, Blackmore, & Nalivaiko, 2017). For this light, considering the sensitivity of older adults, this study was conducted using nIVE.

The majority of the literature research that was examined concerned lighting in public spaces such as marketplaces, nursing homes, and other public areas. There is a lack of studies about circulation paths (corridors at home) in the literature. Hence, the lighting conditions for older adults in residential corridors is the topic that this dissertation examined and concentrated on.

CHAPTER VI

CONCLUSION

The effects of different lighting arrangements and lighting levels on lighting preferences were investigated in a non-immersive virtual environment. The impact of the yellow-green neon tape on the door frames and light switches was also examined in terms of lighting preferences. The experiment was conducted in six different environments;

- 1) 200 lux ceiling lighting
- 2) 200 lux ground lighting
- 3) 200 lux ground lighting and yellow-green neon tapes
- 4) 60 lux ceiling lighting
- 5) 60 lux ground lighting
- 6) 60 lux ground lighting and yellow-green neon tapes

The lighting preferences are a subjective assessment, and in particular, those of older adults differ significantly from those of young adults (Kunduraci, 2017). When designing a light for an older adult's home, it should be designed according to the needs of older adults; but this is ignored (Shikder, Mourshed, & Price, 2012). In this respect, according to the requirements of older adults, different lighting conditions were created in the virtual home corridor, and the SPSS statistical software was used to analyze the results of lighting preferences. Lighting level preferences were examined

by conducting a within-group analysis. Then the arrangement of lighting and the effect of yellow-green neon tapes on lighting preferences were investigated by conducting a between-group analysis.

According to the finding, in CL, there was a significant difference in all adjective pairs under 200 lux and 60 lux. 200 lux CL was found more comfortable, clear, pleasant, well arranged, and less special and non-glare than 60 lux CL. In GL and GL with yellow-green neon tapes, there was a significant difference in all adjective pairs under 200 lux and 60 lux, except visually cool-visually warm. GL and GL with neon tapes at 60 lux were perceived as more clear, beautiful, comfortable, pleasant, well-arranged, functional, stimulating, and non-glare than 200 lux GL and GL with neon tapes. The difference between GL and GL with neon tapes was that GL with neon tapes was found to be more special than 200 lux GL with neon tapes. However, GL was not found to be more special than 200 lux GL. The findings of the effect of the arrangement of lighting and yellow-green neon tapes on lighting preferences showed that there was a significant difference in all adjective pairs at 200 lux, except dim-bright. CL was perceived as clearer, more comfortable, well-arranged, functional, and satisfying than GL and GL with neon tapes. In addition, there was a significant difference in all adjective pairs at 60 lux, except glare-non glare. GL with neon tapes was found to be more beautiful, with no eye discomfort, pleasant, clear, functional, and satisfying than CL and GL. As a result, the participants mostly preferred CL when there was a 200-lux lighting level. However, when there was a 60-lux lighting level as night lighting, they mostly preferred GL with yellow-green neon tapes.

The importance of this study is to understand the light preferences of older adults and to provide them with the appropriate lighting that is different from the standards and according to their needs in the home corridors, which is the most frequently used area in the house. Consequently, it is very

important to design lighting according to their physical characteristics and the needs of older adults.

The limitations of this study were studying with older adults in pandemic conditions. An immersive virtual environment was not used during pandemic conditions considering both the disadvantages of HMDs and the sensitivity of older adults. Another limitation of this study is that Kelvin values and natural lighting were not included in this study and only the lighting level was studied. Moreover, the virtual corridor was in gray scale with a white ceiling. One of the most important limitations of this study was that it was investigating older adults to experience the experiment after waking up in a virtual environment. Therefore, it was an issue to examine the state of adaptation to the environment after sleep.

In future studies, it can be investigated how to integrate neon colors into designs in the design process for older adults. Moreover, the lighting condition of the other areas of the residential environment can be investigated such as bedrooms, kitchens, or bathrooms in night conditions because older adults mostly spend their time in residential environments. Further studies could examine the effect of color temperature on lighting preferences in a residential environment. Virtual reality is developing rapidly. Therefore, lighting preferences can also be researched by creating a virtual house setting and using HMD by eliminating disadvantages such as cybersickness. Most of the studies on lighting preferences for older adults were for public areas (e.g. office lighting by Zhong and his team (2017), and nursing home bedroom lighting by Yang and his coworkers (2021)). This study can be a starting point for future lighting research to have a research topic in its residential corridors.

