THE IMPACT OF ART OBJECT COLOR AND STYLE ON MUSEUM VISITORS' CORRELATED COLOR TEMPERATURE (CCT) LIGHT PREFERENCES

A Master's Thesis

by

TUNA ZİŞAN EMİRTEKİN

The Department of

Interior Architecture and Environmental Design

İhsan Doğramacı Bilkent University

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The Graduate School of Economics and Social Sciences
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İhsan Doğramacı Bilkent University

by

TUNA ZİŞAN EMİRTEKİN

In Partial Fulfillment of the Requirements for the Degree of
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THE DEPARTMENT OF

INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN

İHSAN DOĞRAMACI BİLKENT UNIVERSITY

ANKARA

May 2018

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.

N. Olguntürk

Assoc. Prof. Dr. Nilgün Olguntürk

Supervisor

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.

Asst. Prof. Dr. Çağrı İmamoğlu

Examining Committee Member

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.

Asst. Prof. Dr. Elif Güneş

Examining Committee Member

Approval of the Graduate School of Economics and Social Sciences

Halime

Prof. Dr. Halime Demirkan

Director

ABSTRACT

THE IMPACT OF ART OBJECT COLOR AND STYLE ON MUSEUM VISITORS' CORRELATED COLOR TEMPERATURE (CCT) LIGHT PREFERENCES

Emirtekin, Tuna Zişan

MFA, Department of Interior Architecture and Environmental Design

Supervisor: Assoc. Prof. Dr. Nilgün Olguntürk

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The aim of this study is to understand the effect of art objects' color and style on museum visitors' CCT light preferences. In order to analyze both color and style of art objects' effect on museum lighting preference, a small exhibition room was designed. The study was conducted with three sample groups for three styles of paintings. Those styles were still life paintings, drip paintings and contemporary figurative art paintings with three color schemes for each style which are blue, red and neutral. Three CCT of light were used in the experiment which are 3000 K warm white, 4000 K neutral white and 6000 K cool white LED spots all at 200 lux illuminance. Besides the CCT preference, participants were asked to evaluate factors that would appropriately describe the exhibited objects, painting color and lighting relations. Those evaluative factors were warmth, brightness, comfort, pleasantness, naturalness and relaxation. The results showed that most preferred CCT of light was 4000 K for all styles and colors. The general indication that could be done about the CCT preference results is that visitors want to see warm color paintings under lower

CCTs while in case of cool color paintings the choice of visitors are towards higher CCTs. This preference tendency is the most significant on paintings that have facial depictions. According to the evaluative emotional states results, for all bipolar adjectives both color and CCT have an impact. The results of the study can be beneficial for museum curators, lighting designers and interior architects while designing a museum environment.

Keywords: Art Objects, Color, Correlated Color Temperature, Display Lighting, Museum Lighting

ÖZET

SANAT OBJESİNİN RENK VE STİLİNİN MÜZE ZİYARETÇİLERİNİN IŞIK RENK SICAKLIĞI TERCİHİ ÜZERİNE ETKİSİ

Emirtekin, Tuna Zişan

İç Mimarlık ve Çevre Tasarımı Yüksek Lisans Programı

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Bu çalışmanın amacı, sanat objelerinin renk ve tarzının müze ziyaretçilerinin ışık renk sıcaklığı üzerindeki etkisini anlamaktır. Sanat objelerinin müze ziyaretçilerinin aydınlatma tercihi üzerindeki etkisini hem renk hem de stil açısından analiz etmek için küçük bir sergi salonu tasarlandı. Çalışma üç farklı resim stili için üç farklı denek grubu ile gerçekleştirilmiştir. Deneyde kullanılan stiller mavi, kırmızı ve nötr renk opsiyonları ile natürmort resimler, damlatma resimler ve çağdaş figüratif sanat resimlerdi. Deneyde 3000 K (sıcak beyaz ışık), 4000 K (nötr beyaz ışık) ve 6000 K (soğuk beyaz ışık) LED spotlarla 200 lux aydınlık ile sağlanan üç farklı ışık sıcaklığı kullanılmıştır. CCT tercihinin yanı sıra katılımcılardan sergilenen nesneleri, resim renklerini ve aydınlatma ilişkilerini tanımlamak üzere seçilmiş faktörleri değerlendirmeleri istenmiştir. Bu değerlendirme faktörleri sıcaklık, parıltı, konfor, hoşluk, doğallık ve rahatlık olarak belirlenmiştir. Sonuçlar, tüm stil ve renkler için en çok tercih edilen ışık renk sıcaklığının 4000 K olduğunu göstermektedir. Ziyaretçilerin ışık renk sıcaklığı üzerine yaptıkları tercihlere göre, sıcak renkli resimlerin düşük ışık renk sıcaklığı, soğuk renkli resimlerin ise yüksek ışık renk sıcaklığı altında görülmek istendikleri belirlenmiştir. Bu tercih eğilimi en belirgin şekilde yüz tasviri içeren resimlerde gözlenmiştir. Duygusal durum gösteren faktörlerin hepsinin hem renk hem ışık renk sıcaklığından etkilendiği görülmüştür. Bu çalışmanın sonuçları bir müze mekanı tasarlarken müze küratörleri, aydınlatma tasarımcıları ve iç mimarlar için faydalı olabilir.

Anahtar Kelimeler: Işık Renk Sıcaklığı, Müze Aydınlatması, Renk, Sanat Eseri, Sergi Aydınlatması

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CHAPTER I

INTRODUCTION

A museum is a place where people understand the world, explore and learn about the past, present and future of creativity and discover history by using objects and ideas (Hume & Mills, 2011, p.275; Hunt, 2009). While presenting history through historical objects and presenting future and present through creative art objects; conservation, presentation and education are the main purposes (Berns, 2011). In here, lighting plays a significant role for the first two, conservation and presentation issues, in museum spaces. For the presented objects, it is required to have adequate illumination for detailed appearance, while it is a must that lighting is controlled not to damage them (Kurtay et al., 2003). In a museum space with its interiors and lighting design influence, the visitors' understand the presented artwork that lead them to comprehend the particular concept of that exhibition. Visitors' experience is positively affected from comfortable environments having appropriate lighting design (Lee, 2010). Thus, lighting designer should provide a solution of aesthetical and satisfying appearance for objects without damaging them. According to The Commission Internationale de L'Eclairage (CIE), the illumination of museum interiors must be in the range of 50-200 lx with respect to the sensitivity level of museum objects in order not to damage them and UV radiation below 400 nm must be eliminated. Also, there are limits for annual lighting exposures measured with lux-hours per year for objects (CIE, 2004). There is no specific CCT preference for museum lighting in CIE, but it is suggested to have high color rendering index (CRI).

Kruithof associated CCT and illuminance level with a curve called ‘Kruithof curve’ and proposed a ‘pleasing area’ for indoor lighting. (Rea,2000) With respect to this curve, lower CCTs at lower illumination levels and higher CCTs at higher illumination levels make pleasant feelings possible about interior lighting (Kruithof,1941). The contemporary application of pleasing illumination for interiors is based on Kruithof’s rule. Not to damage presented objects in museum interiors, higher illuminances are not preferred in display areas especially for having the ultraviolet (UV) and infrared (IR) spectral components (Cuttle,2000). For both appearance and conservation issues of museum lighting, LED lighting is the most suitable option for the displays because of its individual characteristics of having next to none IR and UV radiation (Zhai et al., 2015).

When CIE guidelines and Kruithof’s rule are analyzed together, required low illumination level of museum interiors must combine with lower CCTs range between 2700-4000K (Chen et al., 2016). Nevertheless, in museum spaces art preservation is crucial but not the only concern, so this low illumination-low CCT combination for display lighting may not be suitable for general museum lighting concerns.

When the concern is appearance of the exhibits, it can be important to produce spaces through intentions of the artist or more basically preference of the observer's. Observers' preferences are affected by naturalness and variety of colors, but also this interaction give signals about illumination effect on art object's impression (Pinto et al., 2008).

1.1. Aim of the Study

The study aims to measure whether there is a preference difference in museum lighting between CCT of lighting and color scheme and style of the painting. In the literature, although there are many experimental studies based on illumination preference in museums, there is no significant research to analyze CCT preference over both color scheme and style of the paintings. The study also aims to understand effect of the CCT on the selected evaluative bipolar adjectives which are warm-cool, natural-unnatural, relaxing-tense, pleasant-unpleasant, comfortable-uncomfortable, bright-dark. So, this study aims to fill the gap in the literature. The findings of the study can be useful for museum curators, lighting designers and interior architects while designing a museum environment.

1.2.Structure of the Thesis

This thesis contains four chapters. The first chapter is the introduction, the museum environment, lighting issues, importance of CCT in museum environment and lighting design criteria for museum areas are briefly indicated. In addition, the aim of the study and the structure of the thesis are stated in this chapter.

In the second chapter, lighting and color in museum environment are investigated. Psychological effect of museum on the visitors and a whole museum experience are explained. The general information about lighting design terms which are illuminance, luminance, color rendering index and correlated color temperature are clarified. Relation between correlated color temperature and illuminance level are discussed in the structure of pleasant interior lighting and more specifically proper lighting design of museum spaces. Main features of museum lighting and CCT preference observations in previous studies are discussed. In this study, color is also an important concern, so color basics and color order systems are briefly indicated. Finally, review of museum lighting studies are clarified.

Third chapter is the methodology part that explain the aim and the method of the study. With the research questions and hypothesis of the study, the aim of the study are defined. The method of the study is stated with the explanation of the sample group, setting of the experiment, sets of the experiment and experimental procedure. In the experimental procedure part, how the designed museum room is generated, how lighting arrangements are done, the selected paintings and sessions of the experiment are explained in detail. Participants' demographic information, statistical analysis of all data and evaluation of the data are explained. Finally, the findings are examined and compared with results of previous works in the literature.

In the fourth chapter, conclusion of the study are signified. Moreover, limitations and suggestions for further research are given.

CHAPTER II

LIGHTING IN MUSEUMS AND COLOR

2.1. Museum Experience and Psychology in Museums

A museum is an institution that helps people investigate and find out about past, present and future and understand the world by using objects and ideas (Hume & Mills, 2011, Hunt,2009). According to Goulding, museum and art gallery visitors come to the exhibition environment to become socialized, experience the nature and customer service besides experience the exhibited work (2000). Visitors go to the museum mainly with the aim of social-recreational reasons, educational reasons and reverential reasons. (Graburn 1977; Falk and Dierking 1992). Museums are designed to present historical objects that visitors educate themselves with or creative art objects that visitors enjoy and renew their minds. Thus, a visitor coming to a museum environment anticipate to find an experience with enjoyable, educational and peaceful aspects (Paulino, 2013). Approaching the museum space beyond educational considerations and engaging in restorative aspects make contribution to health and welfare of museum visitors (Packer & Bond, 2010, p. 432). The museum space must be designed comfortable enough for visitors spend more time, educate themselves, interact with others and have intellectual conversations (Gurian,2005). Museum spaces must also be restorative with the meaning of “the process of renewing physical, psychological and social capabilities diminished in ongoing efforts to meet adaptive demands” (Packer & Bond, 2010). The words restoration also refers to “the experience of a psychological and/or physiological recovery process that is triggered by particular environments and environmental configurations.” People improve their health and can be away from their tense lives with the help of restorative environments. As reported by Packer and Bond, people are in search of a place to restore themselves.

For perception and interaction with the museum environment, physical characteristics of the space is important. It is essential for visitors to create meaningful experiences and obtain satisfying outcomes from the museum space (Lee, 2010). According to Newman, the museum building effect the way visitors experience the presented objects, in other words the museum building can be regarded as the work of art itself (1991). Crowding level, scene setting and circulation mapping are important aspects that affect relation between museum visitor and museum environment. Beginning from the entrance of the space, location decisions of the area and mapping and signage of the environment must be clearly defined to provide a distressful space for visitors and let them more focus on the exhibited work. Signage of the circulation, descriptive labels and informative wall texts are crucial for true perception of the museum environment. Inadequacy of informative labelling, lessen the positive perception of the visitors (Gurian,1991). In a museum space with its interiors and lighting design influence the visitors’ understanding on the artwork that presented and lead them to comprehend the concept of the exhibition itself. In 2010 Lee stated that, visitors' experience is positively affected from comfortable environments with appropriate temperature, seating arrangement and lighting design. These aspects influence visitor's emotional, cognitive and physiological responses to the designed space (Packer, 2008). According to the results of his research, appropriate lighting design is suggested in museum environment and it is concluded that inadequate lighting design interfere with the pleasure visitor get from the exhibitions. According to Gurian, visitors of museums can spend more time in the museum space under favour of the design layout of the space. The museum space must be both comfortable and alluring. To provide such a space, open air connections of the interior circulation areas must be well defined and lighting design of the environment must not be disturbing (Gurian, 2005).

2.2. Lighting in Museums

Light can be considered as the focal concept of visual experience and architecture, because it enables people to see and interpret the environment. The physical qualities of the environment cannot be noticed without presence of light (Egan & Olgyay, 2002). Lighting design of an interior space affect its' users both physiologically and psychologically, so light is a very important architectural element that should be considered well to have better quality environments (Karlen et al., 2017).

2.2.1. The Luminous Environment

A museum is a place where people understand the world, explore and learn about the past, present and future of creativity and discover history by using objects and ideas (Hume & Mills, 2011; Hunt,2009). While displaying objects one of the most important issues is light. In a display environment, the place of light is indispensable for creating a museum place to discover and learn for visitors and also preserving the artwork (Hunt,2009). With respect to visualization and conservation issues, museum and art gallery lighting has its own specific requirements (Pinto et al., 2008). Display lighting affects different professionals such as administrative staff of museum, museum curators, designers and visitors of the museum. There are expectation differences and different concerns among these groups about lighting decisions. For example, administrative staff of museum want to have a sustainable and economic lighting system, while designers demand firstly to achieve clear object form. Meantime, for the museum curators detrimental effect of the lighting is the major concern, because colored surfaces of artworks can be damaged by visible and invisible radiation of lights. On the other hand, visitors are most concerned with object form and perception of true color. Successful and competent museum lighting must consider each groups' considerations. Lighting design is a collaborative art (IESNA, 1996).

In order to discuss effect of art objects' color and style on CCT light preferences of museum visitors, first understanding the main elements of lighting is important.

Lighting parameters such as the **color rendering index**, **correlated color temperature**, **luminance** and **illuminance** are extremely important aspects of the museum lighting environment (IESNA, 1996).

Luminance and illuminance are the two major properties of light. **Luminance** is the intensity per unit area radiated by a surface in a given direction. It is measured with cd/m2. **Illuminance** is the density of the luminous flux incident on a surface; it is the quotient of the luminous flux by the area of the surface (IESNA, 1996). It is measured in lumens per square meter, lux. Lux can be measured with an illuminance meter (Egan & Olgyay, 2002).

According to The Commission Internationale de L'Eclairage (CIE), the illumination of museum interiors must be in the range of 50-200 lx with respect to the sensitivity level of museum objects in order not to damage them. According to IESNA guidelines, accessible lighting levels for museums range from 50-300 lux according to the exhibit and lighting type (1996). High sensitivity materials like paintings, watercolors, manuscripts and colored silk having sensitive pigments are recommended to lit illuminance level up to 50 lx, while medium sensitivity materials such as wood, leather and canvases should be illuminated up to 100 lx. In case of low sensitivity materials lux level can be raised to 300 lx (See Table 1). If the object is stone even daylight could be used which has much higher levels of illuminance.

Table 1. Recommended lux level in museums according to sensitivity of the objects (Sylvania, 2015)

Material/Exhibit	Sensitivity	Recommended Lux Level
Costumes and other textiles, fur and feathers, dyed leather, prints, drawings, watercolours, stamps, manuscripts, coloured, old photographs, miniatures, transparencies, and unprimed thinly coloured paintings on canvas	High	50 Lux
Oil and tempera paintings, lacquer ware, plastics, wood, furniture, horn, bone, ivory, undyed leather, minerals and modern black and white photographs	Medium	100 Lux
Stone Ceramic, Glass and Metal	Low	300 Lux

Light contains UV and IR radiations and while former one causes pigment photodegradation, latter one produces heat. For protecting unwanted effects of these radiations, UV and IR light must be filtered, illuminance level must be controlled and light exposures of artworks must be limited (Pinto et al, 2008) (See Table 2).

Table 2. Limiting illuminances and annual exposures for material sensitivity classifications

(Source: http://www.kolumbus.fi/jold/tiedostot/museumlight.pdf)

Material classification	Examples of materials	Limiting annual exposure
a) Insensitive	metal, stone, glass, ceramic	no limit
b) Low sensitivity	canvases, frescoes, wood, leather	600 000 lxh/a
c) Medium sensitivity	watercolor, pastel, various papers	150 000 lxh/a
d) High sensitivity	silk, newspaper, sensitive pigments	15 000 lxh/a

Color rendering is another major factor that should be considered when lighting museums and galleries. **The Color Rendering Index (Ra)** gives a general indication of the rendering ability of a light source (CIBSE, 1994). The Color Rendering Index

(Ra) is the measure of how well the light source renders color. The higher the CRI, the better the light source render true and natural color of the object (IESNA,1996). A CRI of 100 means true color rendering, while those over 80 are considered good. Museum curators aim to have an object appear as ‘natural’ as possible when illuminated (See Figure 1). Good color rendering is significantly essential when the viewing true color of the object is important especially in the case of paintings (Philips Lighting Manual, 1986). With good color rendering, in addition to natural appearance of color, discrimination of similar colors are also achieved (Rea, 2000; van der Burgt & van Kemenade, 2010).

Figure 1. Color Differentiation under Different CRI values

(Source: Sylvania, F. (2015) Lighting for Museums and Art Galleries)

Correlated color temperature of a light source is defined in the Planckian Locus with chromaticity coordinates of the light. It means blackbody temperature of the Planckian radiator (McCamy, 1992). According to the Planck’s law of radiation, blackbody features at distinct temperatures are described. With the rise of the color temperature, light of the color show an alteration from warm to cool as such reddish to bluish (Rea, 2000). In the planckian locus diagram, color temperature is determined with a chromaticity point. Absolute temperature in Kelvin degree of the black body which gives the light source color is the correlated color temperature (See Figure 4). The correlated color temperature is not spectral power distribution of the light source nor the physical temperature. It describes coolness and warmth of the light for the appearance (Egan & Olgyay, 2002).

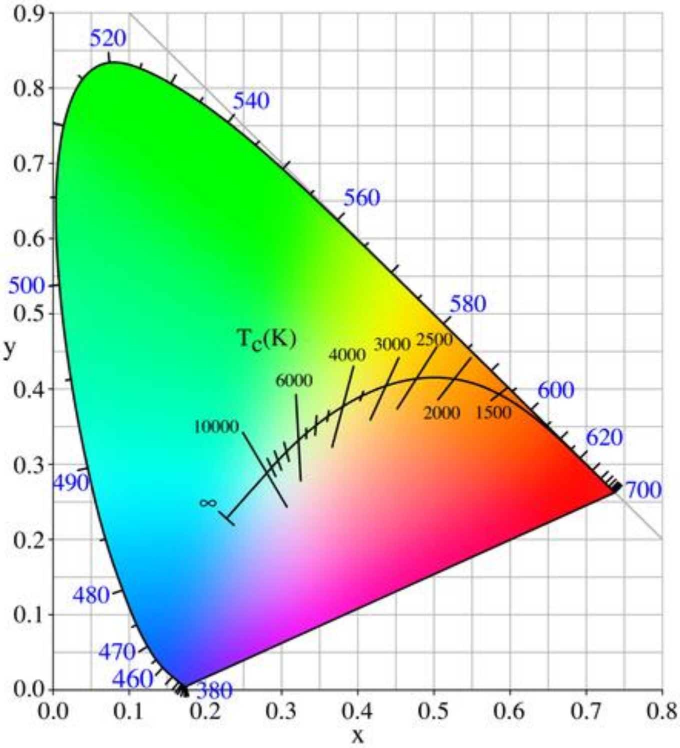


Figure 2. Black body locus on CIE chromaticity diagram

(Source: https://www.led-professional.com/resources-1/articles/guidance-on-specifying-solid-state-lighting-luminaires)

Blue appearance of the light source increases with higher color temperature, while with the lower color temperature the appearance is red (Katsuura, 2000). In this study 3000 K, 4000 K and 6000 K are used since 3000 K signify warm white light, 4000 K signify mid- range neutral white and 6000 K means daylight white (See Figure 2).

Table 3. A chart demonstrates specifications of correlated color temperature (Source: http://www.westinghouselighting.com/color-temperature.aspx)

	2000-3000K	3100-4500K	4600-6500K
Color Temperature (KELVIN)	2000K - 3000K	3100K - 4500K	4600K - 6500K
Light Appearance	Warm White	Cool White	Daylight
Ambience	Cozy, calm, inviting, intimate	Bright, vibrant	Crisp, invigorating

Traditional standards determine the illuminance level of a museum environment between 50 and 300 lux with a relatively warm CCT of 3000K. These limits have been accepted solely true for the basis of surveys by a set of major museums. Low illuminance levels are better for artwork preservation and common spectrum is decided by accessible light sources (Scuello & Abramov, 2003). Kruithof worked with CCT and illuminance level to define pleasing combinations of these two for interior lighting. For ‘pleasing area’ Kruithof proposed that higher illuminance level with higher CCT and lower illuminance level with lower CCT are required (Scuello et al. ,2004) (See Figure 3).

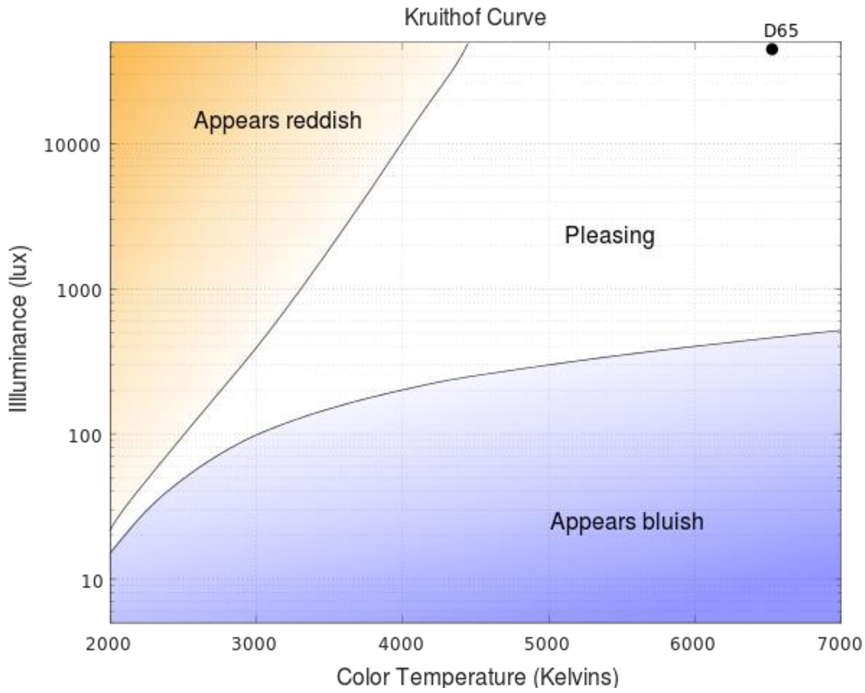


Figure 3. A diagram showing the Kruithof Curve

(Source: https://en.wikipedia.org/wiki/Kruithof_curve)

The contemporary application of pleasing illumination for interiors is based on Kruithof's rule. According to him the color temperature of the light change according to the illuminance level. For an illumination scenario of 50 lux, the color temperature must be ranged between 2200-2500 K, while from 2000 lux the color temperature range between 3500 K to 10.000 K. The common application of 200 lux is 3000 K. However Kruithof did not straightly work with the museum lighting, he worked for defining optimal lighting for interiors with the aim of best cool or warm color temperature. Some current studies done to validate Kruithof's study for interior lighting are contradicted with the Kruithof's finding. Oi and Takahashi examined several combinations of CCT and illuminance for different domestic activities such as dining, cooking, studying and resting (2007). They resulted that the CCT and illuminance combination preferences depend on the specific activity and case. Also they concluded that Kruithof's rule is not appropriate when studying with especially relaxing activities.