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APPENDICES

APPENDIX A

QUESTIONNAIRES IN ENGLISH

Participant Number:

Bilkent University Faculty of Art, Design and Architecture

Department of Interior Architecture and Environmental Design

EXAMINING THE EFFECT OF LIGHTING LEVELS ON SAFETY IN
RESIDENTIAL CORRIDORS FOR PEOPLE OF ADVANCED AGE USING A
VIRTUAL ENVIRONMENT

Master's Thesis Study by Ece Esin Ilgaz

Supervisor: Assist. Prof. Dr. Semiha Yilmazer

These questionnaires are conducted for the master thesis study within
the scope of I.D Bilkent University Department of Interior Architecture and

Environmental Design graduate program. It will not be used for any other purpose and your personal information will not be recorded or published. For participating in this study, you need to be over 60 and fluently speak either English or Turkish language.

There are 4 parts in the following. First, you are expected to answer demographic questions before the experiment. Then, after the experiment, you are expected to answer part II which is to rate impressions and feelings created by the scenarios using a series of rating scales. This is the Lighting Impression Questionnaire. Part III is the Lighting Survey and part IV is about the scenario questionnaire. You are expected to answer these surveys separately for each experiment except part IV. There are 4 separate questions for each scenario in part IV and you are expected to answer this part after the experiment. For each scenario from part II, III, and IV, you have three copies to answer.

This study is approved by I.D Bilkent University Ethical Committee. No content that could upset you. This participation is totally on voluntary basis. Thus, if you feel uncomfortable at any time during the experiment, you can stop the experiment and request us to delete the information obtained from you. You can free to change your answers during the experiment.

For more detailed information on the research study, please contact with:

Ece Esin Ilgaz: esinn.bayramli@gmail.com

Assist. Prof. Dr. Semiha Yilmazer: semiha@bilkent.edu.tr

Considering the information above, please tick the box below if you are approving to participate in this research study voluntarily.

☐

I agree to participate in the research study that is explained above.

PART I: Demographic Information

1. Age:

2. Gender:

3. Educational Status: Primary School High School Graduate School

4. City/Country that you are currently living:

5. Do you have any visual impairment? Yes No

Note: Your confidentiality will be preserved

The following 3 questionnaires will be answered with the scale written below.

The ratings are shown below. For instance, if you would describe the lighting in the corridor in a scenario as very good, you would place a checkmark on the scale.

Bad _____:_____:_____:_____:_____:_____ ✓ _____ Good

In addition, if you would describe the lighting in the corridor in a scenario as very bad, you would place a checkmark on the scale as follows.

Bad ✓ _____:_____:_____:_____:_____:_____ _____ Good

Use the intermediate categories of the scale to indicate intermediate judgments. Be sure to read both words at each end of a scale before you decide where to place your checkmark. There are no right or wrong answers: we are interested only in your subjective judgment concerning the corridor's appearance under its present lighting system.

You can experience each scenario for one minute. Fill out these surveys after experiencing each scenario. The task will take approximately half an hour. Now, you can start to rate your subjective impressions of the lighting in corridors using the rating scales provided. Thank you.

PART II: Lighting Impression Questionnaire

Ugly	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Beautiful
Hazy	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Clear
Uncomfortable	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Comfortable
Unpleasant	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Pleasant
Dislike	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Like
Poorly Arranged	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Well Arranged
Dim	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Bright
Ordinary	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Special
Non-functional	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Functional
Frustrating	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Satisfying
Great Eye Discomfort	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	No Eye Discomfort
Depressing	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Stimulating
Visually Cool	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Visually Warm
Glare	_____	:	_____	:	_____	:	_____	:	_____	:	_____	:	_____	Non-glare

PART III: Lighting Survey

All of the statements below relate to the corridor created in virtual reality.
Answer the following questions using the answering system above.

1) Overall, the lighting is comfortable.