2.2.2. CCT Preference Observations

In the literature, there are various works that focus on correlated color temperature of light. Pardo et al. (2014) worked on effect of CCT on color discrimination. They worked with 14 color samples from Farnsworth-Munsell 100 Hue test and 7 participants who evaluated these samples under six different CCT of light which are 2800, 3800, 5000, 6500, 7800, and 9700 K. Subjects saw the juxtaposed FM100 test samples from 50 cm distance and they were questioned if the colors of the samples were different from each other under different CCT conditions. The color discrimination success rate was at the maximum for 5000 K with the percentage of 88.6. The average correct answer ratio of all lighting conditions was 84%. While designing an interior if the color discrimination is an important design input, this data can be used.

Another research conducted by Dangol et al. (2013) focused on naturalness preference of people according to the LED and fluorescent lamp spectral power distributions at CCT of 2700 K, 4000 K and 6500 K. They used a three partition light booth which was coated with matte gray paint. They experimented with 24 different spectral distribution conditions at CCT of 2700 K, 4000 K and 6500 K. As evaluated objects they chose a Coke can, a smartphone, a picture, a wooden sample, printed texts and Macbeth Color Checker (MCC) chart and total 60 subjects were participated in the experiment. Subjects made comparative evaluations on different spectral distributions and CCT conditions. For 2700 K, different spectras of fluorescent lamp and LED, subjects mostly chose fluorescent lamp for naturalness and preference with the evaluated objects and difference results between these lamps were statistically significant. For the evaluation of 4000 K and 6500 K, according to the evaluative objects preference between LED lamp and fluorescent lamp varied. Another result from the study was, color rendering index of the light did not describe the naturalness of the evaluated objects and preference.

Baniya et al. (2015) worked on favored combination of CCT and illuminance level of the office environments. They experimented with fifty three observers and nine different lighting conditions which are combinations of 3000 K, 4000 K and 5000 K and 300 lux, 500 lux and 750 lux. They concluded that CCT was more significant than a higher illuminance level for supplying a better visual impression with lighting. For pleasantness, visual comfort and naturalness the preferred lighting conditions were 750 lux with 4000 K CCT. It was also stated that the brightness perception increased with a higher CCT. Compared to a lower CCT, with a high CCT arousal of people also increased.

The study conducted by Kim et al. (2015) experimented brightness perception of subjects under different CCT conditions of LED light. They concluded that, under same illuminance level, higher CCT are perceived brighter than a lower CCT level.

Another study was conducted by Manav (2007) who worked on the appraisal of the visual environment at offices in relation to color temperature and illuminance. For the illuminance level she used 500, 750, 1000 and 2000 lux and for the CCT levels of light 2700 K and 4000 K were used in the experiment. The illumination level and CCT were tested independently controlling one variable while testing the other. According to the results, as illumination level increases comfort and spaciousness levels of subjects increased. Also, with the rise of illumination level, brightness perception and subjective impressions except relaxation had a positive impact on participants. For the comparison of the CCT levels, it was found that 2700 K was preferred for relaxation while 4000 K was chosen for comfort and spaciousness. In addition to these, the results showed that particularly warm colors were noticed as more saturated at 2700 K than 4000 K.

According to Huang et al. (2017), with a higher CCT at the same luminance discomfort glare of the subjects increased.

The study conducted by Huang et al. (2015) investigated the effect of correlated color temperature on focused and sustained attention with white LED light conditions. They worked with three different CCT conditions which are 2700 K, 4300 K and 6500 K. Beyond focused and sustained attention, in this experiment comfort and clarity issues depending on the CCT were also tested. According to the results, there was not a significant difference among the CCT levels with respect to the comfort issue, while for the clarity there was an increase with the rise of the CCT level.

According to the study of Ju et al. (2011) which experimented with nine lighting combinations of 3000 K, 5000 K, 8000 K and 100 lux, 300 lux, 500 lux on spatial brightness perception, with the rise of correlated color temperature, spatial brightness perception of subjects also increased.

Hong et al. (2017) worked with colored samples to evaluate visibility characteristics of objects under LED light with different correlated color temperature. According to their results, at lower CCTs visibility of red color is good while purple, blue, blue green, green and green yellow colors have good visibility under higher CCTs with higher brightness perception. Also, for warm colors such as red, yellow and yellow red higher color visibility can be achieved with lower CCTs while brightness perception is relatively low.

In the study of Wang et al. (2016) the influence of correlated color temperature of light on comfort and preference of the subjects for LED lighting was investigated. They used twelve CCT conditions from 2000 K to 100000 K and three illuminance levels which were 350lux, 500 lux and 1000 lux. They concluded that, lower CCTs were preferred for relaxing activities and chosen as more comfortable, while for working activities higher CCTs were considered comfortable and preferred.

Masuda and Nascimento (2013), worked with commercial food counters that include fruit, vegetables and meat to evaluate subjects' naturalness and preference inclination for lighting conditions. They used hyperspectral images of the food counters to ask the subjects and they concluded that subjects found 6040 K as most natural and 4410 K as most preferred.

Vienot et al. (2009) worked on effect of CCT and illuminance level on visual responses of the subjects. They used three different CCTs which are 2700 K, 4000 K and 6500 K and three different illuminance levels namely 150, 300 and 600 lux. In their experiment, they examined with subjective scales of brightness, clearness, glare, pleasantness, comfort, relax, warmth, cheerfulness and color rendering. According to mean results of 20 subjects, at all illumination levels higher CCT was perceived as brighter and clear, while in case of pleasantness, relax, warmth and comfort lower CCTs were preferred more.

In a research conducted by Liu et al. (2017) the effect of different correlated color temperature on color preference were examined. They used LED lights to illuminate selected objects with different CCTs and subjects were asked to evaluate these objects and lighting conditions by a 5 level ranking and 7 point scale method. The 9 CCT were ranged between 2500 K and 6500 K. They used a variety of objects which are different colored fruits and vegetables, Chinese calligraphies with different colors, mural painting, a Van Gogh painting, a Chinese traditional painting, modern oil painting and multicolor flowers. The illumination level was fixed at 200 lux of all cases. They stated that light, object and the observer affect the color preference and concluded about that the light is the most significant factor of all. According to the mean values of the 7 point scale for red, green and multicolor fruit and vegetables the most preferred CCT was 4500 K while for the yellow fruit and vegetables it was 5500 K. For orange, white, light white and yellowish white Chinese calligraphies CCT of 3500 K was preferred mostly while for red calligraphy 4500 K was chosen mostly. For multicolor flowers and modern oil painting composed of mostly cool colors most liked CCT was 5500 K while for mural painting with neutral colors the most liked CCT was 3500 K. Van Gogh painting and Chinese traditional painting was in the color of green and yellow and they evaluated in 5 level ranking method and the top ranked CCT of two was 4500 K. They stated that people prefer cool and higher CCTs for cool and cold colors while they prefer a warm and lower CCT for warm colors. They also indicated that people mostly choose lighting conditions that enable the objects to be seen more saturated.

Table 4. Review of the CCT Preference Studies

Authors	Subject	Results
Pardo et al. (2014)	Color Discrimination	The color discrimination success rate was at the maximum for **5000 K**.
Dangol et al. (2013)	Naturalness Preference	Color rendering index of the light did not describe the naturalness of the evaluated objects and preference.
Baniya et al. (2015)	Favored Combination of CCT and illuminance	For pleasantness, comfort and naturalness preferred lighting condition was **4000 K** at 750 lux. Brightness perception increased with a higher CCT.
Kim et al. (2015)	Brightness Perception with Different CCTs	Under same illuminance level, **higher CCT** are perceived brighter.
Manav (2007)	Appraisal of the Visual Environment at Offices	**2700 K** was preferred for relaxation, **4000 K** was chosen for comfort and spaciousness. Warm colors were noticed more saturated at 2700 K than 4000 K.
Huang et al. (2017)	Discomfort Glare with LEDs	With a **higher CCT** at the same illuminance, discomfort glare increased.
Huang et al. (2015)	Effect of CCT on Focused and Sustained Attention	There was not a significant difference among the **CCT levels** with respect to the comfort issue.
Ju et al. (2011)	Spatial Brightness Perception	With the **rise of CCT**, spatial brightness perception of subjects increased.
Hong et al. (2017)	Visibility Characteristics of Objects under LED light	With **lower CCTs** visibility of warm colors are better. Brightness perception is relatively low at **lower CCTs**.
Wang et al. (2016)	Effect of CCT on Comfort and Preference	**Lower CCTs** were preferred for relaxing activities, while for working activities **higher CCTs** were considered comfortable.

Table 4 (cont'd)

Masuda and Nascimento (2013)	Naturalness and Preference with Lighting	**6040 K** was found as the most natural and **4410 K** as most preferred CCT.
Vienot et al. (2009)	Effect of CCT and Illuminance on Visual Responses	**Higher CCTs** was perceived as brighter and clear, while in case of pleasantness, relaxation, warmth and comfort **lower CCTs** were preferred more.
Liu et al. (2017)	Effect of CCT on Color Preference	Light, object and observer affect the color preference and concluded about that light is the most significant factor of all. **Higher CCTs** were preferred for cool colors while **lower CCTs** were chosen for warm colors.

2.2.3. Museum Lighting Basics

In exhibition context, presentation requires to be the most interesting and appealing work regardless of the focus that can be technology, history, art or science. To build visual experiences in an exhibition, lighting design plays a significant role. Lighting design adjusts and emphasizes the visual landscape, it increases the effect of displayed items. Ambiance of the exhibition must not raise the feeling of dullness and it should excite people (IESNA,1996). For the amusement of art and spatial impression, lighting is essential. According to the different needs of the exhibition, different lighting applications can be designed by using different colors of light, beam angles, luminaire arrangements and lamp specifications. While designing the exhibition, lighting conservation issues must not be forgotton. In any exhibition area, light exposure of the presented object is an important matter (Raynham et al., 2012).

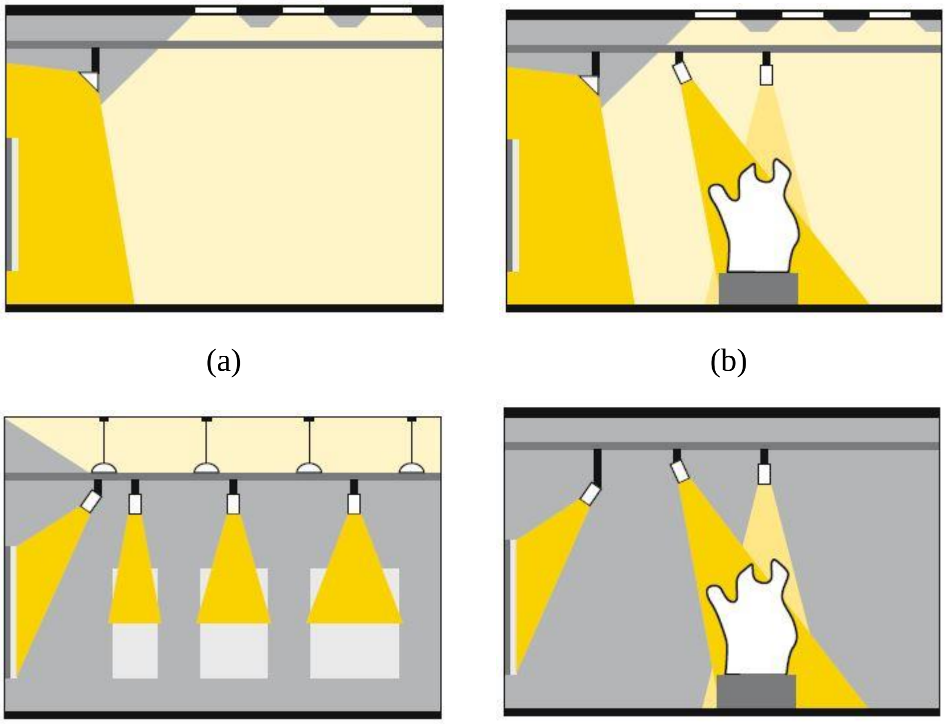
Besides the display function of a museum, it is a place where people search and artworks are collected, conserved and administered. Museum staff can productively work in an appropriate lighting condition. Also, lighting attracts notice in the circulation environment and decreases the danger of accidents. Even though the critical issue in exhibition context is display lighting, functional lighting is also a design issue in museums (FGL, 2015).

There are many parameters to design lighting of the exhibition area. The most critical among these parameters is architecture of the building which the lighting design must be compatible (Gurian, 2005). Proportions of the area, interior design, selected colors, daylight properties and intended ambiance of the exhibition are the other important factors. In an exhibition area, because the exhibits are repeatedly changed the lighting installation must be flexible and support different display choices (Philips Lighting Manual, 1986).

Diffuse and directional or accent lighting are used to illuminate exhibition areas (See Figure 7). Harmonious use of these lighting systems specify the volume and distribution of the shadows on pictures and also three dimensional effect of sculptures. The overall effect of the exhibition space is also an outcome of using proportion and shape of diffuse and directional lighting (FGL, 2015). There is a distinction between overall illumination of the room and specific lighting of the exhibit. Diffuse lighting is used for general illumination of the space, but this may not satisfy the lighting requirements of the exhibition. So, directional or accent lighting is used to illuminate exhibited objects specifically (Karlen et al., 2017).

To illuminate individual items on the exhibition, rigid directional lighting is used. As a supplementary lighting with this directional lighting a soft diffuse lighting is also used. If a particular dramatic impression is desired, spot lighting can be used for the exhibits (Zumtobel, 2017). However, for an arousal spatial impression of the exhibition space, diffuse lighting and directional lighting must be used harmoniously. Diffuse lighting illuminates whole space or objects from an illuminant system that radiates light in all directions (Oksanen & Norvasuo,2011). The lighting source direction cannot be apparently decided at the illuminated area, because the light into the illuminated space is not directional, it comes from all directions and the light generates almost no shadowing (Egan, 1997).

Directional lighting is mostly produced by small and punctual luminaires and spots with a small distance to the illuminated object (Boer & Fischer, 1981). Light rays fall straight to the illuminated object and reveal shadows. With directional lighting, a focal illumination is achieved for the two or three dimensional object. According to the needs of the exhibitions usage proportions and lighting design of the diffuse and directional lighting is differed (FGL, 2015).



(a) (b)

(c) (d)

Figure 4. a) Diffuse lighting for the room, directional lighting for the wall b) Supplementary directional lighting for objects in the room c) Indirect and direct illumination d) Directional Lighting (Source: http://en.licht.de/fileadmin/Publications/licht-wissen/0703_lw18_E_light_museums_galleries_web.pdf)

The most used lighting systems in exhibition spaces are luminous ceilings, diffuse lighting by indirect luminaires, cove lighting, wallwashers and accent lighting with spots.

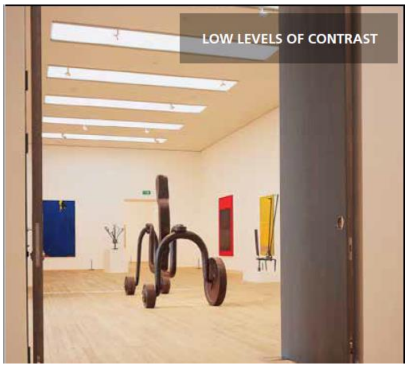
In exhibition spaces, regarding conservation issues illumination with daylight is very restricted. The idea to use luminous ceiling is to pretend the daylight. Luminous ceilings can be an appropriate choice for museums especially painting galleries. It emits a diffuse lighting over the entire area (Sylvania, 2015). Generally, fluorescent tubes are used for luminous ceilings and because it can constitute dark areas between the lamps, the distances and placement of the lamps are important to decide (Egan and Olgyay, 2002). The contrast ratio between walls, floors and ceiling must be appropriate to avoid discomfort glare in luminous ceilings (Boer and Fischer, 1981).

With indirect luminaires, an identical effect of a luminous ceiling can be achieved. A uniform diffuse light is obtained with this lighting and it is mostly used in spaces with no daylight. Indirect lighting is acquired with luminaires that illuminate the light upwards. Suspended rail systems can be a choice for indirect luminaries, while spots for accent lighting are placed at a lower level (Philips, 2000). Another diffuse lighting or ambient luminescence solution for museum lighting is cove lighting. With a proper placement of cove on the wall, a diffuse lighting situation can be achieved from the ceiling. Illuminated ceilings can give people a sense of orientation and a diffuse light from ceiling can reduce the adaptation difficulty between the brightest direct light and the rest of the place. However, enormous amount of luminance from ceiling may cause glare and should be prevented for accurate perception of the space. For cove lighting fluorescent tubes are widely used (Egan,1997)

Wall washing is a continuous and even illumination over a wall area (Egan, 1997). Different luminaires can be used as wallwashers such as fluorescent, compact fluorescent halogen lamps. The choice of the light source is related with measurements of the area, light intensity and requested texture level (Egan and Olgyay, 2002). For emphasizing the texture on the wall, the placement of the luminaire must be close to the wall surface (Bean, 2004). For the artwork illumination grazing is not an appropriate choice, because the distance between the wall and the luminaire is too close and only the upper part of the artwork can be illuminated (Egan, 1997). Wall washing can be achieved with both continuous arrangement of light and individual luminaires. By using continuous arrangement of light a diffuse-directional lighting is obtained and at the edges of the two dimensional objects on the wall shadows will occur (Bean, 2004). Individual luminaires or point sources for wall washing create a scallop effect and uneven distribution of light. The created scallops must be in coordination with design of the wall and in museum case placement of the artwork (Egan & Olgyay, 2002).

If a particular dramatic impression is desired, spot lighting can be used for the exhibits. With the appropriate beam angle, spots are the most used lighting fixtures in museum and art gallery environment (Boer & Fischer, 1981). With spot lighting, a focal illumination is achieved for the two or three dimensional object. By means of using spot light, brightness of the illuminated area is above the rest of the space. (FGL, 2015).

For visual performance, contrast, brightness, adaptation and glare are important factors. Contrast is the ratio between the luminance of the object and the luminance of the background (Egan and Olgyay, 2002). Luminance ratio or brightness perception is significant for comfortable museum lighting. Having a proper contrast ratio with no shadows and avoiding as much glare as possible are main objectives (Rainer and Hilger, 2004). For creating bright and spacious interiors and let people to perceive the space as a whole low levels of contrast are applicable. On the other hand, with high levels of contrast more concentrated and focal points are created in the whole area and this builds a more theatric environment (Sylvania,2015) (See Figure 5).



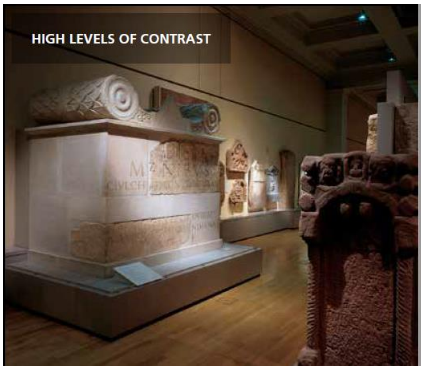


Figure 5. Different levels of contrast in the exhibition environment (Source: http://en.licht.de/fileadmin/Publications/licht-wissen/0703_lw18_E_light_museums_galleries_web.pdf)

In the museum environment the displayed objects must be the brightest element in the perception area. According to Cuttle, for noticeable perception of the focus the contrast ratio must be 1.5 to 1, for a distinct perception it must be 3 to 1, for a strong perception it must be 10 to 1 and 40 to 1 for an emphatic perception of the focal object (2008). According to Sylvania, the contrast ratio advised for the museum spaces is 6 to 1 and 2 to 1 for the art galleries (2015).

Under bright lighting conditions, human eye must adapt itself to the different lighting levels. The amount of time that it takes a human eye adapt to different lighting conditions is called adaptation (CIBSE, 2004). Accommodation is the ability of human eye to change its shape to focus on objects. Depending on visual impairments and age of the visitors in museum, illuminance differentiation may influence adaptation and accommodation of people (Hunt, 2009). According to IESNA, eye can adapt between high to low illuminance levels in eight minutes in normal conditions while one hour for extreme conditions (1996). With the decrease of size of objects, more light is essential to see details of these objects. The human eye is capable of responding to light, however while illuminating a museum environment passing through one luminance to another, the amount of difference is significantly important.

“Glare is the bright light that can interfere with visual perception” (Egan and Olgyay, 2002). Discomfort glare does not prevent visibility action, however it creates uncomfortable situations. Disability glare restrict the visibility action required for task performance (Egan, 1997). In museum environment, glare can create serious visual problems and cause a decrease in spatial perception. In the exhibition environment it is important to diminish or remove glare (CIBS, 1980).

The most current types of museum lighting are natural daylight, tungsten halogen lamps and fluorescent lamps. Also modern light sources such as SoLux lamps with different CCT and white LED lamps are commonly used for display lighting (Pinto et al, 2008). LED lighting has many advantages over fluorescent, halogen, gas and incandescent lamps. Traditional lamps, even with protective filters, can damage exhibits in museums very quickly. LED technology however, does not create IR and UV light and is therefore ideal for sensitive environments such as galleries and museums. (Sylvania, 2015) LED lamps have lower power consumption and longer lamp life than the other lamps (Hong et al., 2016). For both appearance and conservation issues of museum lighting, LED lighting is the suitable option for the displays because of its individual characteristics of having little IR and UV radiation. (Zhai et al., 2015) With the improved technology, LED lamps with high color rendering, a wide range of beam angles and color temperature can be found (Sylvania, 2015).

2.3. Review of Museum Lighting Studies

In the literature, there are many studies that focus on museum lighting design, color, correlated color temperature and LED lighting in museum environment. Pinto et al. (2008) worked on most preferred correlated color temperatures for the illumination of artistic paintings. They used 11 oil paintings and with hyperspectral data the paintings were digitalized. The CCT of light ranged between 3600 K and 25000 K. According to the results of 80 subjects, the most preferred CCT for illuminating artistic paintings was found to be 5100 K.

In a study conduct by Masuda and Nascimento (2014), they examined best lighting option for artistic paintings. They evaluated the lighting condition both on real and monitor conditions with 11 oil paintings. Their CCT choices ranged between 3600 K and 20000 K. They concluded that for the real museum conditions the most preferred CCT for the painting was 5500 K while in the monitor viewing similar to the real condition the most preferred CCT was 5700 K. This indicated that the best lighting for artistic paintings was found to be higher than traditionally used in museums.

The study conducted by Chen et al. (2016) evaluated museum lighting environments to define proper combinations of CCT and illuminance. They used 9 oil paintings illuminated by LED lamps with CCT range 2700 K to 5000 K and illuminance level with 50 to 200 lux. They made two different experimentation setup which included a light booth experience and a real museum experience. The evaluative adjective pairs were used in the experiments which were high visibility/low visibility, comfortable/ uncomfortable, colorful/dull, relaxing/tense, bright/dark, pleasant/unpleasant, clear/

blurry, natural/unnatural, warm/cold, soft/hard, active/passive, classic/modern and lively/boring. With the evaluative results they reduced the emotional scales into two groups: visibility and warmth. They concluded about emotional scales that illuminance was in a correlation with visibility issue while CCT was correlated with warmth. According to this the emotional scales related with appearance like comfortable-uncomfortable, clear-blur, bright dark were influenced by the illuminance while warm-cold and soft-hard were inconsiderably in a relation with the illuminance but in correlation with the CCT. Also, their study partly concurred with the Kruithof's rule. Their results included a pleasant area of 2700 K-4000 K with 100 to 300 lux and 3000 K-5000 K with 150 to 500 lux in concurrence with Kruithof's curve.

A study conducted by Scuello et al. (2004) focused on the museum lighting and especially correlated color temperature. They used three light booths that were separated from each other with a partition illuminated by 200-250 lux illuminance and 11 different correlated color temperatures ranged between 2500 K and 7000 K. They used postcard reproductions as evaluative paintings in the light booth. According to CIE chromaticity diagram two violet blue and two yellow red postcards were used. The most preferred CCT of all conditions was 3600 K for this study, but there was a relation between illumination and dominant color of the painting. The cool colored paintings had a positive perception under cooler color temperatures, while warm colored paintings under warm color temperatures were more liked by observers.

Luo et al. (2013) conducted a study about museum lighting environment. They used three different illumination levels which were 50, 150 and 300 lux and five correlated color temperatures ranged between 2700 K and 6500 K in a light booth. They used 11 emotional scales and with the results they reduced them into two: visibility and warmth. They concluded about the study that pleasantness would rise with higher illuminance while brightness, clearness and coolness will increase with higher CCT level.

Yoshizawa et al. (2013) worked on the artwork illumination with LED lighting at different correlated color temperatures, illumination levels and color rendering index. They used adjective pairs to describe the relation of oil paintings and lighting conditions and they stated that the most significant of two were texture and visibility. They indicated that CCT was positively correlated with visibility while it had a negative correlation with texture. On the other hand, higher illuminance affected the visibility and texture positively.

In a study conducted by Zhai et al. (2015) the impact of CCT and illuminance on lighting art paintings were evaluated. The experiment was done in an empty room illuminated by four CCTs which were 2850 K, 4000 K, 5000 K and 6500 K and three illuminance levels that were 50, 200 and 800 lux combinations. They used 14 evaluative scales that were grouped into two: atmosphere and appearance. As evaluative paintings they used four oil and two gouache paintings. According to the results with the rise of CCT, naturalness, relax, warmth, comfort and pleasantness perceptions were negatively affected. But, brightness, clearness and contrast perceptions indicated little change with the CCT. The most apparent effect was that with the rise of CCT the perception of coolness also increased while with the rise of illuminance level brightness perception increased. 4000 K at 200 lux level was found to be optimal illumination for museums.

Another research conducted by Zhai et al. (2016) evaluated the impact of LED lighting parameters on artwork paintings. They used oil and gouache paintings and evaluative scales that were used in their former study. They concluded that CCT of 3500 K was the most preferred lighting condition and high color rendering index is vital for the lighting of art paintings.

The study conducted by Khanh et al. (2017) researched about color preference of still life arrangements with different CCT levels. They used multi channel LED device of four different CCTs which were 3100 K, 4100 K, 5000 K and 5600 K. All of them had nine different spectra at 750 lux illuminance level. According to the results, a significant inclination through 4100 K a neutral white light and cool white lights 5000 K and 5600 K were observed against warm white light which was 3100 K. The art paintings are presented both in museums and art galleries. In the art galleries beyond visual pleasure commercial sale of the artworks are also important (Haja, 2013; Sunish, 2015). Areni and Kim (1994) conducted an experiment in a wine store to evaluate the lighting conditions effect on customers' behavior in the store. They concluded that at bright light conditions the purchase and the items touched on the store had a significant increase.

As a summary, as it was mentioned above in the example studies, it can be said that CCT and illuminance level are important criteria in museum environments and within different experimental contexts distinct lighting conditions are preferred. Under different CCT and illuminance conditions, people's emotional states are also affected. In the next chapter, experimental part of the study is defined. Aim and method of the study, sample group, procedure and findings of the study are analyzed in detail.

Table 5. Review of Museum Lighting Studies

Authors	Subject	Results
Pinto et al. (2008)	Most preferred CCT s for illumination of artistic paintings	The most preferred CCT for illuminating artistic paintings was found to be **5100 K**.
Masuda and Nascimento (2014)	Best lighting option for artistic paintings	For real museum condition the most preferred CCT was **5500 K** while in monitor viewing the chosen CCT was **5700 K**.
Chen et al. (2016)	Proper combinations of CCT and illuminance in museum environments	A pleasant area of 2700 K-4000 K with 100 to 300 lux and 3000 K-5000 K with 150 to 500 lux was suggested.
Scuello et al. (2004)	CCT in museum lighting	The most preferred CCT was **3600 K** and there was a relation between illumination and dominant color of the painting. Cool colored paintings had a positive perception under **higher CCTs.**
Luo et al. (2013)	Museum lighting environment	Pleasantness would rise with higher illuminance while brightness, clearness and coolness will increase with **higher CCT levels**.
Yoshizawa et al. (2013)	Artwork illumination with LED lighting and different CCTs	CCT was positively correlated with visibility while it had a negative correlation with the texture.
Zhai et al. (2015)	Impact of CCT and illuminance on lighting art paintings	With the **rise of CCT**, naturalness, relax, warmth, comfort and pleasantness perceptions were negatively affected. Brightness, clearness and contrast perceptions indicated little change with the CCT. **4000 K** at 200 lux level was found to be optimal illumination for museums.
Zhai et al. (2016)	The impact of LED lighting parameters on artwork paintings	CCT of **3500 K** was the most preferred lighting condition and high CRI is vital for the lighting of art paintings.

Table 5 (cont'd)

Khanh et al. (2017)	Color preference of still life arrangements	Significant tendency through **4100 K** and **5000 K** were observed against **3100 K**.
Areni and Kim (1994)	Lighting effect on customers' behavior in store	At **bright light** conditions the purchase and items touched on the store had a significant increase.

2.4. Fundamentals of Color

Color perception is made from the environment through different wavelengths of light and it is noticed by the eye and then construed by the human brain (Nassau, 1997). On humans' perception of the environment, emotions, mental state and preferences, color has significant effects. It is a powerful input for subjective feelings about the neighboring environment (Mahnke, 1996).

2.4.1. Color Basics

Human eye and brain make the true color perception with three basic features of color which area hue, value (brightness or lightness) and chroma (saturation). These are the dimensions of the color and they can be separately measured. (Gosney & Dayton,1995; Fehrman &Fehrman, 2000). To make the true application of color to the environment, it is essential to know the difference between these dimensions.

The attribute which enables the naming of the color such as blue, red, yellow and black is the hue. By means of hue, colors can be differentiated from each other (Fehrman & Fehrman, 2000). Hue is determined according to the wavelength (Mahnke & Mahnke, 1987). Colors that do not own a primary hue are called achromatic colors which are black, gray or white (Ruskin,1986). The other colors that own a significant hue like red, purple or yellow are called chromatic colors. With respect to the placement in the spectrum, colors are distinguished as cool colors such as blue, green or purple and warm colors like red, brown, orange or yellow.

Another attribute of color is saturation or chroma, that is color’s purity. Low saturated colors are perceived as grayish while high saturated ones look more vivid. The hue of the color can be identical but due to the changing saturation level they might look different from each other (Mahnke & Mahnke, 1987).

Brightness or value is another dimension of color that relates with the colors’ diffusing capacity of light and it shows an alteration through white to black (Cooper, 1941).

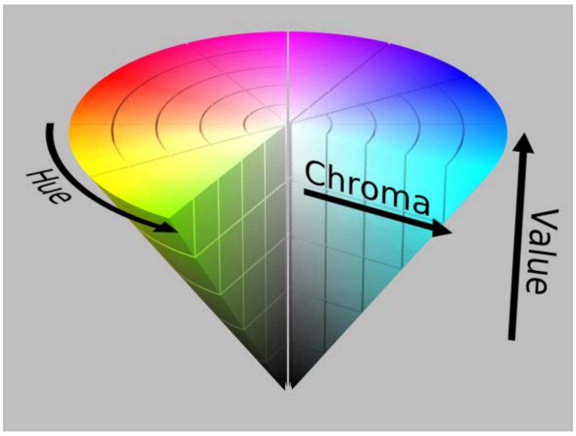


Figure 6. Hue, chroma and value

(Source: http://www.lightingschool.eu/portfolio/understanding-the-light/)

2.4.2. Color Order Systems

The human eye can distinguish approximately ten million colors (Fehrman & Fehrman, 2000). Color order systems are required for classifying and identifying colors from each other and to do this a single color order system is not sufficient. Thus different color systems have been developed. The organization of color order systems are based upon three dimensions of colors. Owing to color order systems, the relationship between colors can be explained and organization of colors with a different defined order can be made. Nevertheless, all color order systems intend to determine dimensions of colors which are hue, saturation and value and to discriminate colors in a standardized form. (Holtzchue, 2006). There are commonly used color order systems in diversified investigation areas which are CIELAB, RGB, Munsell Color Order System and NCS Natural Color System.

The color diversity of paintings used in this study are measured with NCS Natural Color System Color Scan (See Appendix D). With the NCS major features of the color can be identified and variations, similarities and relationships between colors can be described (Hard &Sivik, 2001). The system is directly used to determine the envisioned surface color. NCS uses six primary colors which are red, yellow, green, blue, black and white (Agoston,1987). The first step to determine a color in NCS system is specifying the hue of the color. In NCS color circle, paired structure of hues which are yellow, red, blue and green are organized. Four quadrants constitute the hue circle of NCS that stand for Y-R, R-B, B-G and G-Y. A color code consists of the features of blackness, chromaticness and hues. For example a code named S 3060- B50G have 30% blackness, 60% chromaticness, 50% unitary blue and 50% unitary green.

CHAPTER III

EXPERIMENTAL STUDY

3.1. Aim of the Study

To understand lighting preferences of museum visitors a lot of experimental studies were done as mentioned in Chapter II. However, most of the experimental studies based on illumination preferences in museums are focused just on differentiation of the lighting in terms of CCT and illuminance level. There was no significant research on museum lighting preference with differentiation of color scheme of the paintings and style of the paintings. The main purpose of this study is to understand effects of color and style of the paintings on preferences of museum visitors CCT of light. To do this, three styles (drip painting, still life and contemporary figurative art) paintings in three color scheme (red, blue and neutral) conditions were used. All these conditioned paintings were illuminated by 3000 K, 4000 K and 6000 K led spots. Understanding the CCT of light preference of museum visitors with respect to the changes of color scheme and style of the paintings can be helpful for museum curators, lighting designers and interior architects while designing a museum environment.

3.1.1. Research Questions

In order to reach the aim of the study four research questions were formulated. The research questions of the study are as follows:

Q1: What is the most preferred CCT of light among museum visitors?

Q2: Is there a significant effect of paintings' color on the museum visitors' preference of CCT of light?

Q3: Is there a significant effect of paintings' style on the museum visitors' preference of CCT of light?

Q4: Is there a perception difference between evaluative emotional states and the CCT of the paintings in a museum environment?

3.1.2. Hypotheses

H1: The most preferred CCT of light among museum visitors is 4000 K.

H2: Visitors preference are towards high color temperature when color of the paintings getting cooler.

H3: Style of paintings affects choice of museum visitors' CCT of light.

H4: There is a significant difference between different CCTs on evaluative emotional states of visitors for exhibited paintings.

H4.1. Warmth perception increases with the decrease of the color temperature for all color schemes which are red, blue and neutral.

H.4.2. Brightness perception increases with the increase of the color temperature for all color schemes which are red, blue and neutral.

H.4.3. There is a significant difference between different CCTs and comfort state.

H4.3.1. Comfort perception increases with the decrease of the color temperature when the color of the painting is red.

H4.3.2. Comfort perception increases with the increase of the color temperature when the color of the painting is blue.

H4.3.3. Comfort perception increases with the increase of the color temperature when the color of the painting is neutral.

H.4.4. There is a significant difference between different CCTs and pleasantness state.

H4.4.1. Pleasantness perception increases with the decrease of the color temperature when the color of the painting is red.

H4.4.2. Pleasantness perception increases with the increase of the color temperature when the color of the painting is blue.

H4.4.3. Pleasantness perception increases with the increase of the color temperature when the color of the painting is neutral.

H.4.5. There is a significant difference between different CCTs and naturalness state.

H4.5.1. Naturalness perception increases with the decrease of the color temperature when the color of the painting is red.

H4.5.2. Naturalness perception increases with the increase of the color temperature when the color of the painting is blue.

H4.5.3. Naturalness perception increases with the increase of the color temperature when the color of the painting is neutral.

H.4.6. Relax perception increases with the increase of the color temperature for all color schemes which are red, blue and neutral.

3.2. Methodology

3.2.1. Sample Group

The sample group of the study consisted of graduate and undergraduate people from Bilkent and Middle East Technical University. The total number of the sample group were 81 people. There were 52 female participants and 29 male participants in the experiment with the mean age of 24. The experiment was performed with three sample groups for three styles (drip painting, still life and contemporary figurative art) paintings in three dominating color (red, blue and neutral) conditions. Because the experiment basically concerned perception of color, color perception of participants was an essential criteria. For this, with the questionnaire whether participants had color blindness or any other eye deficiencies that affect color perception were asked. There was no participant having color blindness, so none of them were excluded from the experiment. For other correctable visual impairments they were instructed to wear eyeglasses or contact lenses. This experiment did not particularly focus on age, gender and education level, however for representing the demographic aspects of the sample group these information were also asked with the questionnaire.

3.2.2. Procedure

3.2.2.1. Setting of the Experiment

The experiment was conducted in an experiment room at the Department of Interior Architecture and Environmental Design FF Building at Bilkent University. The experiment room was set up as a small exhibit room. The room is 4.00 m in length, 4.10 m in width and 3.20 m in height (See Figure 7 and Figure 8). On one side of the room there are windows that are covered with nontransparent black sheets in order to eliminate outdoor light and bring under control the effect of the artificial LED spot lighting on participants' preference of CCT of light. The experiment was setup on one wall with neutral matte gray painting. The ceiling was painted matte white color. The current general direct (downward) lighting by the luminaries of recessed troffer with parabolic louvers were not used in the experimental setup. To illuminate the paintings on neutral matte gray painted wall, a rail LED spot system with three LED spots were specially constructed and set up to the room. Three LED spots were different in CCT of light. The CCT of the spots were 3000 K, 4000 K and 6000 K. The illuminance level of the experimental set up was measured by using Konica Minolta T-1 Illuminance Meter (range of 0.01 to 99,900 lux). The average illuminance level of the experimental set up was 200 lx when three of the LED spots directed to the paintings on the wall were on (See Appendix E). For display lighting, CRI of the light is so important to truly render colors of the exhibited objects. The CRI value of the light should be at least 90 Ra (CIBSE,1994). In order to fulfill this requirement, the specially constructed LEDs had 90 Ra CRI level (Group 1A).

Painting colors that were used in the experiment were blue (cool), red (warm) and neutral (achromatic) colors. Paintings with having average surface color dominancy of red according to the NCS codes was referred as red (warm) while paintings with blue dominance NCS codes was referred as blue (cool) and paintings with gray and black dominance NCS codes was referred as neutral(achromatic) (See Appendix D).

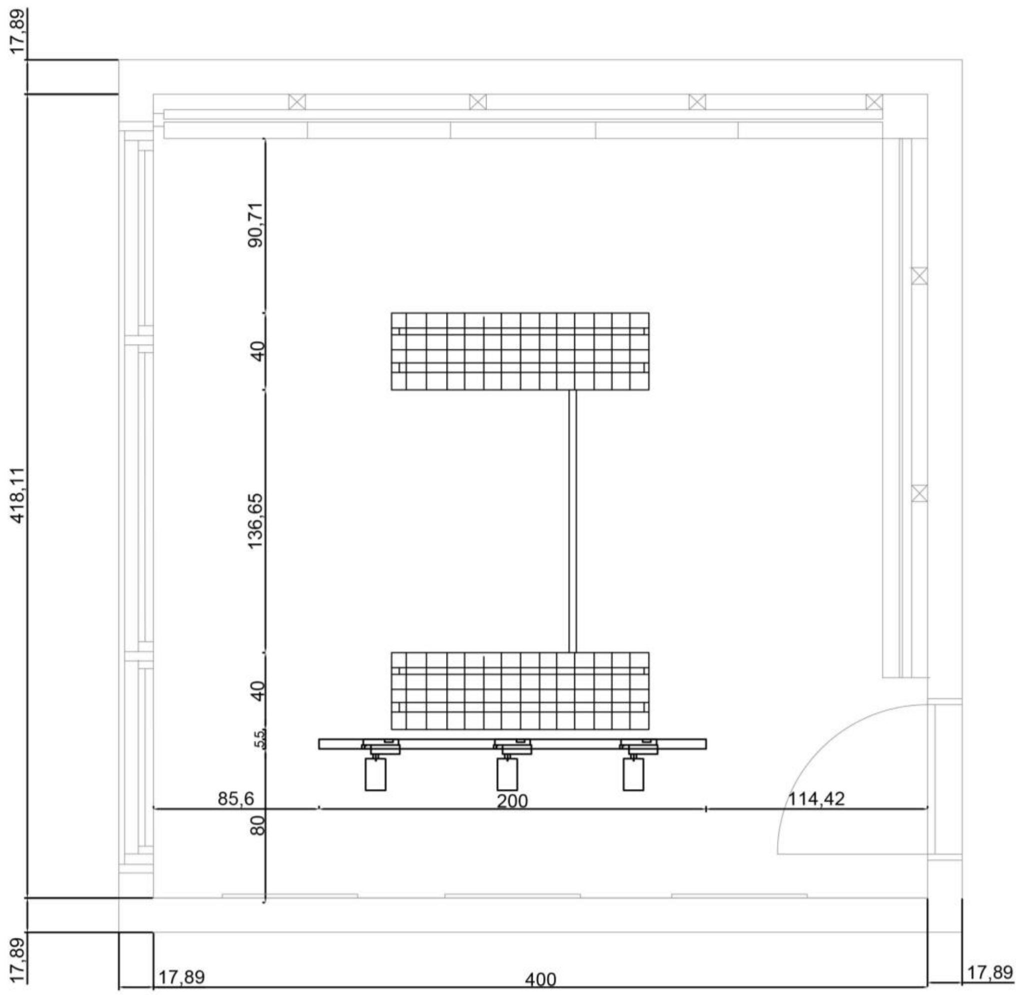


Figure 7. Reflected ceiling plan of the experiment room

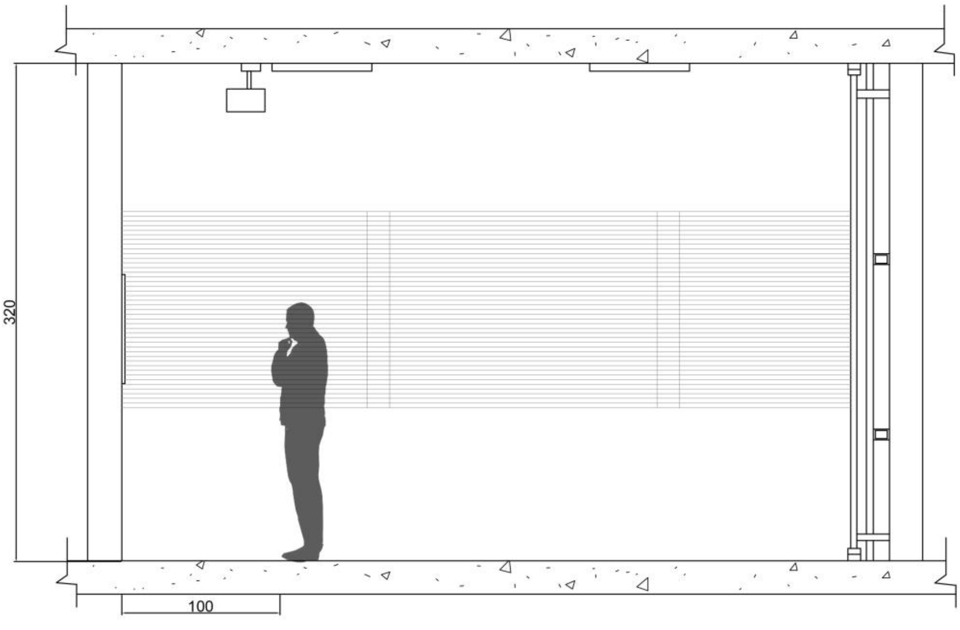


Figure 8. Section of the experiment room

Painting styles that were used in the experiment were drip paintings, still life paintings and contemporary figurative art paintings. Drip paintings are in modern abstract style, they do not include any object depictions. On the other hand, still life paintings have object, vegetable and fruit depictions and contemporary figurative art paintings have facial depictions. It was assumed that they would cause perception difference while evaluating color and light preferences. High resolution samples of paintings were found on the web according to the intended color schemes which are red, blue and neutral. Then, high quality prints of paintings were taken suitable for the experiment room size (See Figure 9, 10 and 11).

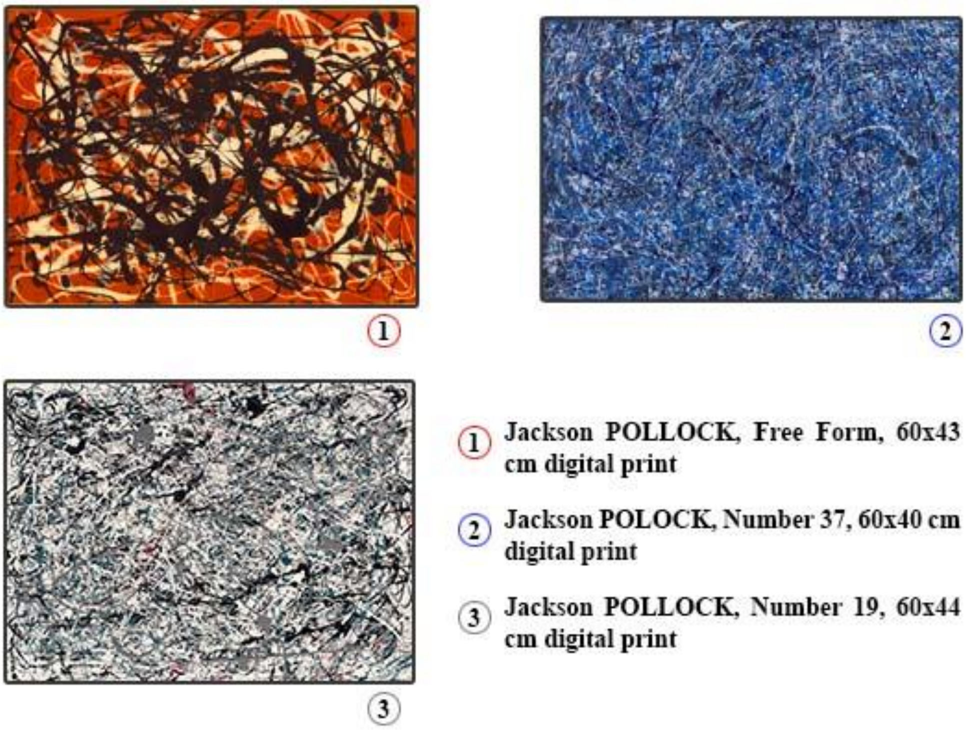


Figure 9. A diagram showing the artist and names of the drip paintings

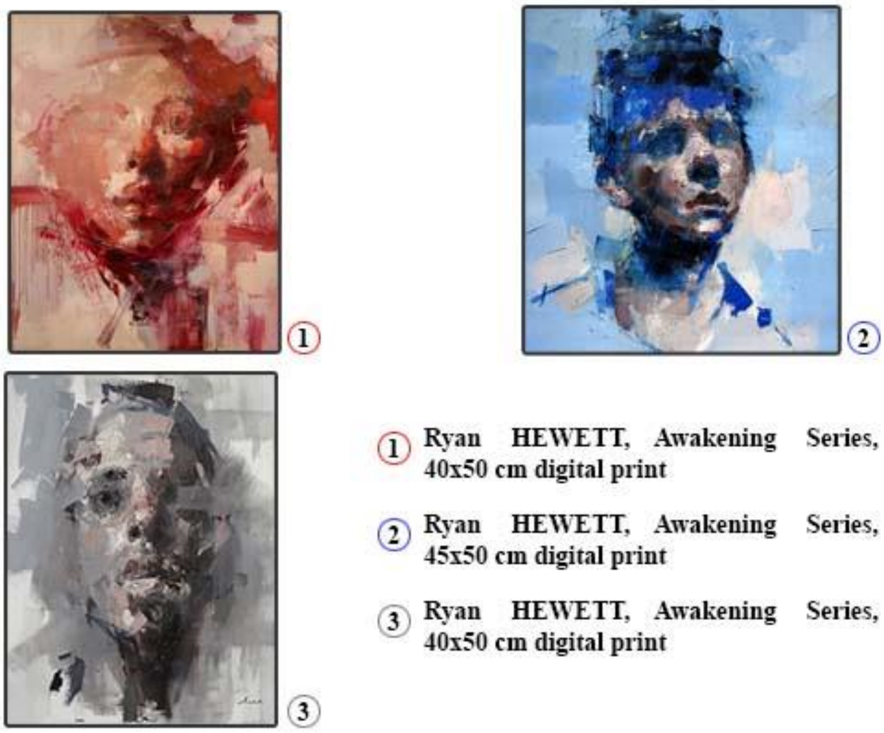


Figure 10. A diagram showing the artist and names of the contemporary figurative art paintings

Figure 11. A diagram showing the artist and names of the still life paintings

There are bipolar adjectives in the prepared questionnaire to evaluate museum visitors' perception differences regarding different CCTs and color of the paintings. In order to develop the questionnaire, word pairs from previous studies about color, lighting and lighting design of museums were collected. Bipolar adjectives that most frequently used and most appropriate to evaluate experiment setting were chosen among collected word pairs (See Appendix B).