Disagree ____:____:____:____:____:____:____ **Agree**

2) The lighting is uncomfortably bright as I walk down the corridor at night.

Disagree ____:____:____:____:____:____:____ **Agree**

3) The lighting is uncomfortably dim as I walk down the corridor at night.

Disagree ____:____:____:____:____:____:____ **Agree**

4) The lighting is poorly distributed.

Disagree ____:____:____:____:____:____:____ **Agree**

5) Reflections from the light fixtures prevent me from walking.

Disagree ____:____:____:____:____:____:____ **Agree**

6) The light fixtures are too bright.

Disagree ____:____:____:____:____:____:____ **Agree**

7) How do you evaluate the lighting compared to the lighting in the corridor of your own home?

Bad ____:____:____:____:____:____:____ **Good**

PART IV: Scenario Questionnaire

A: Control Group

1) I prefer ceiling lighting with 60 lux in the corridor at night.

Disagree ____:____:____:____:____:____:____ **Agree**

2) At 200 lux, my comfort level increases at night.

Disagree ____:____:____:____:____:____:____ **Agree**

3) At 200 lux, my pleasantness level increases at night.

Disagree ____:____:____:____:____:____:____ **Agree**

4) I prefer the ceiling lighting with 60 lux to stay on all night.

Disagree ____:____:____:____:____:____:____ **Agree**

B: Group 1

1) I prefer ground lighting with 60 lux in the corridor at night.

Disagree ____:____:____:____:____:____:____ **Agree**

2) At 200 lux, my comfort level increases at night.

Disagree ____:____:____:____:____:____:____ **Agree**

3) At 200 lux, my pleasantness level increases at night.

Disagree ____:____:____:____:____:____:____ **Agree**

4) I prefer the ground lighting with 60 lux as night lighting to stay on all night.

Disagree ____:____:____:____:____:____:____ **Agree**

C: Group 2

1) I prefer ground lighting with neon tapes at 60 lux in the corridor at night.

Disagree ____:____:____:____:____:____:____ **Agree**

2) At 200 lux, my comfort level increases at night.

Disagree ____:____:____:____:____:____:____ **Agree**

3) At 200 lux, my pleasantness level increases at night.

Disagree ____:____:____:____:____:____:____ **Agree**

4) I prefer the ground lighting with the neon tapes on the doorframes and lighting switches at 60 lux as night lighting to stay on all night.

Disagree ____:____:____:____:____:____:____ **Agree**

APPENDIX B

ANKETLER

Katılımcı Numarası:

Bilkent Üniversitesi Güzel Sanatlar, Tasarım ve Mimarlık Fakültesi

İç Mimarlık ve Çevre Tasarımı Bölümü

SÜRÜKLEYİCİ OLMAYAN SANAL KONUT ORTAMINDAKİ AYDINLATMA
SEVİYELERİNİN YAŞLI YETİŞKİNLERİN AYDINLATMA TERCİHLERİNE
ETKİSİ

Yüksek Lisans Tezi

Ece Esin Ilgaz

Tez Danışmanı: Assist. Prof. Dr. Semiha Yılmaz

Bu anketler, İ.D Bilkent Üniversitesi İç Mimarlık ve Çevre Tasarımı Bölümü yüksek lisans programı kapsamında yüksek lisans tez çalışması için yapılmıştır. Başka bir amaç için kullanılmayacak ve kişisel bilgileriniz kaydedilmeyecek veya yayınlanmayacaktır. Bu çalışmaya katılmak için 60

yaşını doldurmuş olmanız ve akıcı bir şekilde İngilizce veya Türkçe konuşuyor olmanız gerekmektedir.

Aşağıda 4 bölüm var. İlk olarak, deneyden önce demografik soruları yanıtlamanız beklenmektedir. Deneyden sonra, bir dizi derecelendirme ölçeği kullanarak senaryolar tarafından oluşturulan izlenimleri ve duyguları derecelendirmek için oluşturulan Bölüm II'ü yanıtlamanız beklenmektedir. Bu, Aydınlatma İzlenim Anketidir. III. Bölüm Aydınlatma Anketi ve IV. Bölüm ise Senaryo Anketidir. Bölüm IV hariç her senaryo için bu anketleri ayrı ayrı yanıtlamanız beklenmektedir. Bölüm IV'de her senaryo için 4 ayrı soru vardır ve birer kopya olarak verilecektir. Bölüm II, III ve IV'den her senaryo için cevaplayacağınız üçer kopya bulunmaktadır.