3.2.2.2. Sets of the Experiment

In this experimentation, it is important to measure museum visitors' CCT of light preference with respect to the changes of color scheme and style of the paintings. To do this three color scheme (red, blue and neutral) paintings of three style (drip painting, still life and contemporary figurative art) were used. This is to say, nine phases of placing paintings were experimented with the three participant groups. For example, for the first participant group red, blue and neutral color schemed drip paintings under constructed LED spots were experimented respectively. Firstly, three of the same red color schemed drip paintings were hung on to the wall side by side and illuminated by 3000 K, 4000 K and 6000 K spots at the same time. Then three of the same blue color schemed and finally neutral color schemed three drip paintings were hung on and illuminated by the spots at the same time. This was one session of the experimentation and it was repeated with still life and contemporary figurative art paintings in red, blue and neutral color schemes with a total of three different participant groups.

3.2.2.3. Experimental Procedure

The experimentations were held at Bilkent University, Interior Architecture and Environmental Design Department FF Building room FZ29 between December 4th, 2017 and December 31st, 2017. The experiment was conducted in three sessions and three phases in each (See Figure 13, 14 and 15). Participants of each session were taken to the designed room one by one and were informed by the surveyor about the procedure of experiment briefly. Participants evaluated the paintings from 1 meter observation distance to the wall which is the optimal positioning for the observation (See Figure 12).

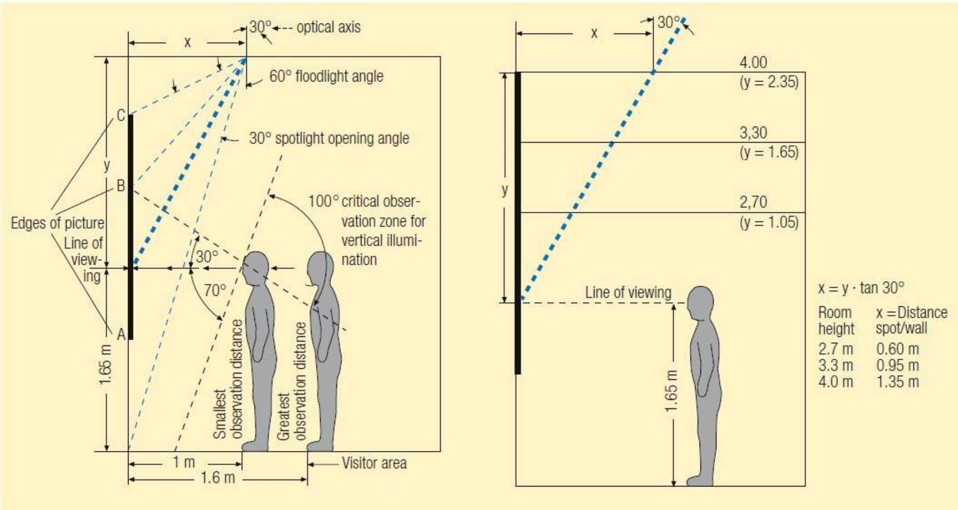


Figure 12. A diagram showing the optimal positioning of the luminaire and observation distance

(Source: http://en.licht.de/fileadmin/Publications/licht-wissen/0703_lw18_E_light_museums_galleries_web.pdf)

In the first session participants of the experiments were taken into the room one by one, drip paintings were hung on to the wall and the questionnaire that measured about preference of CCT of light was applied. In first phase of the first session three same red color scheme drip paintings were hung on to the wall and they are illuminated by 3000 K, 4000 K and 6000 K LED spots at the same time. With the questionnaire, participants were asked to choose in which CCT condition they wanted to see the paintings. Continuation of the questionnaire included word pairs that measured the paintings state under three CCT conditions. Each three red drip paintings were evaluated with selected word pairs by the participants. This is one phase of the experiment, and in each session this phase was repeated with the other color schemes, blue and neutral. The order of viewing color schemes of paintings was differentiated in each sample group. Each sample group included 27 participants and every 9 participants' viewing order was changed in order to evaluate whether color order affects CCT preference for the paintings.

Table 6. Distribution of Participants (n=81)

COLOR VIEWING ORDERS	Drip paintings	Contemporary figurative art paintings	Still life paintings
R-B-N	9	9	9
B-N-R	9	9	9
N-R-B	9	9	9

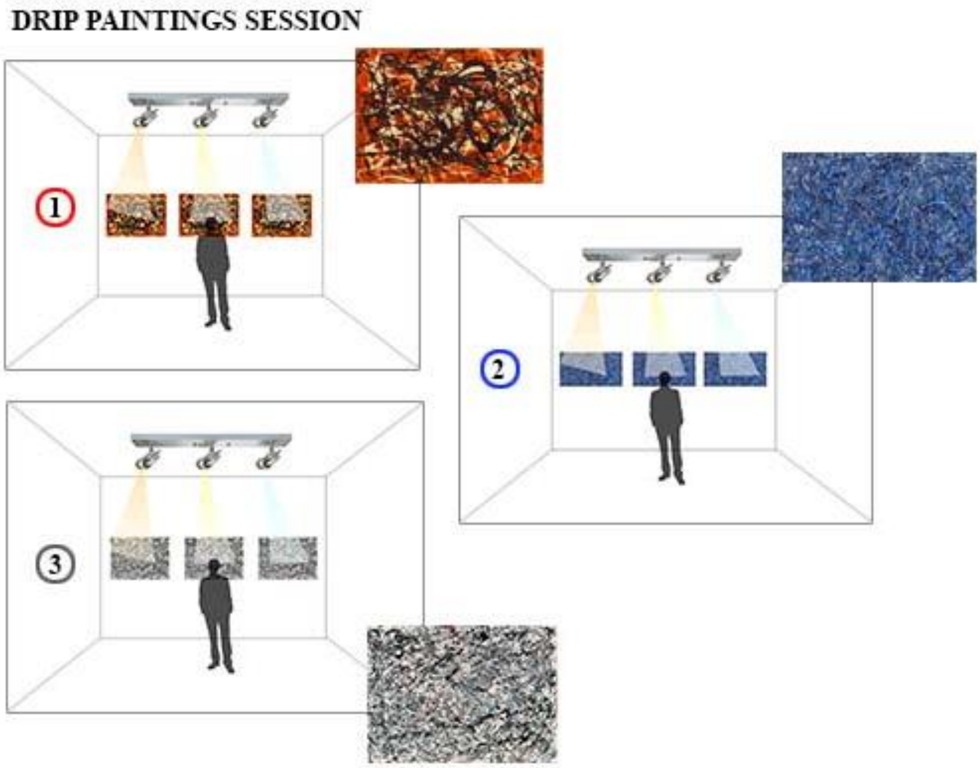


Figure 13. A diagram demonstrating the drip painting session of the experiment

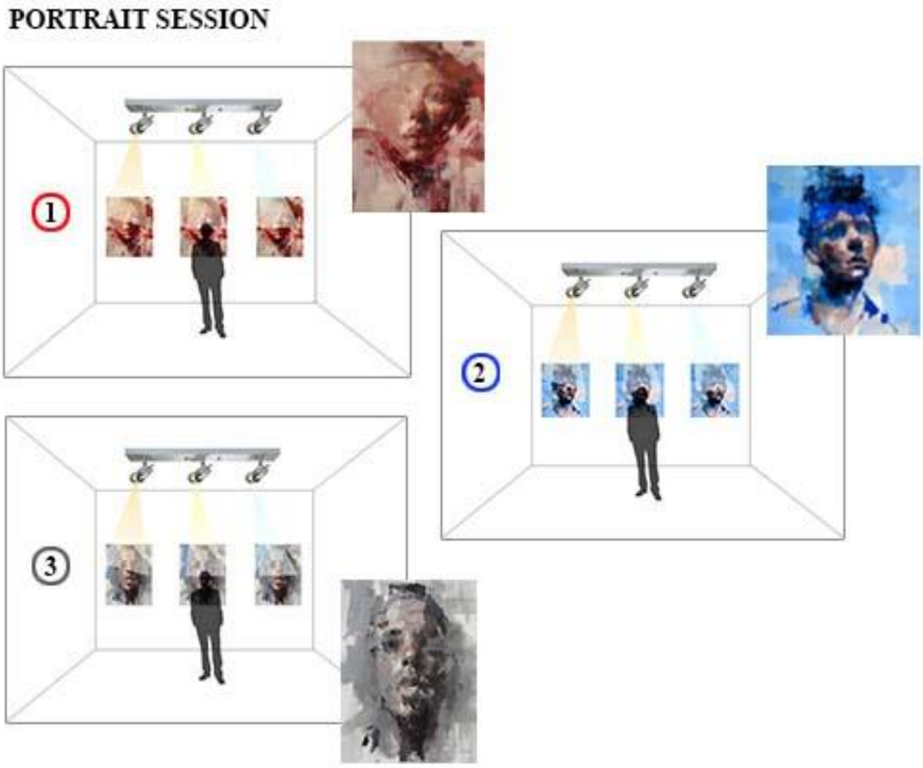


Figure 14. A diagram demonstrating the contemporary figurative art painting session of the experiment

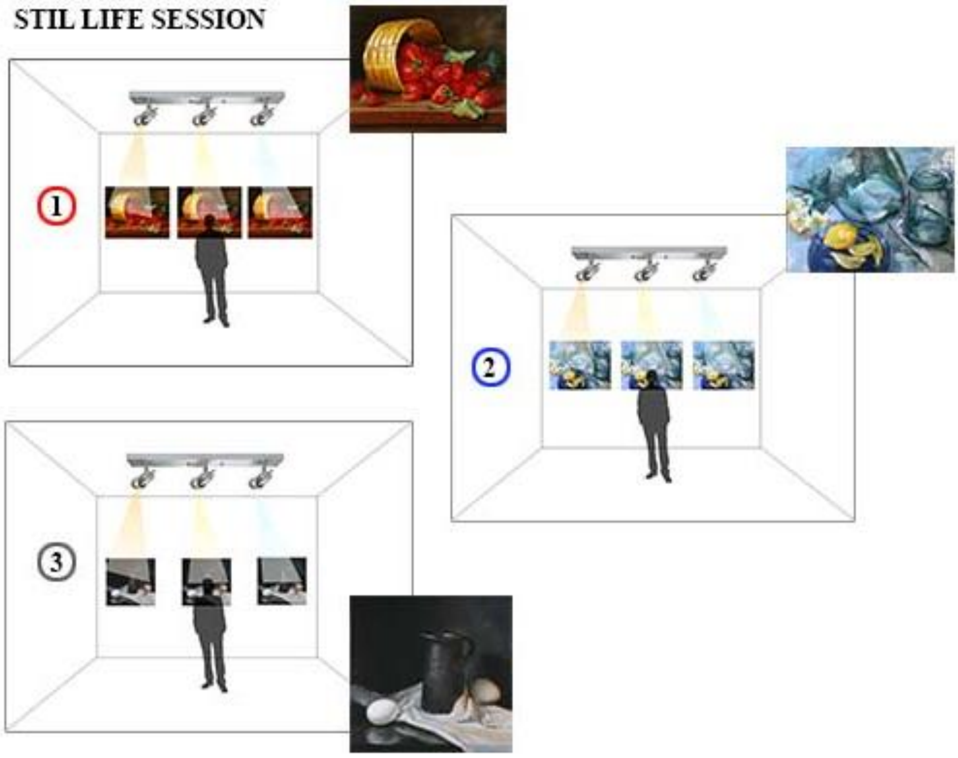


Figure 15. A diagram demonstrating the still life painting session of the experiment

3.3. Findings

To test the data gathered from questionnaire, Statistical Package for the Social Sciences (IBM Corp. SPSS) 24.0 and Microsoft Office Excel were used. For the analysis of the data, Shapiro Wilk-W Test, Friedman Test, Wilcoxon Signed-Rank Test, Kruskal Wallis-H Test and Mann Whitney-U Test were used.

Firstly, Shapiro Wilk-W test was used to determine either non-parametric or parametric test should be done to the data. Shapiro Wilk-W test is a strong normality test that is appropriate to use for all distribution types and sample sizes (Razali& Wah, 2011). The test evaluates whether the data is normally distributed or not. For this data non-parametric tests were used, since data were not normally distributed, P-values were lower than 0.05. Friedman Test is used to detect difference between related samples while having more than two groups of scores, similar to parametric repeated measures ANOVA (Cramer, 1998). Wilcoxon Signed-Rank Test is used to analyze two related samples when the data is not normally distributed. Kruskal Wallis- H test is used to compare three or more independent sample groups, while Mann Whitney-U test is for two independent sample groups.

3.3.1. Findings of Participants' Demographic Information

In the experiment there were 52 female participants (64,2 %) and 29 male participants (35,8%). The age of the participants ranged between 18 to 30. The majority of the participants were undergraduate students (74,07%) while 14,81% of the participant were graduate students and 11,11% of them were recent graduates with a master's degree. 79,01% of the participants took color and light related courses during their education, whereas 20,99% of the subjects did not take those courses. Even though, 29,63% of the participants stated that they have visual impairment, they used correction equipment during the experiment. None of the subjects had color blindness (See Table 7).

Table 7. Characteristics of Participants (n=81)

Characteristics		n	%
Gender	Female	52	64,2
	Male	29	35,8
Age	18-22	16	19,75%
	23-26	51	62,96%
	27-30	14	17,28%
Educational Background	Undergraduate Student	60	74,07%
	Graduate Student	12	14,81%
	Master Degree	9	11,11%
Color and Light Courses During Education	Yes	64	79,01%
	No	17	20,99%
Eye Deficiency	Yes	24	29,63%
	No	57	70,37%
Correction Equipment	Yes	24	29,63%
	No	57	70,37%
Color Blindness	Yes	0	0,00%
	No	81	100,00%

3.3.2. The Effects of Color of the Paintings on CCT Preference for Different Styles Separately

To test the effects of color of the artwork on viewers' CCT preference, three different analysis were done separately for each style of the paintings which were drip paintings, contemporary figurative art paintings and still life paintings. For each style, 27 participants saw and evaluated three color schemes of paintings with three orders. The view order of the paintings were changed per 9 visitors (See Figure 16).

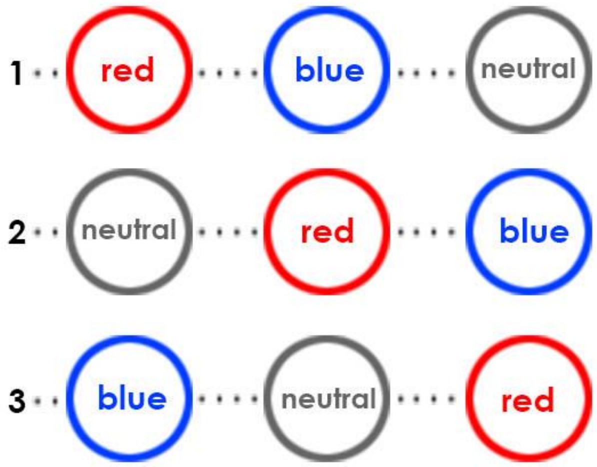


Figure 16. A diagram demonstrating the applied three order in the experiment

To combine three groups that saw the colors of paintings in different orders and analyze all population as one group, a statistical test, Kruskal Wallis-H Test was used. It helped to understand whether there is a difference among those three independent groups. The test was repeated three times for one style to understand whether the view order affect visitors' CCT preference for red paintings, CCT preference for blue paintings and CCT preference for neutral paintings or not.

3.3.2.1. The Effects of Color of the Artwork on CCT Preference for Drip Paintings

According to Kruskal Wallis-H tests that were applied to understand order effect of viewing colors for drip paintings, there was not a significant difference among three groups. Test result for red paintings ($\chi2$=0.69, df=2, p=0.966), for blue paintings ($\chi2$=1.627, df=2, p=0.443) and for neutral paintings ($\chi2$=1.753, df=2, p=0.416) were not statistically different from each other at 99.5% Confidence Interval (See Appendix F.1.). So, different groups that see the colors of the paintings in different orders can be combined to analyze the drip painting style as a whole.

Friedman Test which determines the difference between related samples while having more than two groups of scores was used to evaluate the effects of painting color on viewers' CCT preference for drip paintings. The results showed that there was a significant difference between color of the paintings and CCT preference of viewers at 99.5% Confidence Interval ($\chi2$=9.852, df=2, p=0.007) (See Appendix F.2.).

In order to further understand the relationship between dominating paintings colors and preferred CCTs, Wilcoxon Signed Rank test was used. The significance levels of all preferred CCTs of viewers were accepted as 0.0167 by applying the Bonferroni correction which was obtained by dividing 0.05 by 3 (Field & Hole, 2008). The test results showed that there was a significant difference between effect of red painting color and blue painting color on CCT preference of visitors (z= -2.736, p=0,006). However, according to test results there was not a significant difference between neutral painting color and red painting color (z= -1.994, p=0.046) and neutral painting color and blue painting color (z= -1,057, p=0.290) (See Appendix F.2.). Therefore, the results indicated that there was a significant difference between effect of cool and warm color schemes on CCT preference for drip paintings.

When the CCT preference distributions of viewers according to painting color were compared, the distributions showed that viewers want to see warm color paintings under lower and warm CCTs (3000 K or 4000 K), while in the case of cool color paintings the choice of is towards higher and cool CCTs (4000 K or 6000 K) (See Figure 17).

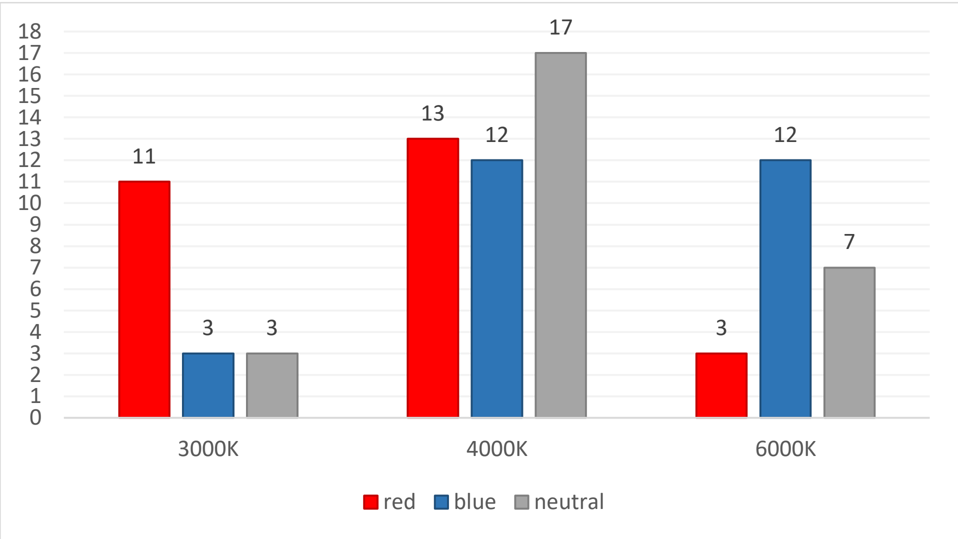


Figure 17. Preference distribution of the CCT according to different colors for drip paintings

The most preferred CCT level of all color schemes for drip paintings by viewers was 4000 K. 27 participants preferred CCT for three color schemes, red, blue and neutral;

so 81 CCT preferences were done for drip paintings. According to the distributions of preference, 52% of preferences were towards 4000 K (See Figure 18).

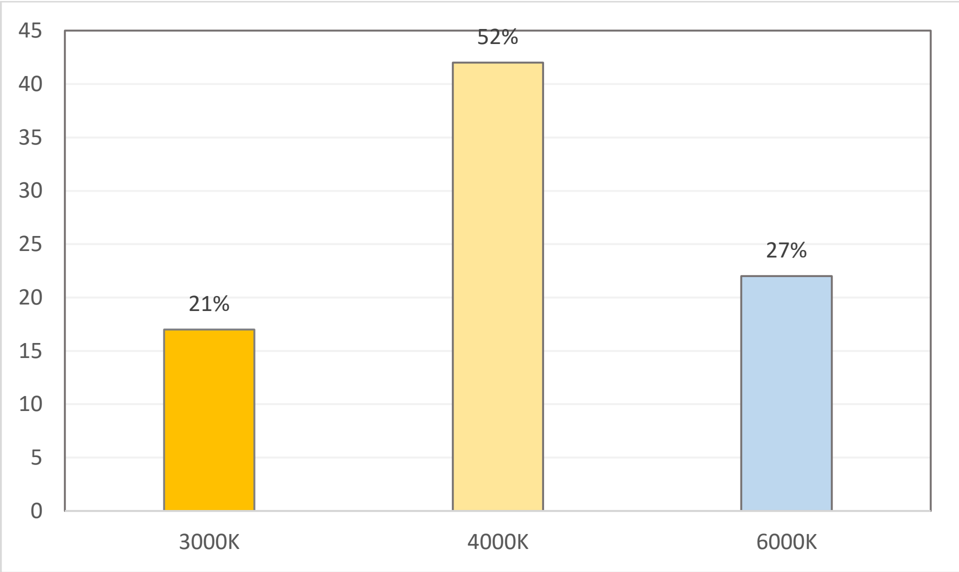


Figure 18. Preference distribution of visitors on CCT for drip paintings

3.3.2.2. The Effects of Color of the Artwork on CCT Preference for Contemporary Figurative Art Paintings

According to Kruskal Wallis-H tests that were applied to understand order effect of viewing colors for contemporary figurative art paintings, there was not a significant difference among three groups. Test results for red paintings ($\chi 2=1.126$, df=2, p=0.569), for blue paintings ($\chi 2=0.963$, df=2, p=0.618) and for neutral paintings ($\chi 2=1.733$, df=2, p=0.420) was not statistically different from each other at 99.5% Confidence Interval (See Appendix F.3.). So, different groups that saw the colors of the paintings in different orders can be combined to analyze the contemporary figurative art paintings as a whole.

Friedman Test which determines the difference between related samples while having more than two groups of scores was used to evaluate the effects of painting color on viewers CCT preferences for contemporary figurative art paintings. The results showed that there was a significant difference between color of the paintings and CCT preference of viewers' at 99.5% Confidence Interval ($\chi 2=17.416$, df=2, p=0.000) (See Appendix F.4.).

In order to further understand the relationship between dominating paintings colors and preferred CCTs, Wilcoxon Signed Rank test was used. The significance levels of all CCT preferences of viewers were accepted as 0.0167 by applying the Bonferroni correction which was obtained by dividing 0.05 by 3 (Field & Hole, 2008). The test results showed that there was not a significant difference between neutral painting color and blue painting color on CCT preferences of viewers (z= -2.120, p=0,034). However, according to test results there was a significant difference between blue painting color and red painting color (z= -3.359, p=0.001) and neutral painting color and red painting color (z= -2.839, p=0.005) (See Appendix F.4.). Therefore, the results indicated that there was a significant difference between effects of cool and warm color schemes and also achromatic and warm color schemes on CCT preferences for contemporary figurative art paintings, while cool and achromatic color schemes do not show any statistical difference for this data.

When the CCT preference distributions of visitors according to painting color were compared, the distributions showed that visitors wants to show warm color paintings under lower and warm CCTs, while in the case of cool color paintings the choice of visitors are towards higher and cool CCTs. For neutral color schemes, majority of the CCT preferences are 4000 K (See Figure 19).

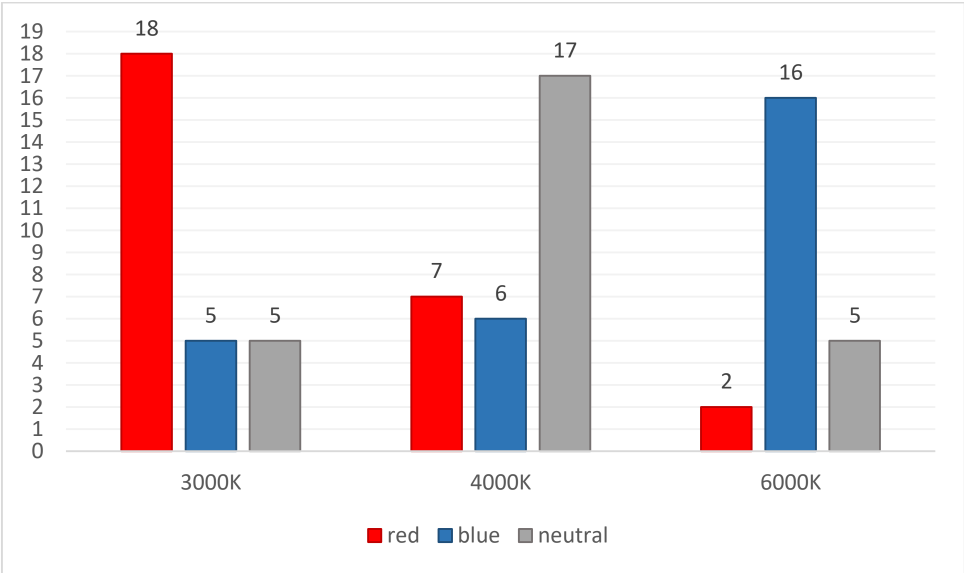


Figure 19. Preference distribution of the CCT according to different colors for contemporary figurative art paintings

27 viewers prefer CCT for three color schemes, red, blue and neutral; so 81 CCT preferences were done for contemporary figurative art paintings. According to the distributions of preference, 37% of 81 preference were towards 4000 K, while 35% of the preferences towards 3000 K and 28% of the preferences towards 6000 K (See Figure 20). Different from drip paintings, for paintings with facial depictions dominant color and CCT preference relation is stronger and clear. Viewers preferred CCTs with respect to the nature of the color of the paintings.

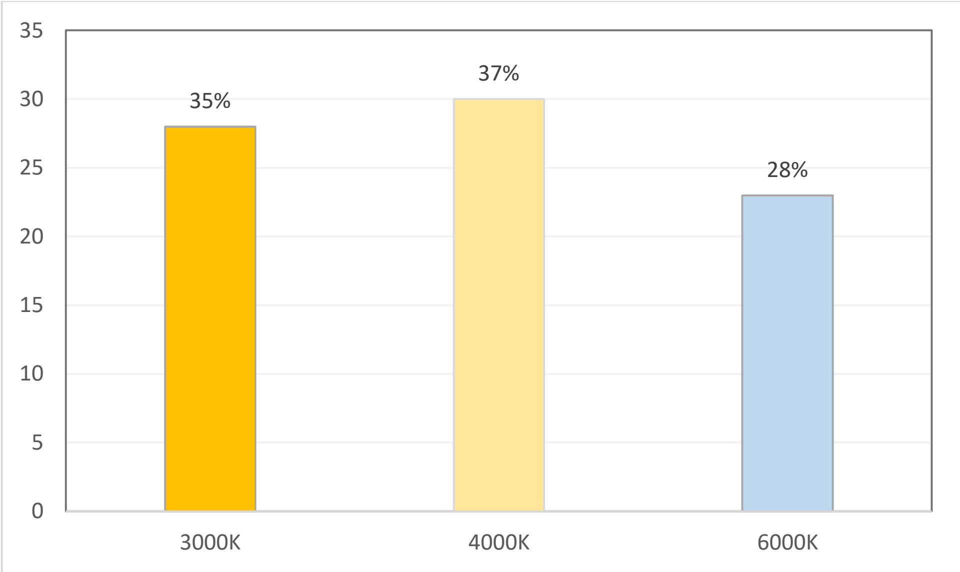


Figure 20. Preference distribution of visitors on CCT for contemporary figurative art paintings

3.3.2.3. The Effects of Color of the Artwork on CCT Preference for Still Life Paintings

According to Kruskal Wallis-H tests that were applied to understand order effect of viewing colors for still life paintings, there was not a significant difference among three groups. Test result for red paintings ($\chi2$=0.054, df=2, p=0.973), for blue paintings ($\chi2$=2.920, df=2, p=0.232) and for neutral paintings ($\chi2$=5.425, df=2, p=0.066) were not statistically different from each other at 99.5% Confidence Interval (See Appendix F.5.). So, different groups that saw the colors of the paintings in different orders can be combined to analyze the still life painting style as a whole.

Friedman Test which determines the difference between related samples while having more than two groups of scores was used to evaluate the effects of painting color on viewers' CCT preference for still life paintings. The results showed that there was a significant difference between color of the paintings and CCT preferences of viewers at 99.5% Confidence Interval ($\chi2$=18.909, df=2, p=0.000) (See Appendix F.6.).

In order to further understand the relationship between dominating paintings colors and preferred CCTs, Wilcoxon Signed Rank test was used. The significance levels of all CCT preferences of viewers were accepted as 0.0167 by applying the Bonferroni correction which was obtained by dividing 0.05 by 3 (Field & Hole, 2008). The test results showed that there was not a significant difference between effect of neutral painting color and blue painting color on CCT preferences of viewers (z= -1.360, p=0,174). However, according to test results there was a significant difference between blue painting color and red painting color (z= -3.917, p=0.000) and neutral painting color and red painting color (z= -2.660, p=0.008) (See Appendix F.6.). Therefore, the results indicated that there was a significant difference between effect of cool and warm color schemes and also achromatic and warm color schemes on CCT preferences for still life paintings, while cool and achromatic color schemes do not show any statistical difference for this data.

When the CCT preference distributions of viewers according to painting color were compared, the distributions showed that viewers want to see warm color paintings under lower and warm CCTs (3000 K and 4000 K), while in the case of cool color paintings the choice of viewers are towards higher and cool CCTs (4000 K and 6000 K). For neutral color schemes, majority of the CCT preferences are 4000 K (See Figure 21).

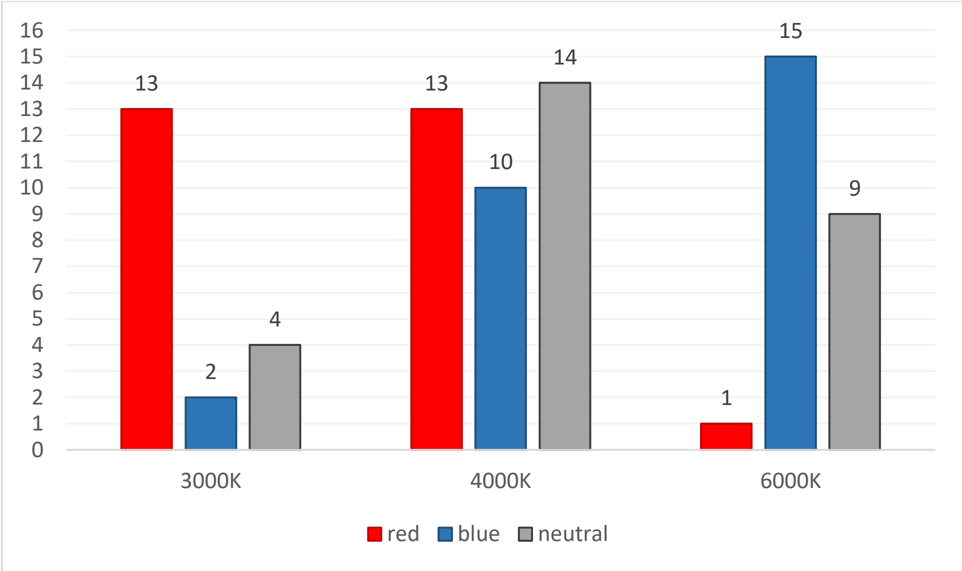


Figure 21. Preference distribution of the CCT according to different colors for still life paintings

The most preferred CCT level of all painting colors for still life by viewers is 4000 K. 27 visitors preferred CCT for three color schemes, red, blue and neutral; so 81 CCT preference were done for still life paintings. According to the distributions of preferences, 46% of 81 preferences were towards 4000 K, while 31% of the preferences towards 6000 K and 23% of the preferences were 3000 K (See Figure 22).

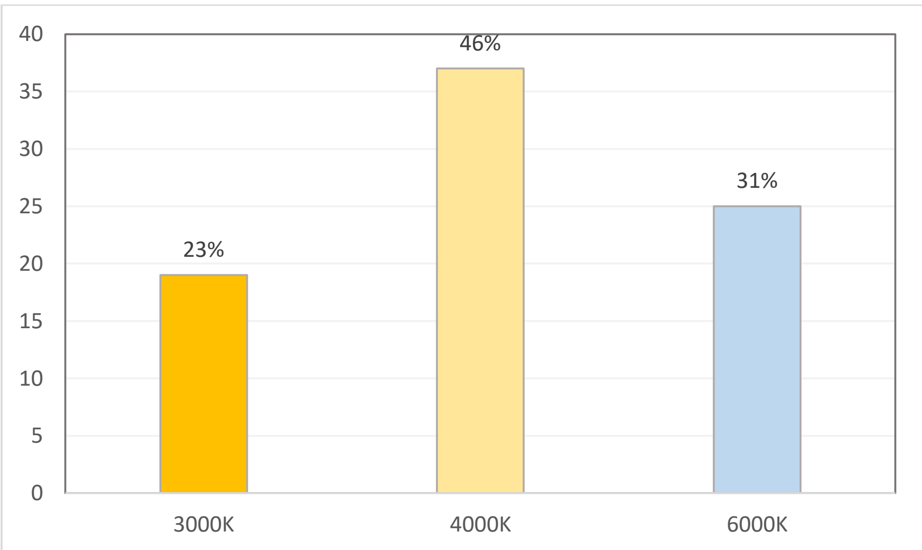


Figure 22. Preference distribution of visitors on CCT for still life paintings

To see the relation and differences among painting styles for CCT preferences of participants a table showing statistical results and distributions of preferences was constituted.

Table 8. Statistical results and distributions for CCT preference of three styles

	Drip Paintings	**Cont. Figurative Art Paintings**	**Still Life Paintings**
Friedman Test Results (R-B-N)	**p= 0.007** (significant difference)	**p= 0.000** (significant difference)	**p= 0.000** (significant difference)
Wilcoxon Signed Rank Test (R-B)	**p= 0.006** (significant difference)	**p= 0.001** (significant difference)	**p= 0.000** (significant difference)
Wilcoxon Signed Rank Test (R-N)	p= 0.046 (not significant difference)	**p= 0.005** (significant difference)	**p= 0.008** (significant difference)
Wilcoxon Signed Rank Test (B-N)	p= 0.290 (not significant difference)	p= 0.034 (not significant difference)	p= 0.174 (not significant difference)
Preference percentage of 3000 K	21%	35%	23%
Preference percentage of 4000 K	**52%**	**37%**	**46%**
Preference percentage of 6000 K	27%	28%	31%

3.3.3. The Effects of Color of the Paintings on CCT Preference for All Styles

As mentioned before, Kruskal Wallis- H test is used to compare three or more independent sample groups, while Mann Whitney-U test is for two independent sample groups. In order to analyze three sample groups that saw only one of the three styles with three color schemes that is to say red, blue and neutral, Kruskal Wallis- H test was used. With this test, whether there is a significant difference between different sample groups experimented with different styles with respect to CCT preference was measured. Because painting color is a critical factor for CCT preference, the differences between styles were tested for three color schemes separately.

According to Kruskal Wallis-H tests that were applied to understand difference among styles with respect to CCT preference, there was not a statistical difference among three groups which are drip paintings, contemporary figurative art paintings and still life paintings. Test results for red paintings ($\chi2=3.398$, df=2, p=0.183), for blue paintings ($\chi2=0.747$, df=2, p=0.688) and for neutral paintings ($\chi2=1.341$, df=2, p=0.511) was not statistically different from each other at 99.5% Confidence Interval (See Appendix F.7.). So, different sample groups that saw different styles can be analyzed together to test effect of painting color on CCT preference in the whole sample group.

In the whole group, there were 81 viewers that saw different styles of paintings with three colors, so there were 243 CCT preferences which included 81 CCT preferences for red paintings, 81 CCT preferences for blue paintings and 81 CCT preferences for neutral paintings. With Kruskal Wallis-H test applied to the whole group, there was a significant difference among painting colors of all styles with CCT preferences of viewers ($\chi 2$=54.770, df=2, p=0.000) (See Appendix F.8.).

In order to further understand the relationship between dominating paintings colors and preferred CCTs, Mann Whitney-U test was applied to data. Confidence level was transformed to 0.0167 by applying Bonferroni correction to 0.05 confidence level. The test results showed that there was a significant difference between effect of red painting color and blue painting color on CCT preferences of viewers (U=1359, z= -6.838, p=0.000), effect of red painting color and neutral painting color on CCT preferences of viewers (U=1863, z= -5.201, p=0.000) and effect of blue painting color and neutral painting color on CCT preferences of viewers (U=2461, z= -3.007, p=0.003) (See Appendix F.8.). Therefore, the results indicated that there was a significant difference between cool, warm and achromatic color schemes on CCT preferences.

When the CCT preference distributions according to painting color were compared, it can be concluded that for warm colors, preferences of CCT are warmer and lower (3000 K and 4000 K), while for cool colors CCT preferences are towards cooler and higher (6000 K) (See Figure 23).

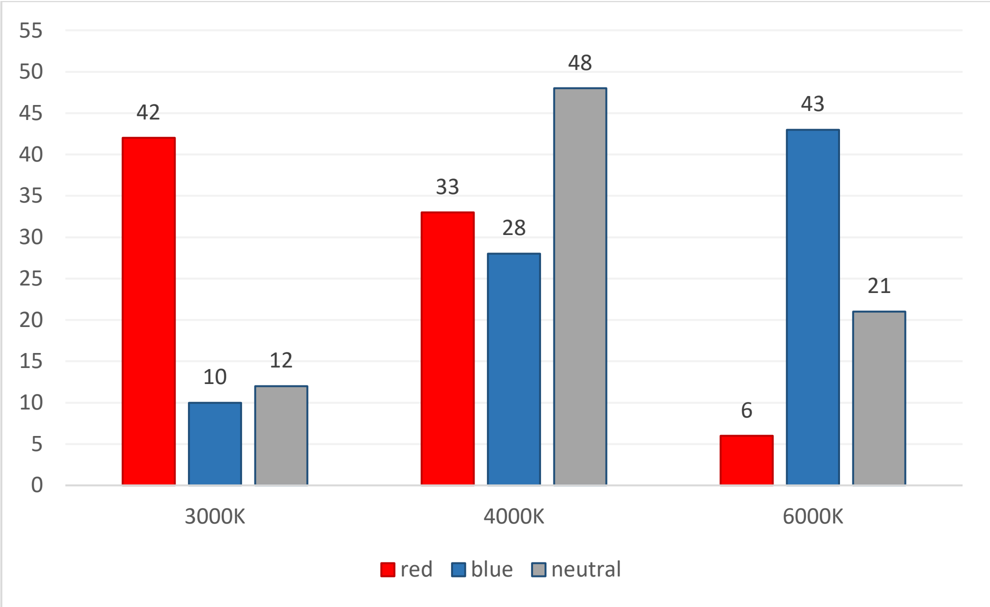


Figure 23. Preference distribution of the CCT according to different colors for all styles

The most preferred CCT level of all painting colors is 4000 K. 81 visitors preferred CCT for three color schemes, red, blue and neutral; so 243 CCT preferences were done for all styles. According to the distributions of preferences, 45% of 243 preferences were towards 4000 K, while 29% of the preferences towards 6000 K and 26% of the preferences were for 3000 K (See Figure 24).

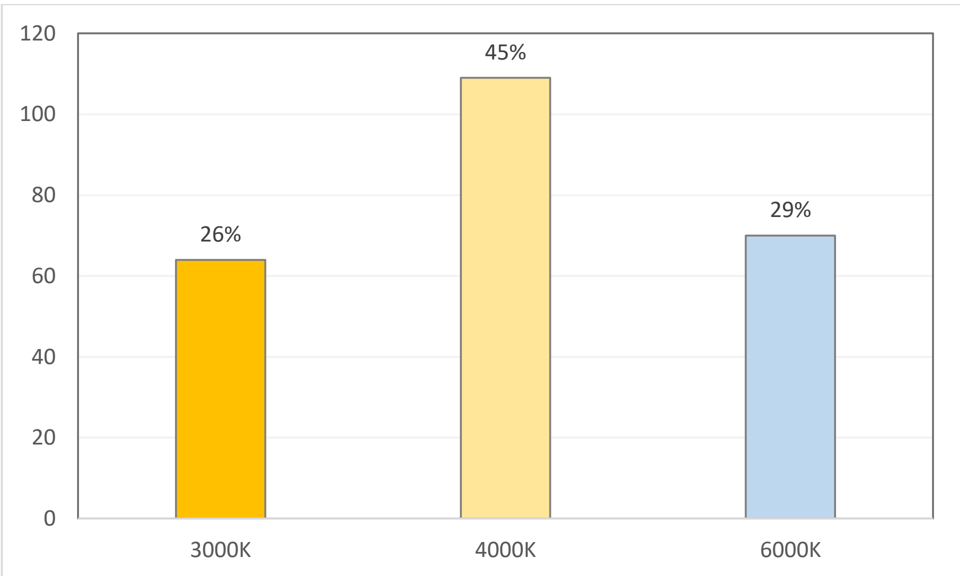


Figure 24. Preference distribution of visitors on CCT for all styles

3.3.4. The Effects of CCT on Evaluation of Selected Word Pairs

To evaluate effect of the CCT on selected bipolar adjectives which are warm-cool, natural-unnatural, relaxing-tense, pleasant-unpleasant, comfortable-uncomfortable, bright-dark, the data were analyzed by separating them according to color. This is to say, for red, blue and neutral paintings regardless of their styles bipolar adjective evaluation were done independently in order to see if there was a difference among effect of CCT of light.

3.3.4.1 The Effects of CCT on Evaluation of Selected Word Pairs for Red Color Schemed Paintings

Word pair evaluations of questionnaire were done in the experiment in a way that one participant saw three the same colored paintings at the same time under three CCTs and evaluated all six word pairs for each painting. For each three styles, 27 participants were experimented with three red paintings illuminated by 3 different CCTs, so 243 evaluations were done regarding a word pair for red painting color.

3.3.4.1.1. The Effects of CCT on Evaluation of Selected Word Pairs for Red Color Schemed Paintings- Warmth Perception

In order to analyze whether there was a difference between warm-cool state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and

6000 K regarding warm-cool state of the red paintings ($\chi 2=31.822$, df=2, p=0.000) (See Appendix F.9.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. Confidence level was transformed to 0.0167 by applying Bonferroni correction to 0.05 confidence level. The test results showed that there was not a significant difference between effect of CCT of 3000 K and CCT of 4000 K on warm-cool perception of visitors (U=2817.5, z= -1.629, p=0.103). On the other hand, there was a significant difference between effect of CCT of 3000 K and CCT of 6000 K on warm-cool perception of visitors (U=1723, z= -5.392, p=0.000) and effect of CCT of 4000 K and CCT of 6000 K on warm-cool perception of visitors (U=2133, z= -3.961, p=0.000) (See Appendix F.10.). Therefore, the results indicated that there was a significant difference between lower and higher CCTs regarding perception of warmth.

In order to determine how warmth perception was affected by CCT, the mean values for all CCTs were compared. While evaluating the mean scores of the data, if the mean score was higher than the middle range (3), it signifies that the CCT has positive effect on warmth perception. Otherwise, if the mean score is lower than the middle range (3), it indicates that the CCT has a negative effect on warmth perception. The mean score results showed that, the means of warmth perception for all CCTs which are 3000 K, 4000 K and 6000 K are higher than the midpoint (m=4.06 for 3000 K; m=3,8 for 4000 K; m=3.06 for 6000 K), so it can be said all CCTs have positive effect on warmth perception of red color schemed paintings (See Figure 25). However inclination of decrease from 3000 K to 6000 K regarding warmth perception can also be perceived. Thus, 3000 K and 4000 K would enhance warmth perception of red paintings further.

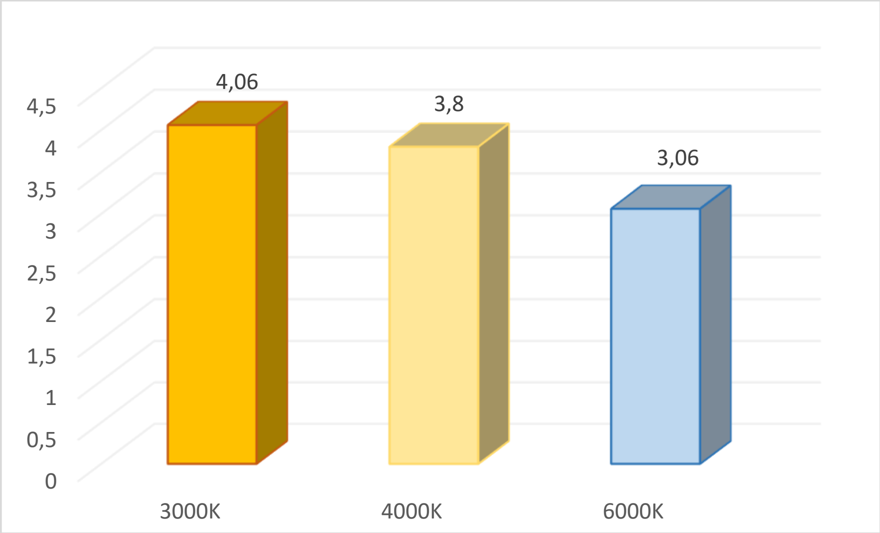


Figure 25. Mean scores of warmth state according to different CCTs for red color paintings

3.3.4.1.2. The Effects of CCT on Evaluation of Selected Word Pairs for Red Color Schemed Paintings- Brightness Perception

In order to analyze whether there was a difference between bright-dark state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding bright-dark state of the red paintings ($\chi 2=109.774$, df=2, p=0.000) (See Appendix F.9.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. Confidence level was transformed to 0.0167 by applying Bonferroni correction to

0.05 confidence level. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=1018.5, z= -7.825, p=0.000), effect of CCT of 3000 K and CCT of 6000 K (U=501.5, z= -9.552, p=0.000) and effect of CCT of 4000 K and CCT of 6000 K on brightness perception of visitors (U=2275.5, z= -3.572, p=0.000) (See Appendix F.10.). Therefore, the results indicated that there was a significant difference between lower and higher CCTs regarding perception of brightness.

In order to determine how brightness perception was affected by CCT, the mean values for all CCTs were compared. While evaluating the mean scores of the data, if the mean score is higher than the middle range (3), it signifies that the CCT has a positive effect on brightness perception. Otherwise, if the mean score is lower than the middle range (3), it indicates that the CCT has a negative effect on brightness perception. The mean score results showed that, the means of brightness perception for 4000 K and 6000 K are higher than the midpoint (m=3,65 for 4000 K; m=4.11 for 6000 K), while mean score of 3000 K are lower than the midpoint (m=2,18 for 3000 K). For 4000 K and 6000 K, it can be said that they have positive effect on perception of brightness for red paintings, while 3000 K has a negative effect (See Figure 26). Also, inclination of increase towards 3000 K to 6000 K regarding brightness perception can also be perceived.

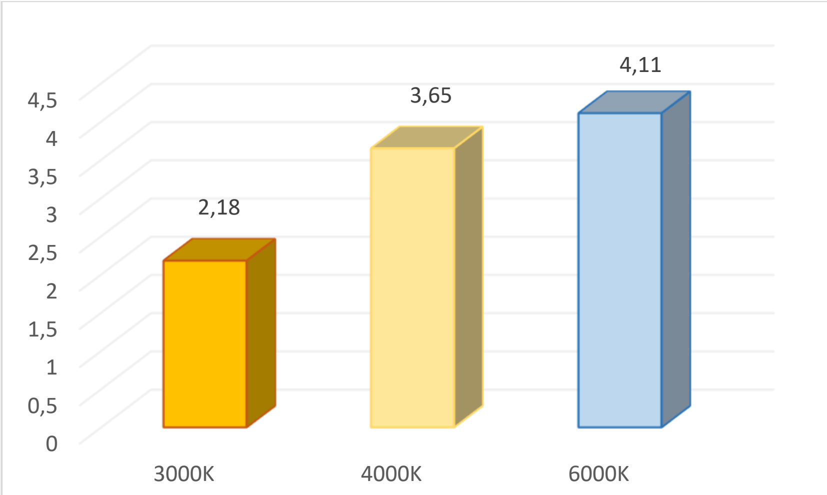


Figure 26. Mean scores of brightness state according to different CCTs for red color paintings

3.3.4.1.3. . The Effects of CCT on Evaluation of Selected Word Pairs for Red Color Schemed Paintings- Comfort Perception

In order to analyze whether there was a difference between comfortable-uncomfortable state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding comfortable-uncomfortable state of the red paintings ($\chi2=6.404$, df=2, p=0.041) (See Appendix F.9.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. Confidence level was transformed to 0.0167 by applying Bonferroni correction to 0.05 confidence level. The test results showed that there was not a significant difference between effect of CCT of 3000 K and CCT of 4000 K on comfort perception (U=3089.5, z= -0.662, p=0.508), and effect of CCT of 4000 K and CCT of 6000 K on comfort perception (U=2746.5, z= -1.851, p=0.064) while there was a significant difference between effect of CCT of 3000 K and CCT of 6000 K on comfort perception (U=2588.5, z= -2.391, p=0.016) (See Appendix F.10.). According to the results, there was a significant difference between warm and cool CCTs for the perception of comfort.