Bu çalışma İ.D Bilkent Üniversitesi Etik Kurulu tarafından onaylanmıştır. Sizi üzecek hiçbir içerik yok. Bu katılım tamamen gönüllülük esasına dayanmaktadır. Bu nedenle, deney sırasında herhangi bir zamanda kendinizi rahatsız hissederseniz, deneyi durdurabilir ve sizden alınan bilgilerin silinmesini talep edebilirsiniz. Deney sırasında cevaplarınızı değiştirmekte özgürsünüz.

Araştırma çalışması hakkında daha detaylı bilgi için lütfen iletişime geçiniz:

Ece Esin Ilgaz: esinn.bayramli@gmail.com

Assist. Prof. Dr. Semiha Yılmaz: semiha@bilkent.edu.tr

Yukarıdaki bilgileri göz önünde bulundurarak, bu araştırmaya gönüllü olarak katılmayı kabul ediyorsanız lütfen aşağıdaki kutucuğu işaretleyiniz.

☐

Yukarıda açıklanan araştırma çalışmasına katılmayı kabul ediyorum.

BÖLÜM I: Demografik Bilgiler

1. Yaş:

2. Cinsiyet:

3.Öğrenim Durumu: İlkokul Lise Üniversite

4. Şu anda yaşadığınız Şehir/Ülke:

5. Görme bozukluğunuz var mı? Evet Hayır

Not: Gizliliğiniz korunacaktır.

Aşağıdaki 3 anket, aşağıda yazılı olan ölçek ile cevaplandırılacaktır.

Derecelendirmeler aşağıda gösterilmiştir. Örneğin, bir senaryoda koridordaki aydınlatmayı çok iyi olarak tanımlarsanız, skalaya bir onay işareti koyacaksınız.

Kötü _____:_____:_____:_____:_____:_____ ✓ _____ İyi

Ayrıca bir senaryoda koridordaki aydınlatmayı çok kötü olarak tanımlarsanız aşağıdaki gibi skalaya onay işareti koyacaksınız.

Kötü ✓ _____:_____:_____:_____:_____:_____ _____ İyi

Ara yargıları belirtmek için ölçeğin ara kategorilerini kullanın. Onay işaretinizi nereye koyacağınıza karar vermeden önce, ölçeğin her iki ucundaki her iki kelimeyi de okuduğunuzdan emin olun. Doğru ya da yanlış cevap yoktur: sadece, mevcut aydınlatma sistemi altında koridorun görünümüne ilişkin öznel yargınızla ilgileniyoruz.

Her senaryoyu 1 dakika boyunca deneyimleyebilirsiniz. Senaryoları deneyimledikten sonra bu anketleri doldurun. Görev yaklaşık 30 dakika sürecektir. Şimdi, sağlanan derecelendirme ölçeklerini kullanarak koridorlardaki aydınlatmaya ilişkin öznel izlenimlerinizi derecelendirmeye başlayabilirsiniz. Teşekkür ederim.

Bölüm II: Aydınlatma İzlenim Anketi

Çirkin	_____	_____	_____	_____	_____	_____	Güzel
Puslu	_____	_____	_____	_____	_____	_____	Net
Rahatsız	_____	_____	_____	_____	_____	_____	Rahat
Memnuniyet verici değil	_____	_____	_____	_____	_____	_____	Memnuniyet verici
Hoş Değil	_____	_____	_____	_____	_____	_____	Hoş
Kötü Düzenlenmiş	_____	_____	_____	_____	_____	_____	İyi Düzenlenmiş
Loş	_____	_____	_____	_____	_____	_____	Parlak
Sıradan	_____	_____	_____	_____	_____	_____	Özel
İşlevsel değil	_____	_____	_____	_____	_____	_____	değil
Moral bozucu	_____	_____	_____	_____	_____	_____	Tatmin edici
Göz rahatsızlığı var	_____	_____	_____	_____	_____	_____	Göz rahatsızlığı yok
Depresif	_____	_____	_____	_____	_____	_____	Neşe verici
Görsel olarak soğuk	_____	_____	_____	_____	_____	_____	Görsel olarak sıcak
Göz kamaştırıcı	_____	_____	_____	_____	_____	_____	Göz kamaştırıcı değil