In order to determine how comfort perception was affected by CCT, the mean values for all CCTs were compared. While evaluating the mean scores of the data, if the mean score is higher than the middle range (3), it signifies that the CCT has a positive effect on comfort perception. Otherwise, if the mean score is lower than the middle range (3), it indicates that the CCT has a negative effect on comfort perception. The mean score results showed that, the means of comfort perception for 3000 K and 4000 K are higher than the midpoint (m=3,41 for 3000 K; m=3.27 for 4000 K), while mean score of 6000 K are lower than the midpoint (m=2,94 for 6000 K). For 3000 K and 4000 K, it can be said that they have positive effect on perception of comfort for red paintings, while 6000 K has a negative effect (See Figure 27). Also, inclination of decrease towards 3000 K to 6000 K regarding comfort perception can also be perceived. Thus, in red paintings 3000 K and 4000 K would increase comfort.

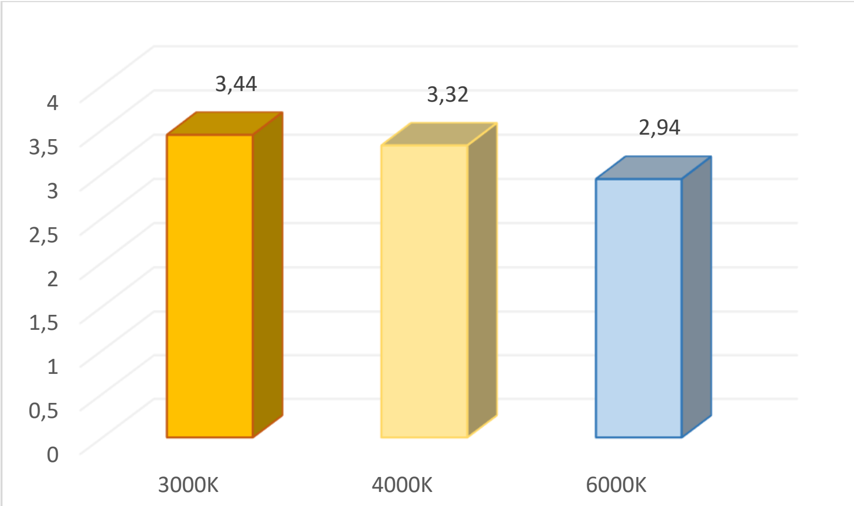


Figure 27. Mean scores of comfort state according to different CCTs for red color paintings

3.3.4.1.4. The Effects of CCT on Evaluation of Selected Word Pairs for Red Color Schemed Paintings- Pleasantness Perception

In order to analyze whether there was a difference between pleasant-unpleasant state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was not a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding pleasant-unpleasant state of the red paintings ($\chi 2=1.364$, df=2, p=0.506) (See Appendix F.9.).

In order to determine whether there is a difference between the mean scores of pleasantness affected by CCTs, mean score distributions of the data was constituted. While evaluating the mean scores of the data, if the mean score is higher than the middle range (3), it signifies that the CCT has a positive effect on pleasantness perception. Otherwise, if the mean score is lower than the middle range (3), it indicates that the CCT has a negative effect on pleasantness perception. The mean score results showed that, the means of pleasantness perception for 3000 K, 4000 K and 6000 K are higher than the midpoint (m=3,55 for 3000 K; m=3.79 for 4000 K; m=3,52 for 6000 K) (See Figure 28). Because they all are higher than the midpoint, their effect on pleasantness is found to be positive. For red paintings, all CCTs were found pleasant.

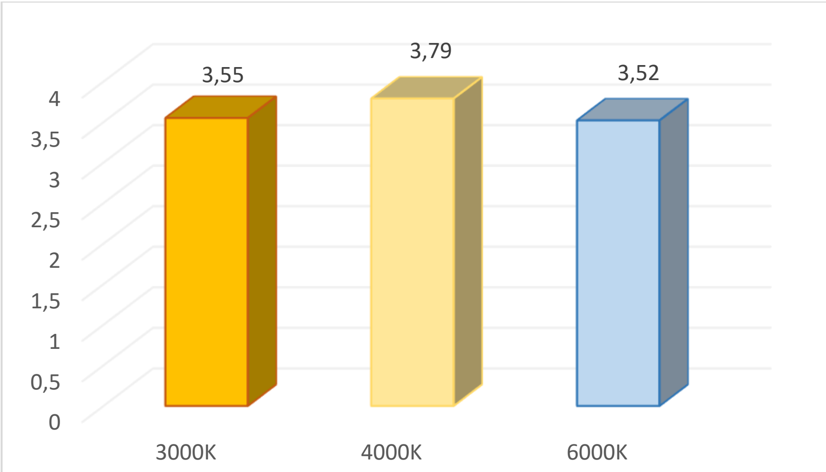


Figure 28. Mean scores of pleasantness state according to different CCTs for red color paintings

3.3.4.1.5. The Effects of CCT on Evaluation of Selected Word Pairs for Red Color Schemed Paintings- Naturalness Perception

Kruskal Wallis-H test was used to measure naturalness perception affected by CCT of light. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding natural-unnatural state of the red paintings ($\chi2$=57.467, df=2, p=0.000) (See Appendix F.9.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K ($U=2196$, $z= -3.783$, $p=0.000$), and effect of CCT of 3000 K and CCT of 6000 K ($U=2041.5$, $z= -4.333$, $p=0.000$) and 4000 K and CCT of 6000 K on naturalness perception of visitors ($U=1170.5$, $z= -7.288$, $p=0.000$) (See Appendix F.10.).

In order to determine how naturalness perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of naturalness perception for 3000 K and 4000 K are higher than the midpoint (m=3,30 for 3000 K; m=3.90 for 4000 K), while mean score of 6000 K are lower than the midpoint (m=2,58 for 6000 K) (See Figure 29). For 3000 K and 4000 K, it can be said that they have positive effect on perception of naturalness for red paintings, while 6000 K has a negative effect. Participants specified the most natural perception of red paintings were under CCT of 4000 K. In red paintings, CCTs complying with warm white or neutral white CCTs (3000 K and 4000K) seem to be tolerated for naturalness while 6000 K was found unnatural.

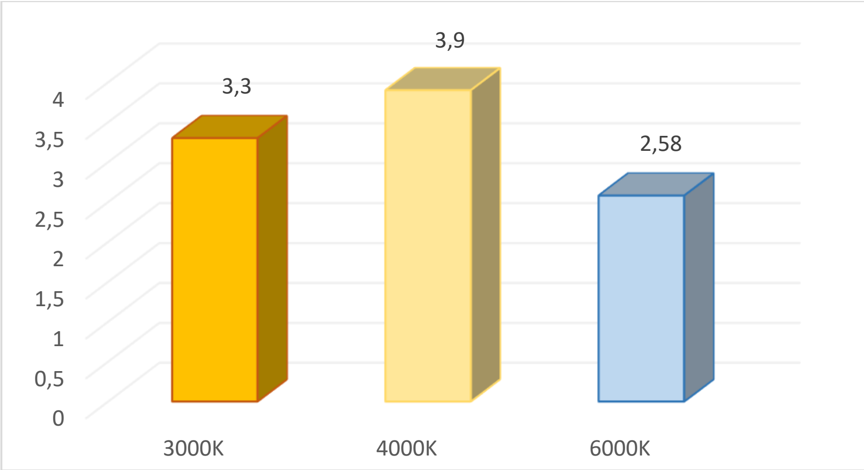


Figure 29. Mean scores of naturalness state according to different CCTs for red color paintings

3.3.4.1.6. The Effects of CCT on Evaluation of Selected Word Pairs for Red Color Schemed Paintings- Relaxation Perception

Kruskal Wallis-H test was used to measure relax perception affected by CCT of light. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding relaxing-tense state of the red paintings ($\chi 2$=22.396, df=2, p=0.000) (See Appendix F.9.).

To find out the differences caused by each CCTs, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=1991.5, z= -4.484, p=0.000), and effect of CCT of 3000 K and CCT of 6000 K (U=2349.5, z= -3.263, p=0.001), while there was not a significant difference between effect of CCT of 4000 K and CCT of 6000 K on relax perception (U=2815, z= -1.639, p=0.101) (See Appendix F.10.).

In order to determine how relax perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of relax perception for 4000 K and 6000 K are higher than the midpoint (m=3,58 for 4000 K; m=3.35 for 6000 K), while mean score of 3000 K are lower than the midpoint (m=2,81 for 3000 K) (See Figure 30). For 4000 K and 6000 K, it can be said that they have positive effect on perception of relax for red paintings, while 3000 K has a negative effect. Visitors specify the most relax perception of red paintings under CCT of 4000 K. Thus, warm white (3000 K) would intensify the already tense look of red paintings. CCT for relaxing-tense effect for red paintings should be chosen according to the conceptual aim or theme of the exhibit.

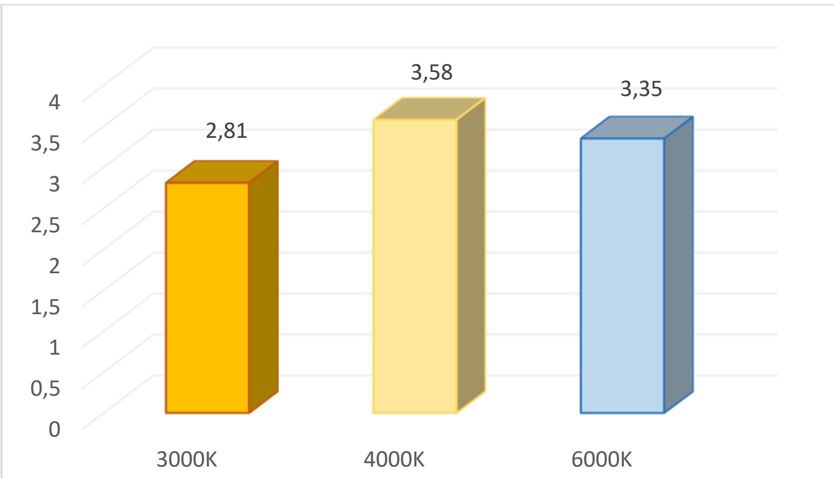


Figure 30. Mean scores of relax state according to different CCTs for red color paintings

For red paintings off all styles, mean scores of word pairs were acutely evaluated with the range of 4<m<5 as very positive, 3<m<4 as positive, m=3 is neutral, 2<m<3 as negative and 1<m<2 as very negative. Firstly, according to the results for 3000 K mean scores for evaluating the bipolar adjectives ranged from 2.18 for ‘bright-dark’ in the categorization of negative to 4.06 for ‘warm-cool’ in the categorization of very positive. Visitors specify 2 items as 'negative' (relaxing and bright), 3 items as 'positive' (natural, pleasant and comfort) and 1 item as 'very positive' (warm). Secondly, according to the results for 4000 K mean scores for word pairs ranged from 3.32 for 'comfortable-uncomfortable' to 3.9 for 'natural-unnatural' in the categorization of positive. Evaluating of all six bipolar adjectives found positive in the range between 3<m<4 for 4000 K. Lastly, the results of 6000 K showed that evaluation of bipolar adjectives ranged between 2.58 for 'natural-unnatural' in the categorization of negative to 4.11 for 'bright-dark' in the categorization of very positive. Participants specified 2 items as 'negative' (natural and comfortable), 3 items as 'positive' (warm, pleasant and relaxing) and 1 item as 'very positive' (bright) (See Figure 31).

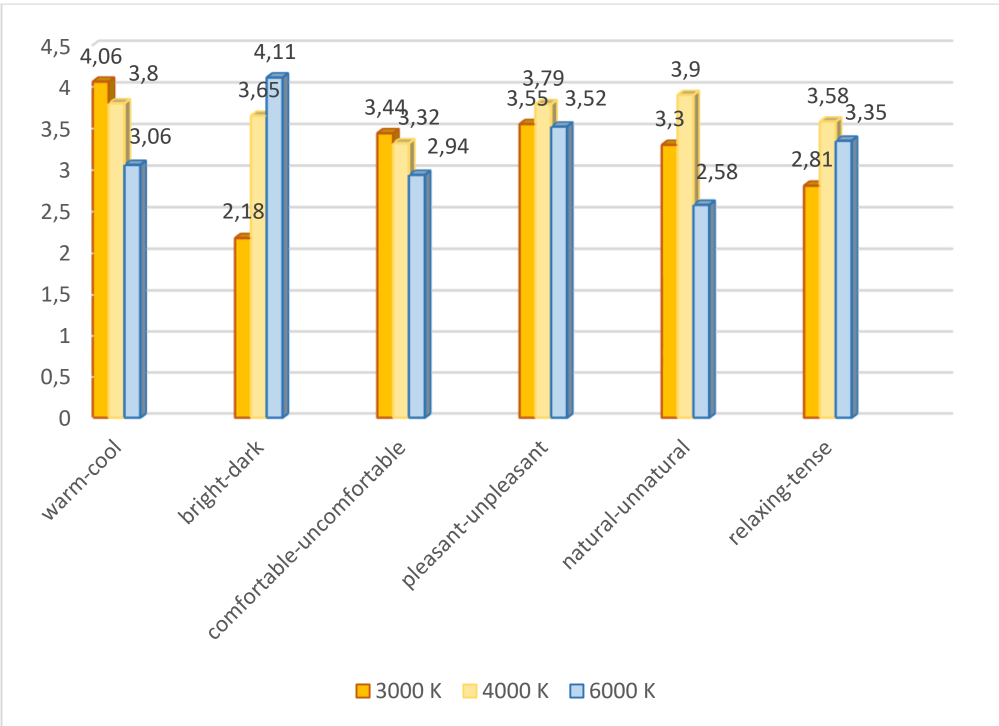


Figure 31. Mean scores of for all evaluative word pairs for red color paintings

3.3.4.2. The Effects of CCT on Evaluation of Selected Word Pairs for Blue Color Schemed Paintings

Word pair evaluation of questionnaire were done in the experiment in a way that one participant saw three same colored paintings at the same time under three CCTs and evaluate all six word pairs for each painting which illuminated by different CCTs. For each three styles, 27 participants experimented with three blue paintings illuminated by different CCTs, so 243 evaluations were done.

3.3.4.2.1. The Effects of CCT on Evaluation of Selected Word Pairs for Blue Color Schemed Paintings- Warmth Perception

In order to analyze whether there was a difference between warm-cool state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K, 4000 K and 6000 K regarding warm-cool state of the blue paintings ($\chi 2=90.636$, df=2, p=0.000) (See Appendix F.11.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results indicated that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=1450, z= -6.333, p=0.000), CCT of 3000 K and CCT of 6000 K (U=666.5, z= -8.974, p=0.000) and effect of CCT of 4000 K and CCT of 6000 K on warm-cool perception of visitors (U=2155, z= -3.937, p=0.000) (See Appendix F.12.). Therefore, the results indicated that there was a significant difference between lower and higher CCTs regarding perception of warmth.

In order to determine how warmth perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of warmth perception for 4000 K and 6000 K were lower than the midpoint (m=2.73 for 4000 K; m=1.98 for 6000 K), while mean score for 3000 K was higher than the midpoint (m=3.86 for 3000 K) (See Figure 32). Thus, it can be said for blue color schemed paintings, 4000 K and 6000 K have negative effect, while 3000 K has a positive impact. Also, inclination of decrease towards 3000 K to 6000 K regarding warmth perception can be stated.

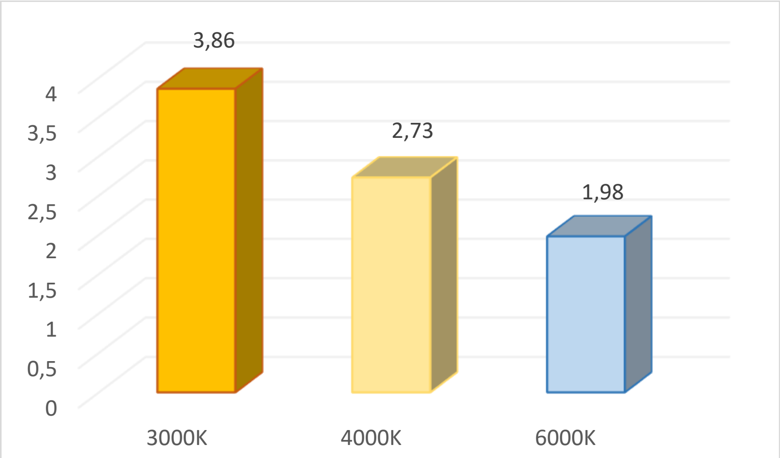


Figure 32. Mean scores of warmth state according to different CCTs for blue color paintings

3.3.4.2.2. The Effects of CCT on Evaluation of Selected Word Pairs for Blue Color Schemed Paintings- Brightness Perception

In order to analyze whether there was a difference between bright-dark state according to CCT of light for blue paintings, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are

3000 K , 4000 K and 6000 K regarding bright-dark state of the blue paintings ($\chi2$=124.441, df=2, p=0.000) (See Appendix F.11.).

To find out the differences caused by each CCTs, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=871.5, z= -8.321, p=0.000), effect of CCT of 3000 K and CCT of 6000 K (U=371.5, z= -9.994, p=0.000) and effect of CCT of 4000 K and CCT of 6000 K on brightness perception (U=1996, z= -4.561, p=0.000) (See Appendix F.12.). Therefore, the results indicated that there was a significant difference between lower and higher CCTs regarding perception of brightness.

In order to determine how brightness perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of brightness perception for 4000 K and 6000 K are higher than the midpoint (m=3,70 for 4000 K; m=4.33 for 6000 K), while mean score of 3000 K are lower than the midpoint (m=2,21 for 3000 K) (See Figure 33). For 4000 K and 6000 K, it can be said that they have positive effect on perception of brightness for blue paintings, while 3000 K has a negative effect. Also, inclination of increase towards 3000 K to 6000 K regarding brightness perception can be also perceived.

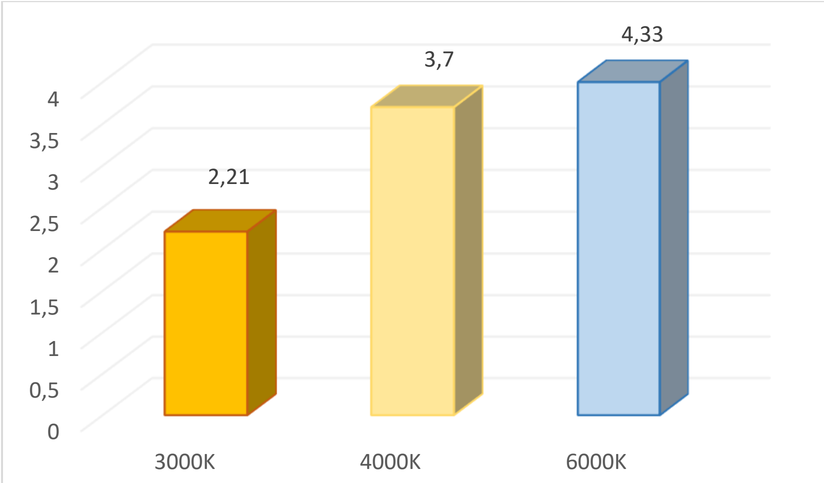


Figure 33. Mean scores of brightness state according to different CCTs for blue color paintings

3.3.4.2.3. . The Effects of CCT on Evaluation of Selected Word Pairs for Blue Color Schemed Paintings- Comfort Perception

In order to analyze whether there was a difference between comfortable-uncomfortable state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding comfortable-uncomfortable state of the blue paintings ($\chi2$=48.227, df=2, p=0.000) (See Appendix F.11.).

To find out the differences caused by each CCTs, Mann Whitney-U test was used. The test results showed that there was not a significant difference between effect of CCT of 3000 K and CCT of 4000 K on comfort perception of visitors (U=3196, z= -0.295, p=0.768), while there was a significant difference between effect of CCT of 3000 K and CCT of 6000 K (U=1517, z= -6.083, p=0.000) and CCT of 4000 K and

CCT of 6000 K on comfort perception (U=1571, z= -5.906, p=0.000) (See Appendix F.12.).

In order to determine how comfort perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of comfort perception for 6000 K is higher than the midpoint (m=3,79 for 6000 K), while mean score of 3000 K and 4000 K are lower than the midpoint (m=2,65 for 3000 K, m=2.70 for 4000 K) (See Figure 34). For 6000 K, it can be said that it has positive effect on perception of comfort for blue paintings, while 3000 K and 4000 K have negative effect. Also, inclination of increase towards 3000 K to 6000 K regarding comfort perception was observed.

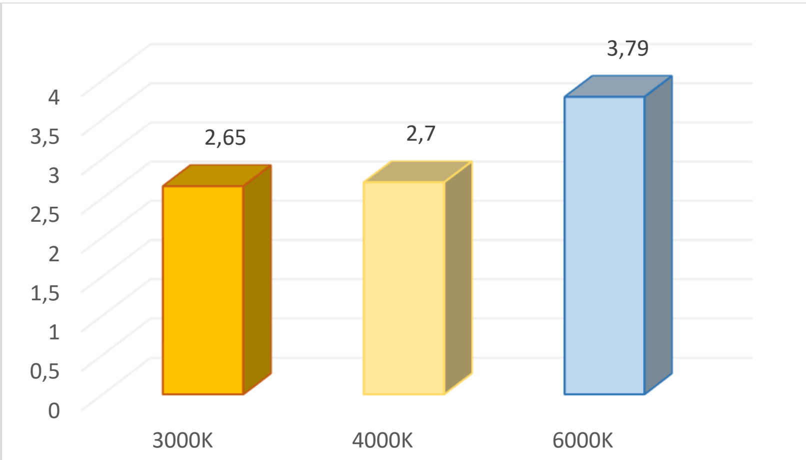


Figure 34. Mean scores of comfort state according to different CCTs for blue color paintings

3.3.4.2.4. The Effects of CCT on Evaluation of Selected Word Pairs for Blue Color Schemed Paintings- Pleasantness Perception

In order to analyze whether there was a difference between pleasant-unpleasant state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K, 4000 K and 6000 K regarding pleasant-unpleasant state of the blue paintings ($\chi2$=8.158, df=2, p=0.017) (See Appendix F.11.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K on pleasantness perception (U=2446, z= -2.893, p=0.004), while there was not a significant difference between effect of CCT of 3000 K and CCT of 6000 K (U=2811, z= -1.623, p=0.105) and CCT of 4000 K and CCT of 6000 K on pleasantness perception (U=2960, z= -1.113, p=0.266) (See Appendix F.12.).

In order to determine how pleasantness perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of pleasantness perception for all CCTs are higher than the midpoint (m=3,21 for 3000 K, m=3.67 for 4000 K, m=3.47 for 6000 K) (See Figure 35). For pleasantness state, all CCTs are found to be positive by the subjects. The most positive of all is 4000 K.

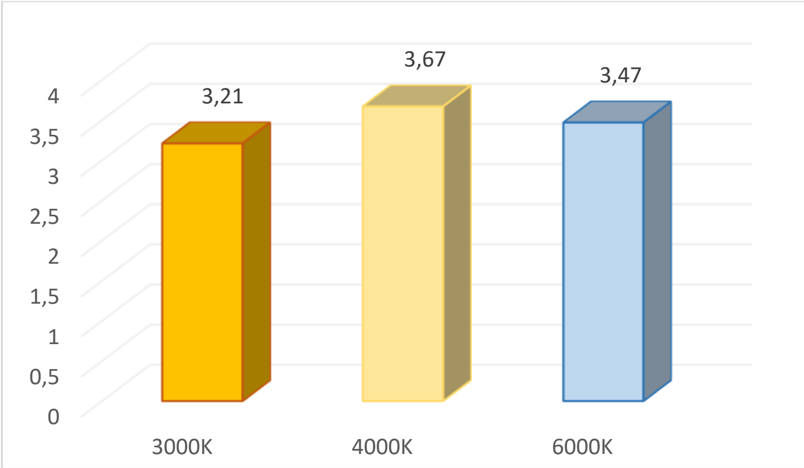


Figure 35. Mean scores of pleasantness state according to different CCTs for blue color paintings

3.3.4.2.5. The Effects of CCT on Evaluation of Selected Word Pairs for Blue Color Schemed Paintings- Naturalness Perception

In order to analyze whether there was a difference between natural-unnatural state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding naturalness state of the blue paintings ($\chi 2$=21.133, df=2, p=0.000) (See Appendix F.11.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=1996.5, z= -4.558, p=0.000) and CCT of 3000 K and 6000 K (U=2526.5 z= -2.610, p=0.009), while there was not a significant difference between effect of CCT of 4000 K and CCT of 6000 K (U=2709, z= -2.004, p=0.045) on naturalness perception (See Appendix F.12.).

In order to determine how naturalness perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of naturalness perception for all CCTs are higher than the midpoint (m=3,02 for 3000 K, m=3.84 for 4000 K, m=3.49 for 6000 K) (See Figure 36). For naturalness state, all CCTs are found to be positive. The most positive of all is 4000 K.

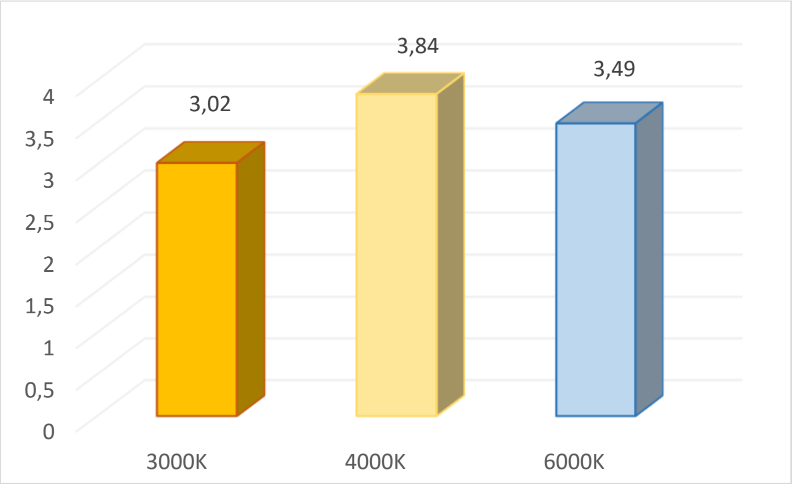


Figure 36. Mean scores of naturalness state according to different CCTs for blue color paintings

3.3.4.2.6. The Effects of CCT on Evaluation of Selected Word Pairs for Blue Color Schemed Paintings- Relaxation Perception

In order to analyze whether there was a difference between relaxing-tense state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding relax perception of the blue paintings ($\chi 2$=50.103, df=2, p=0.000) (See Appendix F.11.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=1344, z= -6.666, p=0.000), CCT of 3000 K and 6000 K (U=2109, z= -4.085, p=0.000) and CCT of 4000 K and CCT of 6000 K (U=2198, z= -3.774, p=0.000) on relax perception (See Appendix F.12.).

In order to determine how relax perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of relax perception for 4000 K and 6000 K are higher than the midpoint (m=3,83 for 4000 K, m=3.23 for 6000 K) while mean score for 3000 K is lower than the midpoint (m=2.57 for 3000 K) (See Figure 37). For relax perception, 4000 K and 6000 K have positive effect, while 3000 K affects relax state negatively.

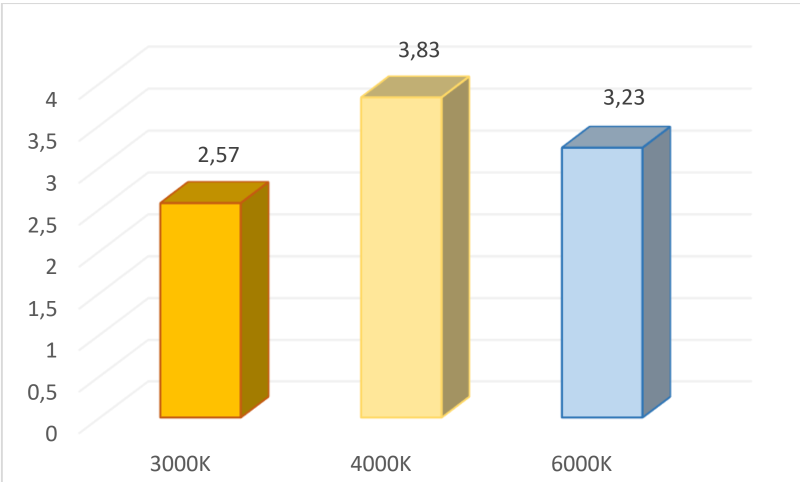


Figure 37. Mean scores of relax state according to different CCTs for blue color paintings

For blue paintings off all styles, mean scores of word pairs were acutely evaluated with the range of 4<m<5 as very positive, 3<m<4 as positive, m=3 is neutral, 2<m<3 as negative and 1<m<2 as very negative. Firstly, according to the results for 3000 K mean scores for evaluating the bipolar adjectives ranged from 2.21 for ‘bright-dark’ in the categorization of negative to 3.86 for ‘warm-cool’ in the categorization of positive. Viewers specified 3 items as ‘negative’ (relaxing, comfortable and bright), 3 items as ‘positive’ (natural, pleasant and warm). Secondly, according to the results for 4000 K mean scores for word pairs ranged from 2.70 for ‘comfortable-uncomfortable’ to 3.84 for ‘natural-unnatural’ in the categorization of positive. Evaluation of 2 bipolar adjectives found negative in the range between 2<m<3 (warmth and comfort) for 4000 K. Lastly, the results of 6000 K showed that evaluation of bipolar adjectives ranged between 1.98 for ‘warm-cool’ in the categorization of very negative to 4.33 for ‘bright-dark’ in the categorization of very positive. Participants specified 1 item as ‘very negative’ (warmth), 4 items as ‘positive’ (comfort, pleasantness, naturalness and relax) and 1 item as ‘very positive’ (brightness) (See Figure 38).

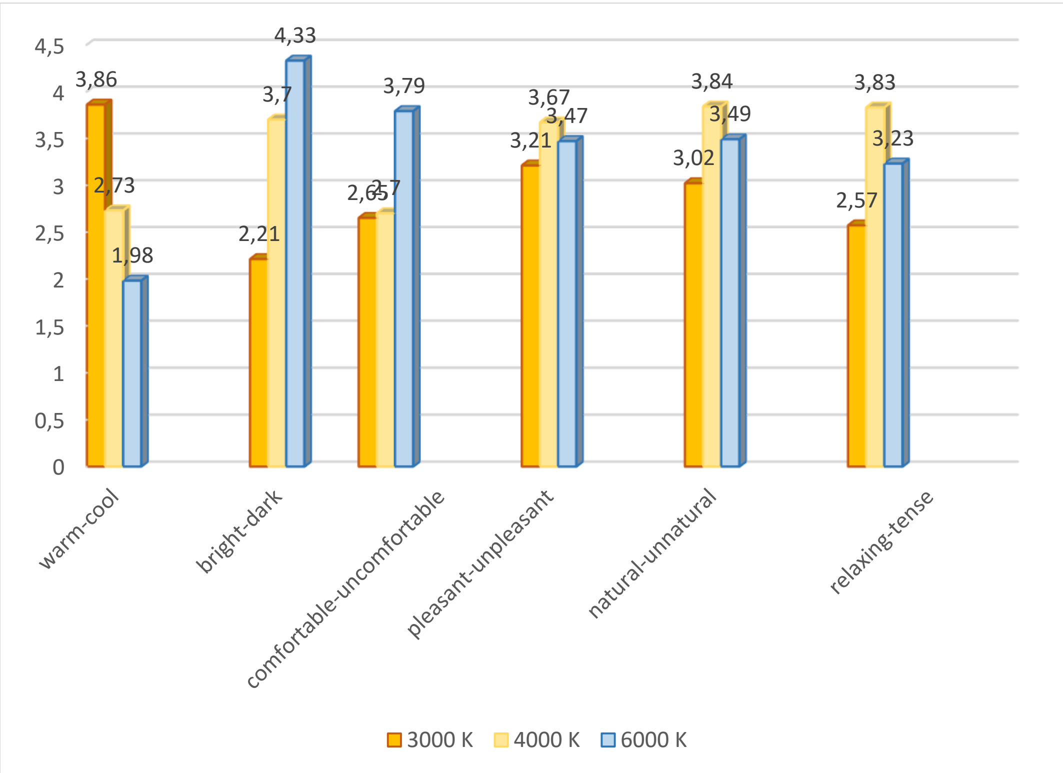


Figure 38. Mean scores of all evaluative word pairs for blue color paintings

3.3.4.3. The Effects of CCT on Evaluation of Selected Word Pairs for Neutral Color Schemed Paintings

Word pair evaluation of questionnaire were done in the experiment in a way that one participant saw three the same colored paintings at the same time under three CCTs and evaluated off all six word pairs for each painting. For each three styles, 27 participants experimented with 3 neutral paintings illuminated by different CCTs, so 243 evaluations were done regarding a word pair for neutral painting color.

3.3.4.3.1. The Effects of CCT on Evaluation of Selected Word Pairs for Neutral Color Schemed Paintings- Warmth Perception

In order to analyze whether there was a difference between warm-cool state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K, 4000 K and 6000 K regarding warm-cool state of the neutral paintings ($\chi 2=75.431$, $df=2$, $p=0.000$) (See Appendix F.13.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results indicated that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K ($U=1713.5$, $z= -5.449$, $p=0.000$), CCT of 3000 K and CCT of 6000 K ($U=870$, $z= -8.293$, $p=0.000$) and effect of CCT of 4000 K and CCT of 6000 K on warm-cool perception ($U=2170.5$, $z= -3.888$, $p=0.000$) (See

Appendix F.14.). Therefore, the results indicated that there was a significant difference between lower and higher CCTs regarding perception of warmth.

In order to determine how warmth perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of warmth perception for 6000 K is lower than the midpoint (m=2.33 for 6000 K), while mean score for 3000 K and 4000 K are higher than the midpoint (m=3.94 for 3000 K; m=3.02 for 4000 K) (See Figure 39). Thus, 3000 K and 4000 K have positive effect on warmth perception while 6000 K has a negative effect for neutral paintings. Also, inclination of decrease towards 3000 K to 6000 K regarding warmth perception can also be stated.

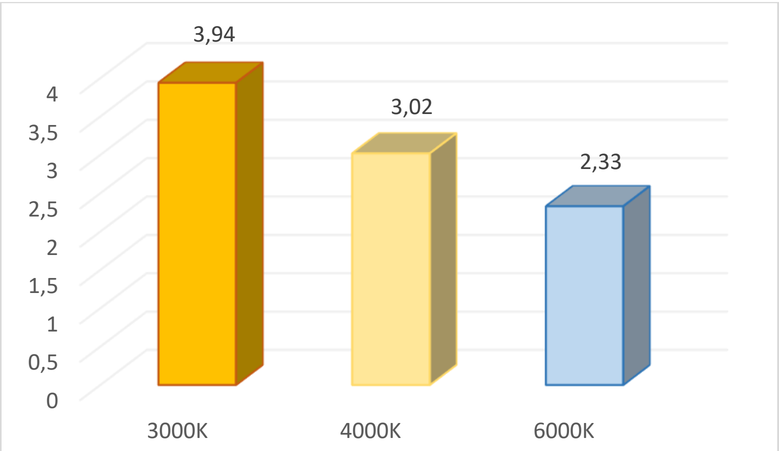


Figure 39. Mean scores of warmth state according to different CCTs for neutral color paintings

3.3.4.3.2. The Effects of CCT on Evaluation of Selected Word Pairs for Neutral Color Schemed Paintings- Brightness Perception

In order to analyze whether there was a difference between bright-dark state according to CCT of light for blue paintings, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K, 4000 K and 6000 K regarding bright-dark state of the neutral paintings ($\chi 2$=114.735, df=2, p=0.000) (See Appendix F.13.).

To find out the differences caused by each CCTs, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=1032, z= -7.772, p=0.000), effect of CCT of 3000 K and CCT of 6000 K (U=447, z= -9.729, p=0.000) and effect of CCT of 4000 K and CCT of 6000 K on brightness perception (U=2011.5, z= -4.461, p=0.000) (See Appendix F.14.).Therefore, the results indicated that there was a significant difference between lower and higher CCTs regarding perception of brightness.
In order to determine how brightness perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of brightness perception for 4000 K and 6000 K are higher than the midpoint (m=3,53 for 4000 K; m=4.21 for 6000 K), while mean score of 3000 K is lower than the midpoint (m=2,12 for 3000 K) (See Figure 40). For 4000 K and 6000 K, it can be said that they have positive effect on perception of brightness for blue paintings, while 3000 K has a negative effect. Also, inclination of increase towards 3000 K to 6000 K regarding brightness perception is observed.

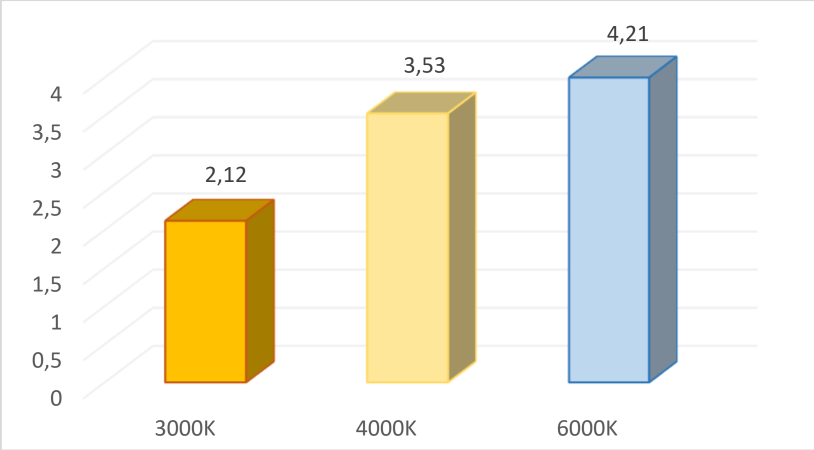


Figure 40. Mean scores of brightness state according to different CCTs for neutral color paintings

3.3.4.3.3. . The Effects of CCT on Evaluation of Selected Word Pairs for Neutral Color Schemed Paintings- Comfort Perception

In order to analyze whether there was a difference between comfortable-uncomfortable state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding comfortable-uncomfortable state of the neutral paintings ($\chi2$=14.579, df=2, p=0.001) (See Appendix F.13.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was not a significant difference between effect of CCT of 3000 K and CCT of 4000 K on comfort perception (U=3201, z= -0.279, p=0.780), while there was a significant difference between effect of CCT of 3000 K and CCT of 6000 K (U=2367.5, z= -3.179, p=0.001) and CCT of 4000 K and CCT of 6000 K (U=2306, z= -3.399, p=0.001) (See Appendix F.14.).

In order to determine how comfort perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of comfort perception for 4000 K and 6000 K is higher than the midpoint (m=3.09 for 4000 K; m=3.57 for 6000 K), while mean score of 3000 K is lower than the midpoint (m=2,97 for 3000 K) (See Figure 41). For 4000 K and 6000 K, it can be said that they have positive effect on perception of comfort for neutral paintings, while 3000 K has a negative effect. Also, inclination of increase towards 3000 K to 6000 K regarding comfort perception is observed.

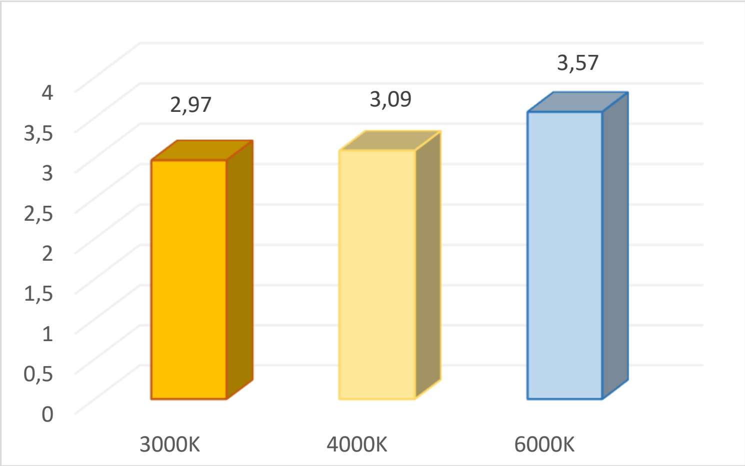


Figure 41. Mean scores of comfort state according to different CCTs for neutral color paintings

3.3.4.3.4. The Effects of CCT on Evaluation of Selected Word Pairs for Neutral Color Schemed Paintings- Pleasantness Perception

In order to analyze whether there was a difference between pleasant-unpleasant state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K, 4000 K and

6000 K regarding pleasant-unpleasant state of the neutral paintings ($\chi2$=6.917, df=2, p=0.031) (See Appendix F.13.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K on pleasantness perception (U=2510.5, z= -2.673, p=0.008), while there was not a significant difference between effect of CCT of 3000 K and CCT of 6000 K (U=2932, z= -1.209, p=0.227) and CCT of 4000 K and CCT of 6000 K on pleasantness perception (U=2895.5, z= -1.334, p=0.182) (See Appendix F.14.).

In order to determine how pleasantness perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of pleasantness perception for all CCTs are higher than the midpoint (m=3,20 for 3000 K, m=3.61 for 4000 K, m=3.38 for 6000 K) (See Figure 42). For pleasantness state, all CCTs are found to be positive. The most positive of all is 4000 K.

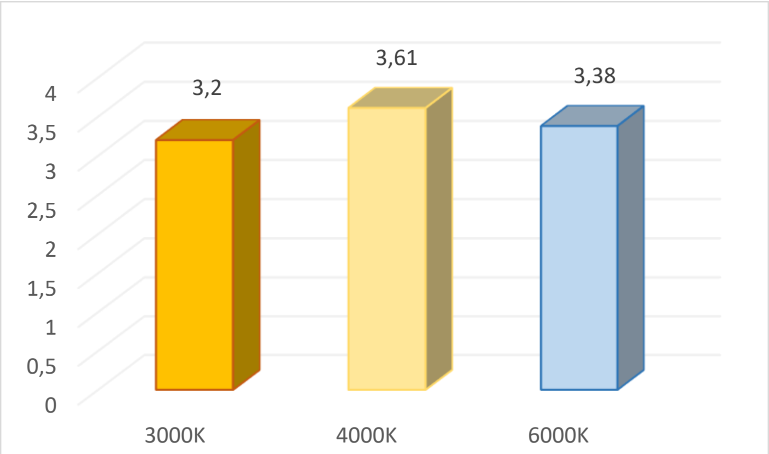


Figure 42. Mean scores of pleasantness state according to different CCTs for neutral color paintings

3.3.4.3.5. The Effects of CCT on Evaluation of Selected Word Pairs for Neutral Color Schemed Paintings- Naturalness Perception

In order to analyze whether there was a difference between natural-unnatural state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K, 4000 K and 6000 K regarding naturalness state of the neutral paintings ($\chi 2=13.727$, df=2, p=0.001) (See Appendix F.13.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=2261, z= -3.594, p=0.001) and CCT of 4000 K and 6000 K (U=2512.5 z= -2.708, p=0.007), while there was not a significant difference between effect of CCT of 3000 K and CCT of 6000 K (U=3076, z= -1.712, p=0.476) on naturalness perception (See Appendix F.14.).

In order to determine how naturalness perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of naturalness perception for all CCTs are higher than the midpoint (m=3.43 for 3000 K, m=4.02 for 4000 K, m=3.54 for 6000 K) (See Figure 43). For naturalness state, all CCTs are found to be positive. The most positive of all is 4000 K.

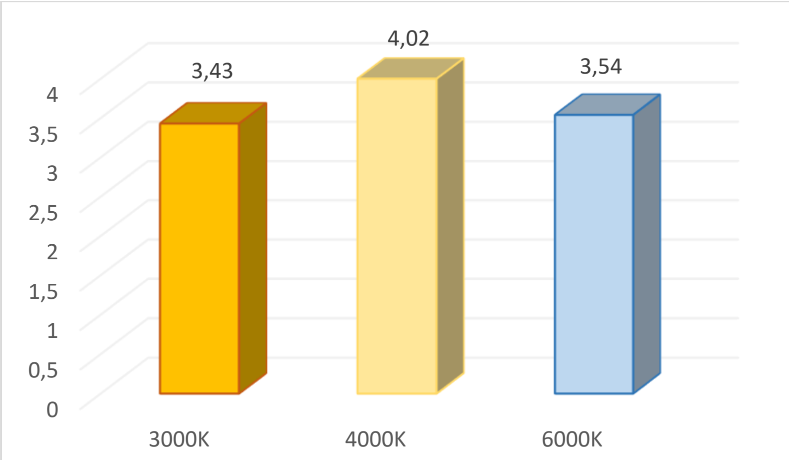


Figure 43. Mean scores of naturalness state according to different CCTs for neutral color paintings

3.3.4.3.6. The Effects of CCT on Evaluation of Selected Word Pairs for Neutral Color Schemed Paintings- Relaxation Perception

In order to analyze whether there was a difference between relaxing-tense state according to CCT of light, Kruskal Wallis-H test was used. The results indicated that there was a significant difference among three CCTs which are 3000 K , 4000 K and 6000 K regarding relax perception of the neutral paintings ($\chi 2$=43.317, df=2, p=0.000) (See Appendix F.13.).

To find out the differences caused by each CCT, Mann Whitney-U test was used. The test results showed that there was a significant difference between effect of CCT of 3000 K and CCT of 4000 K (U=1452.5, z= -6.298, p=0.000), CCT of 3000 K and 6000 K (U=2213.5, z= -3.694, p=0.000) and CCT of 4000 K and CCT of 6000 K (U=2300, z= -3.424, p=0.001) on relax perception (See Appendix F.14.).

In order to determine how relax perception was affected by CCT, the mean values for all CCTs were compared. The mean score results showed that, the means of relax perception for 4000 K and 6000 K are higher than the midpoint (m=4 for 4000 K, m=3.47 for 6000 K) while mean score for 3000 K is lower than the midpoint (m=2.73 for 3000 K) (See Figure 44). For relax perception, 4000 K and 6000 K have positive effect, while 3000 K affects relax state negatively.

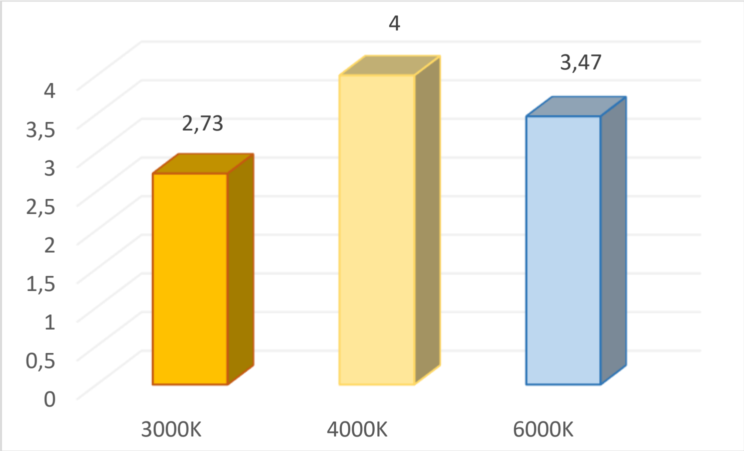


Figure 44. Mean scores of relax state according to different CCTs for neutral color paintings

For neutral paintings off all styles, mean scores of word pairs were acutely evaluated with the range of 4<m<5 as very positive, 3<m<4 as positive, m=3 is neutral, 2<m<3 as negative and 1<m<2 as very negative. Firstly, according to the results for 3000 K mean scores for evaluating the bipolar adjectives ranged from 2.12 for ‘bright-dark’ in the categorization of negative to 4.94 for ‘warm-cool’ in the categorization of positive. Viewers specified 3 items as ‘negative’ (relax, comfort and brightness), 3 items as ‘positive’ (naturalness, pleasantness and warmth). Secondly, according to the results for 4000 K mean scores for word pairs ranged from 3.02 for ‘comfortable-uncomfortable’ to 4.02 for ‘natural-unnatural’ in the categorization of very positive. Evaluation of 5 bipolar adjectives found positive in the range between 3<m<4 for

4000 K. Viewers specified 1 item as ‘very positive’ for naturalness. Lastly, the results of 6000 K showed that evaluation of bipolar adjectives ranged between 2.33 for ‘warm-cool’ in the categorization of negative to 4.21 for ‘bright-dark’ in the categorization of very positive. Participants specified 1 item as ‘negative’ (warmth), 4 items as ‘positive’ (comfort, pleasantness, naturalness and relax) and 1 item as ‘very positive’ (bright) (See Figure 45).