Bölüm III: Aydınlatma Anketi

Aşağıdaki ifadelerin tamamı sanal gerçeklikte oluşturulan koridor ile ilgilidir.
Aşağıdaki soruları yukarıdaki cevaplama sistemini kullanarak cevaplayınız.

1) Genel olarak, aydınlatma rahat.

Katılmıyorum _____ Katılıyorum

2) Koridorda yürürken aydınlatma rahatsız edici derecede parlak.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

3) Koridorda yürürken ışık rahatsız edici derecede loş.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

4) Işık kötü dağıtılmış.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

5) Aydınlatma armatürlerinden yansımalar yürümemi engelliyor.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

6) Aydınlatma armatürleri çok parlak.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

7) Aydınlatmayı kendi evinizin koridorundaki aydınlatmaya göre nasıl değerlendirirsiniz?

Kötü ____:____:____:____:____:____:____ **İyi**

BÖLÜM V: Senaryo Anketi

A: Kontrol Grubu

1) Koridorda geceleri 60 lüks yukardan aydınlatma tercih ederim.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

2) 200 lüks aydınlatmada geceleri konfor seviyem artar.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

3) 200 lüks aydınlatmada geceleri memnuniyet seviyem artar.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

4) Yukarıdan aydınlatmada 60 lüks olan aydınlatmayı gece boyu açık tutmayı tercih ederim.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

B) Grup 1

1) Koridorda geceleri 60 lüks aşağıdan aydınlatma tercih ederim.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

2) 200 lüks aydınlatmada geceleri konfor seviyem artar.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

3) 200 lüks aydınlatmada geceleri memnuniyet seviyem artar.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

4) Aşağıdan aydınlatmada 60 lüks olan aydınlatmayı gece boyu açık tutmayı tercih ederim.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

C: Grup 2

1) Koridorda geceleri neon bantlı aşağıdan aydınlatma 60 lüks tercih ederim.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

2) 200 lüks aydınlatmada geceleri konfor seviyem artar.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

3) 200 lüks aydınlatmada geceleri memnuniyet seviyem artar.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

4) Kapı çerçevelerinde ve ışık anahtarlarının çevresinde neon bantlar olan aşağıdan aydınlatmada 60 lüks olan aydınlatmayı gece boyu açık tutmayı tercih ederim.

Katılmıyorum ____:____:____:____:____:____:____ **Katılıyorum**

APPENDIX C

Table C1. Correlation table of regression analysis for 200 lux

Correlation							
	Ugly Beautiful	Hazy Clear	Uncomfortable Comfortable	Unpleasant Pleasant	Dislike Like	Poorly arranged Well arranged	Dim Bright
Ugly-Beautiful	-	.691**	.843**	.639**	.870**	.512**	-.063
Hazy-Clear	-	-	.743**	.384**	.677**	.315**	.082
Uncomfortable Comfortable	-	-	-	.549**	.848**	.487**	-.079
Unpleasant Pleasant	-	-	-	-	.624**	.473**	-.133
Dislike Like	-	-	-	-	-	.498**	-.083
Poorly arranged Well arranged	-	-	-	-	-	-	-.085
Dim Bright	-	-	-	-	-	-	-
Ordinary Special	-	-	-	-	-	-	-
Non-functional Functional	-	-	-	-	-	-	-
Frustrating Satisfying	-	-	-	-	-	-	-
Great eye discomfort No eye discomfort	-	-	-	-	-	-	-
Depressing Stimulating	-	-	-	-	-	-	-
Visually cool Visually warm	-	-	-	-	-	-	-
Glare Non-glare	-	-	-	-	-	-	-

*. Significant at the .05 level, **: Significant at the .01 level

Correlation							
	Ordinary Special	Non- functional Functional	Frustrating Satisfying	Great eye discomfort No eye discomfort	Depressing Stimulating	Visually cool Visually warm	Glare Non- glare
Ugly-Beautiful	-.440**	.857**	.811**	.696**	.735**	-.185	.607**
Hazy-Clear	-.650**	.546	.650**	.590**	.645**	.020	.596**
Uncomfortable Comfortable	-.585**	.808**	.805**	.724**	.717**	-.058	.654**
Unpleasant Pleasant	.099	.696**	.607**	.494**	.498**	-.258*	.337**
Dislike Like	-.472**	.868**	.864**	.743**	.719**	-.183	.570**
Poorly arranged Well arranged	-.205	.546**	.480**	.261*	.358**	-.027	.321**
Dim Bright	-.105	-.122	-.060	-.088	.059	.081	-.025
Ordinary Special	-	-.295**	-.451**	-.536**	-.548**	-.183	-.413**
Non-functional Functional	-	-	.832**	.679**	.650**	-.183	.523**
Frustrating Satisfying	-	-	-	.688**	.724**	-.159	.527**
Great eye discomfort No eye discomfort	-	-	-	-	.664**	-.022	.433**
Depressing Stimulating	-	-	-	-	-	-.015	.561**
Visually cool Visually warm	-	-	-	-	-	-	-.078
Glare Non-glare	-	-	-	-	-	-	-

*: Significant at the .05 level, **: Significant at the .01 level

Table C2. Correlation table of regression analysis for 60 lux

Correlation							
	Ugly Beautiful	Hazy Clear	Uncomfortable Comfortable	Unpleasant Pleasant	Dislike Like	Poorly arranged Well arranged	Dim Bright
Ugly-Beautiful	-	.948**	.926**	.890**	.914**	.928**	.787**
Hazy-Clear	-	-	.957**	.933**	.939**	.933**	.797**
Uncomfortable Comfortable	-	-	-	.922**	.931**	.922**	.819**
Unpleasant Pleasant	-	-	-	-	.912**	.878**	.732**
Dislike Like	-	-	-	-	-	.906**	.741**
Poorly arranged Well arranged	-	-	-	-	-	-	.774**
Dim Bright	-	-	-	-	-	-	-
Ordinary Special	-	-	-	-	-	-	-
Non-functional Functional	-	-	-	-	-	-	-
Frustrating Satisfying	-	-	-	-	-	-	-
Great eye discomfort No eye discomfort	-	-	-	-	-	-	-
Depressing Stimulating	-	-	-	-	-	-	-
Visually cool Visually warm	-	-	-	-	-	-	-
Glare Non-glare	-	-	-	-	-	-	-

*: Significant at the .05 level, **: Significant at the .01 level

Correlation							
	Ordinary Special	Non- functional Functional	Frustrating Satisfying	Great eye discomfort No eye discomfort	Depressing Stimulating	Visually cool Visually warm	Glare Non- glare
Ugly-Beautiful	.798**	.902**	.897**	.954**	.875**	.781**	.201
Hazy-Clear	.804**	.919**	.906**	.946**	.884**	.795**	.182
Uncomfortable Comfortable	.837**	.910**	.893**	.915**	.893**	.778**	.154
Unpleasant Pleasant	.821**	.915**	.902**	.903**	.825**	.761**	.232*
Dislike Like	.774**	.900**	.892**	.933**	.871**	.777**	.175
Poorly arranged Well arranged	.740**	.883**	.880**	.942**	.848**	.794**	.249*
Dim Bright	.726**	.788**	.738**	.747**	.801**	.804**	.023
Ordinary Special		.856**	.816**	.747**	.778**	.643**	.173
Non-functional Functional	-	-	.894**	.893**	.831**	.757**	.171
Frustrating Satisfying	-	-	-	.905**	.816**	.793**	.222*
Great eye discomfort No eye discomfort	-	-	-	-	.863**	.812**	.164
Depressing Stimulating	-	-	-	-	-	.791**	.160
Visually cool Visually warm	-	-	-	-	-	-	.125
Glare Non-glare	-	-	-	-	-	-	-

*: Significant at the .05 level, **: Significant at the .01 level