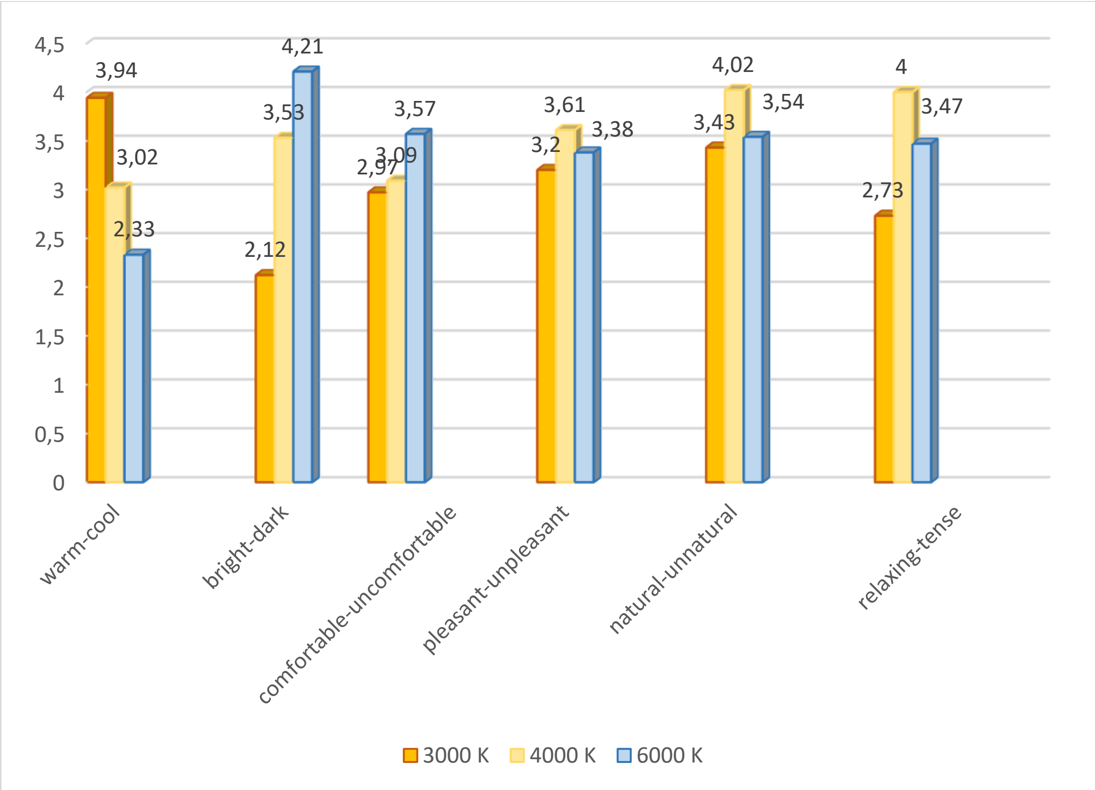


Figure 45. Mean scores of all evaluative word pairs for neutral color paintings

To see the relation between bipolar adjectives and color and CCT a table showing statistical results of the experiment was gathered (See Table 9).

Table 9. All statistical results for bipolar adjectives

		warmth	brightness	comfort	pleasantness	naturalness	relaxation
RED colored paintings	**Kruskall Wallis- H test result (3000K-4000K-6000K)**	p= 0.000	p= 0.000	p= 0.041	p= 0.506	p= 0.000	p= 0.000
	Mann Whitney U test result (3000K-4000K)	p= 0.103	p= 0.000	p= 0.508	-	p= 0.000	p= 0.000
	Mann Whitney U test result (3000K-6000K)	p= 0.000	p= 0.000	p= 0.016	-	p= 0.000	p= 0.001
	Mann Whitney U test result (4000K-6000K)	p= 0.000	p= 0.000	p= 0.064	-	p= 0.000	p= 0.101
BLUE colored paintings	**Kruskall Wallis- H test result (3000K-4000K-6000K)**	p= 0.000	p= 0.000	p= 0.000	p= 0.017	p= 0.000	p= 0.000
	Mann Whitney U test result (3000K-4000K)	p= 0.000	p= 0.000	p= 0.768	p= 0.004	p= 0.000	p= 0.000
	Mann Whitney U test result (3000K-6000K)	p= 0.000	p= 0.000	p= 0.000	p= 0.105	p= 0.009	p= 0.000
	Mann Whitney U test result (4000K-6000K)	p= 0.000	p= 0.000	p= 0.000	p= 0.266	p= 0.045	p= 0.000
NEUTRAL colored paintings	**Kruskall Wallis- H test result (3000K-4000K-6000K)**	p= 0.000	p= 0.000	p= 0.001	p= 0.031	p= 0.001	p= 0.000
	Mann Whitney U test result (3000K-4000K)	p= 0.000	p= 0.000	p= 0.780	p= 0.008	p= 0.001	p= 0.000
	Mann Whitney U test result (3000K-6000K)	p= 0.000	p= 0.000	p= 0.001	p= 0.227	p= 0.476	p= 0.000
	Mann Whitney U test result (4000K-6000K)	p= 0.000	p= 0.000	p= 0.001	p= 0.182	p=0.007	p= 0.001

To see the relation between bipolar adjectives and color and CCT a table showing negative and positive state of all word pairs was constituted (See Table 10).

Table 10. Positive-negative state of all evaluative word pairs for all colors

		warmth	brightness	comfort	pleasantness	naturalness	relax
RED	3000 K	++	-	+	+	+	-
	4000 K	+	+	+	+	+	+
	6000 K	+	++	-	+	-	+
BLUE	3000 K	+	-	-	+	+	-
	4000 K	-	+	-	+	+	+
	6000 K	- -	++	+	+	+	+
NEUTRAL	3000 K	+	-	+	+	+	-
	4000 K	+	+	+	+	++	+
	6000 K	-	++	+	+	+	+

++: very positive

+ : positive

- : negative

- -: very negative

For the general evaluation of the bipolar word pairs, a diagram showing all mean values for three CCTs and three color schemes was constituted (See Figure 46). For the warmth perception, it can be said that the decrease tendency of mean values was always towards 3000 K to 6000 K for all color schemes which are red, blue and neutral. This is to say, people perceived the paintings warmer under low and warm CCTs compared to higher levels of CCTs. Also, when mean scores were investigated for the warmth perception, it can be seen that mean scores for all CCTs decreased towards red to neutral and to blue colors (m=4,06 for 3000 K red paintings, m=3,94 for 3000 K neutral paintings and m=3,86 for 3000 K blue paintings). Warmth perception of visitors affected from color of the paintings and had a more positive relation with warm colors than achromatic and cool colors. For the brightness perception of visitors, the increase tendency of mean scores for all three color scheme paintings were towards 3000 K to 6000 K. Hence, visitors perceived the paintings brighter under high CCTs compared to lower CCT levels. When the mean scores between the different color schemes were compared it can be stated that mean scores for al CCTs increased towards red to neutral and to blue colors (m=4,11 for 6000 K red paintings, m= 4,21 for 6000 K neutral paintings and m= 4,33 for 6000 K blue paintings). Brightness perception of visitors also affected from color of the paintings and had a more positive relation with cool colors than achromatic and warm colors. According to comfort mean scores results, while in red paintings the inclination of decrease was towards 3000 K to 6000 K, it was 6000 K to 3000 K for blue and neutral paintings. For red paintings, visitors specified comfort in a decrease towards 3000 K to 6000 K. On the other hand, for blue and neutral paintings the most comfort results were taken at 6000 K while 3000 K had the lowest comfort scores. It can be said that, for the comfort perception, warm colors differed from cool and achromatic colors. Visitors of the experiment room found the paintings most pleasant under CCT of 4000 K for all three colors. However, the graph of the mean scores showed different tendencies between red colored paintings and blue and neutral paintings. Red color graph showed that pleasantness scores had a positive inclination towards 6000 K to 3000 K and to 4000 K. Visitors found 6000 K least pleasant for the red paintings. On the other side, for blue and neutral paintings 3000 K found to be least pleasant of three CCTs. At 4000 K CCT level, pleasantness mean scores were ranged as 3,79 for red paintings, 3,67 for blue paintings and 3,61 for neutral paintings. So, not only CCT but also color affect the pleasantness perception of the subjects. For the naturalness perception of the visitors 4000 K had the top ranked mean scores for all colors. Red color paintings results differentiated from blue and neutral color paintings with respect to graphic tendency. While for red color paintings visitors perceive 6000 K least natural, for blue and neutral paintings the fewest mean scores were through 3000 K. Mean scores for 4000 K for all colors were close to each other and they increased blue to red and to neutral paintings (m=3,84 for 4000 K blue paintings, m=3,9 for 4000 K red paintings and m=4,02 for 4000 K neutral paintings). Similar to naturalness results, relax perception mean scores had their maximum at CCT of 4000 K. The graph tendencies here were not differed from each other for different colors. For all three colors top ranked CCT was 4000 K while 3000 K was found to be least relax by the visitors. By evaluating mean scores for 4000 K, it can be stated that neutral color paintings had the highest mean score while red colors had the fewest (m=3,58 for 4000 K red color paintings, m=3,83 for 4000 K blue color paintings and m=4 for 4000 K neutral color paintings). To conclude, for the perception of different evaluative measures both CCT and color of the paintings had different but significant effects.

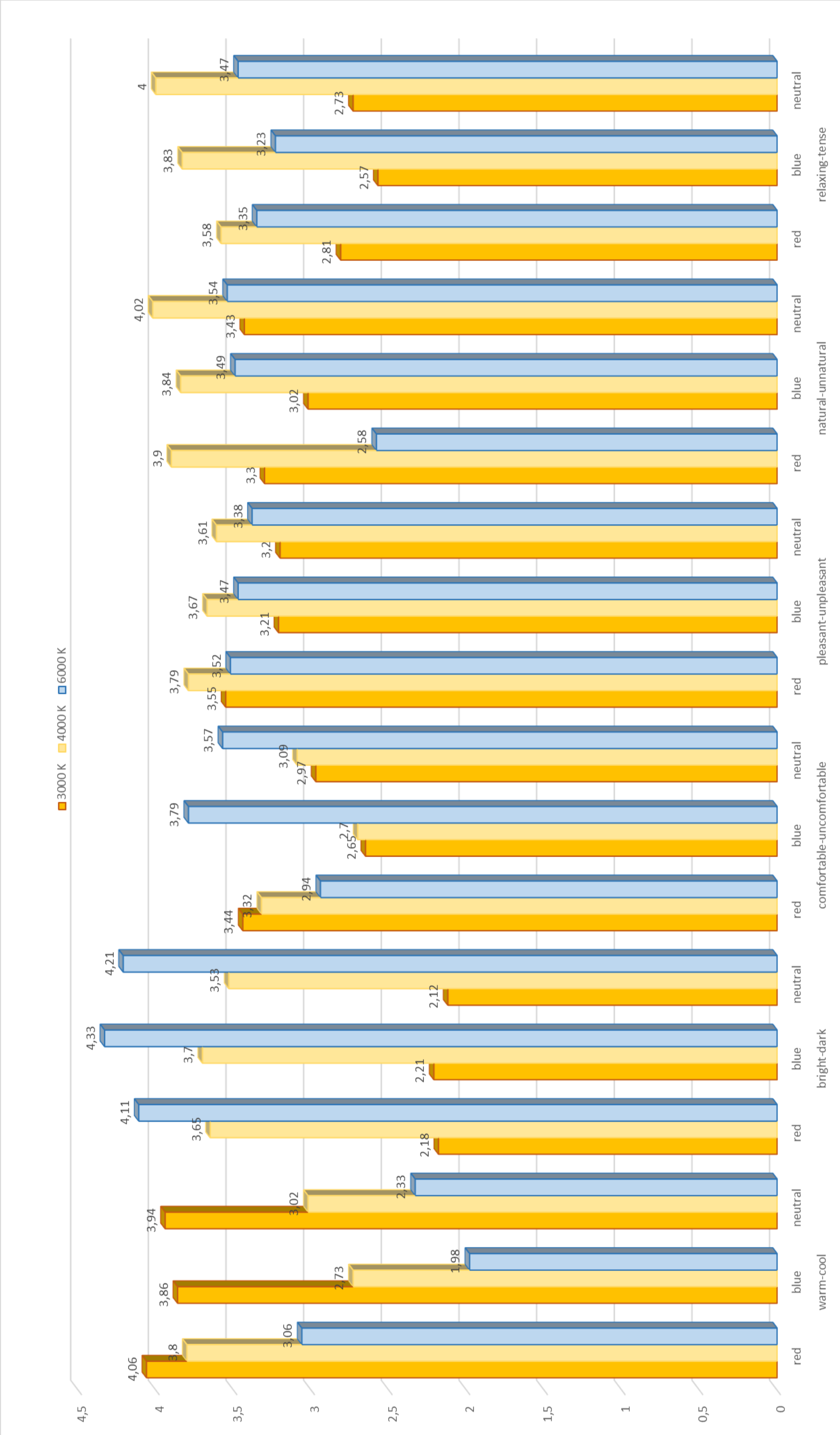


Figure 46. Mean scores of all evaluative word pairs for all colors

3.4. Discussion

In this thesis, effects of color and style of paintings on preferences of museum visitors CCT of light and relation between evaluative bipolar adjectives and CCT of light were studied. It was hypothesized that there are differences between the preferences of viewers with the changing color and style of the paintings. High color temperature were thought to be preferred while color of the painting is cool, on the other hand low color temperature were thought to be preferred when color of the painting is warm. Style of the paintings was thought to have an effect on the preference of the CCT of light. It was also hypothesized that evaluative emotional states which were warmth, brightness, comfort, pleasantness, naturalness and relax were affected the changing CCT of light. It was thought that with the higher color temperature perception of the warmth decreases while perception of brightness and relaxation increases with the rise of color temperature. It was also thought that for comfort, pleasantness and natural states CCT and color have a total effect on the visitors' choices. The differences and preferences in the museum environment were analyzed under three CCTs: 3000 K as warm white, 4000 K as neutral white and 6000 K for cool white and three colors: red as a warm color, blue as a cool color and neutral colors from achromatic color schemes.

In this study, CCT preference of viewers were tested with three styles and three colors of paintings and it was found that the most preferred CCT for all the paintings in the museum environment was 4000 K as neutral white at 200 lux illuminance level. The findings about this hypothesis indicate some similarities and differences with the literature. According to Kruithof, lower CCTs at lower illumination levels and higher CCTs at higher illumination levels make pleasing feelings possible about interior lighting. Although Kruithof did not straightly work with the museum lighting, he worked for defining optimal lighting for interiors with the aim of best cool or warm color temperature. So, founded result 4000 K at 200 lux illuminance level is parallel with the Kruithof's rule. The results of the study is also in line with the results of Chen et al. (2016), Scuello et al. (2004), Zhai et al. (2015), Zhai et al. (2016) and Khanh et al. (2017) while contradicted with the results of Pinto et al. (2008) and Masuda and Nascimento (2014). Although the experiment settings, option of the CCT of light and paintings differed from each other in all these studies the main purpose off all was to indicate most preferred CCT in museum environment while illuminating artistic paintings. In the study of Chen et al. (2016), they worked with 9 oil paintings and the pleasant area that they concluded was 2700 K-4000 K with 100 to 300 lux. Scuello et al. (2004) conducted their researches in light booth with postcard reproductions by using a fixed illuminance level of 200 lux and found 3600 K as the most preferred CCT level. Zhai et al. (2015) worked in an empty room to find the optimal illumination for museums and found 4000 K at 200 lux level as the most appropriate. Another research conducted by Zhai et al. (2016) evaluated the impact of LED lighting parameters on artwork paintings and they concluded that CCT of 3500 K was the most preferred lighting condition. In the study conducted by Khanh et al. (2017) researched about color preference of still life arrangements with different CCT levels by using multi-channel LED device and concluded that 4100 K a neutral white light was better than warm white light which was 3100 K. Pinto et al. worked about appropriate correlated color temperature for the illumination of artistic paintings with the digitalization of the 11 oil paintings. They used a computer screen to experiment with the paintings and they concluded that the most preferred CCT as 5100 K a relatively cooler color temperature. Digitalization of the experiment setting may have a different impact on the choices of the subjects. Masuda and Nascimento (2014) examined best lighting option for lighting of artistic paintings with the two experiment setting: real and monitor viewing conditions. According to the results the most preferred CCT for the paintings in monitor viewing was 5500 K and 5700 K for the real condition. Monitor viewing might affected the CCT perception of visitors and resulted in higher CCT preferences.

Second and third hypothesis are related with the effect of colors and styles of the paintings on CCT preference of visitors. According to the previous studies, visitors' preference for CCT changes with the alteration of the color of the paintings or the art objects. However for the effect of style of the paintings there is not a specific work or statement. In museums and art galleries there are temporary and also permanent painting exhibitions and thanks to the flexible lighting arrangements of the exhibition spaces illuminance and lux levels could be changed according to the requirements of the exhibition. So, style of the paintings were chosen for the study to fill the gap in the literature. It is hypothesized that with cool colors visitors prefer higher color temperature while for warm colors preference of the visitors are towards lower correlated color temperatures. And for the style, according to the changing object depictions of the chosen styles, CCT preference of the visitors are affected. Effect of color on the CCT preference was tested for the drip paintings, contemporary figurative art paintings, still life paintings separately and also for all styles totally.

The findings of the drip paintings showed that there is a significant difference between red and blue colored paintings while there is not a significant difference between red and neutral colored paintings and blue and neutral colored paintings on the CCT preference of the museum visitors. According to the CCT preference distributions results, visitors want to see warm color paintings under lower CCTs while in the case of cool color paintings the choice of visitors are towards higher CCTs. The total distribution of the drip paintings results show that, 4000 K was the most preferred CCT with the percentage of 52% while 6000 K (27%) and 3000 K (21%) were the following results.

According to the results of contemporary figurative art paintings, there was a significant difference between red and blue colored paintings and red and neutral colored paintings, while there was not a significant difference between blue and neutral colored paintings. CCT preference distributions showed that, an obvious effect difference can be stated for the red, blue and neutral colored paintings on CCT preference. While 66% of the subjects preferred 3000 K for red paintings, 59% of the subjects preferred 6000 K for blue paintings. This is to say, lower CCTs are preferred for warm colors while higher CCTs are the best choices for cool colors. The total distribution of the drip paintings results show that, 4000 K was the most preferred CCT with the percentage of 37% while 3000 K (35%) and 6000 K (28%) were the following results.

The findings of the still life paintings showed that there was a significant difference between red and blue colored paintings and red and neutral colored paintings while there was not a significant difference between blue and neutral colored paintings. According to CCT preference distributions results, there was an apparent difference among red, blue and neutral colored paintings. Similar to the other styles, lower CCTs were preferred for red colors while higher CCTs were chosen for cool colors.

The total distribution of the drip paintings results show that, 4000 K was the most preferred CCT with the percentage of 46% while 6000 K (31%) and 3000 K (23%) were the following results.

To test the effect of color on CCT preference for all styles, not specifically for one style, it was needed to understand if there is a significant difference between all three styles. Difference between styles were tested for three color schemes separately and results showed that for all three color schemes which are red, blue and neutral there was not a significant difference between the experimented styles which are drip paintings, contemporary figurative art paintings and still life paintings for CCT preference of visitors. However, according to the distributions of CCT preference among three styles there was obvious differences and tendencies. For all styles the most preferred CCT was 4000 K with different preference ratios. For drip paintings 52% of the preferences was 4000 K, for contemporary figurative art paintings it was 37% and 46% for still life paintings. For drip and still life paintings the second most preferred CCT was 6000 K a cool white light while for the contemporary figurative art paintings it was 3000 K with a 35% ratio. It can be figured out that, for the paintings composed of facial depictions museum visitors prefer lower and warmer CCTs and dominant color and CCT preference relation is stronger and clear. In the case of paintings having no object depictions and having object depictions like vegetable, fruit, pots etc., museum visitors are in favor of more neutral and cool CCTs. Viewers preferred CCTs with respect to the nature of the color of the paintings.

Artists may want to emphasize objects, patterns or total scenes with color dominancy on their paintings. If an artist want to give an object with red color prominence in the painting, this emphasis could be reinforced with a lower CCT display lighting. The results of current study promote this idea in a way that observers tend to prefer color temperatures that enable and emphasize to see nature of the dominant color of the paintings.

The findings of the study support previous studies about the effect of color on CCT preference part. In the study that Scuello et al. (2004) worked with the postcard reproductions in light booth to evaluate CCT preference of visitors they used different colors to test effect of color. According to their results, in line with this study, it was stated that there was a relation between illumination and dominant color of the painting. The results showed that, cool colored paintings had a positive perception under cooler color temperature, while warm colored paintings under warm color temperature were more liked by observers. Another study conducted by Manav (2007) worked on the appraisal of the visual environment at offices in relation to color temperature and illuminance. Although experiment setting and the aim was different from the current study, Manav indicated about color and CCT relation that particularly warm colors were noticed as more saturated at lower CCTs. Liu et al. (2017) indicated that people mostly choose lighting conditions that enable to see the objects more saturated. The results of current study is in line with the study of Liu et al. with the inference of participants lighting preference tendency is towards lighting conditions that enable the illuminated objects more saturated.

Results of Hong et al. (2017) are also in line with the current study. They stated that at lower CCTs visibility of red, yellow and yellow red colors are good while purple, blue, blue green, green and green yellow colors have good visibility under higher CCTs.

In the research conducted by Liu et al. (2017) the effect of different correlated color temperature on color preference were examined. They used a variety of objects which were different colored fruits and vegetables, Chinese calligraphies with different colors, mural paintings, a Van Gogh painting, a Chinese traditional painting, modern oil painting and multicolor flowers. They concluded about relation between color and CCT, but style of the object or painting and CCT could not be reached. With parallel to current study, they stated that people prefer cool and higher CCTs for cool colors while they prefer warm and lower CCT for warm colors.

Fourth hypothesis is related with the relation between CCT and evaluative emotional states which are warmth, brightness, comfort, pleasantness, naturalness and relaxation. For red, blue and neutral paintings regardless of their styles bipolar adjective evaluation were done independently in order to see if there was a difference between effect of CCT of light and perceptions of visitors. For all colors, it was hypothesized as warmth perception increases with the decrease of the color temperature warmer-reddish appearance of light. The findings had similar results for all colors as people perceived the paintings warmer under low and warm CCTs compared to higher levels of CCTs. Also, according to mean score results there were slight differences among colors of paintings and perception of warmth. It could be seen that mean scores for all CCTs decreased towards red to neutral and to blue colors (m=4,06 for 3000 K red paintings, m=3,94 for 3000 K neutral paintings, m=3,86 for 3000 K blue paintings). Therefore, it can be stated that both CCT and color of the painting affect warmth perception. These results are in line with the previous works which indicate that lower CCTs were preferred for warmth perception (Vienot et al., 2009; Chen et al., 2016; Luo et al., 2013; Zhai et al. 2015).

For the brightness perception of visitors, it was hypothesized as brightness perception increases with the increase of CCT level. The increase tendency of mean scores for all three color scheme paintings were towards 3000 K to 6000 K. Hence, visitors perceived the paintings brighter under high CCTs compared to lower CCT levels despite the fixed illuminance. When the mean scores between the different color schemes were compared it can be stated that mean scores for al CCTs increased towards red to neutral and to blue colors (m=4,11 for 6000 K red paintings, m= 4,21 for 6000 K neutral paintings and m= 4,33 for 6000 K blue paintings). Brightness perception of visitors also affected from color of the paintings and had a more positive relation with cool colors than achromatic and warm colors. Current results are analogous with the previous results which stated that brightness perception increases with a higher CCT (Baniya et al.,2015; Kim et al.,2015; Ju et al., 2011; Vienot et al., 2009; Luo et al., 2013). On the other hand, this study also contradicts previous studies which stated that CCT almost has no effect on brightness perception while it affected positively from the illuminance level (Chen et al., 2016; Zhai et al., 2015). At same illuminance level, cool appearance that can be obtained with the higher CCT levels may result in higher brightness perception, however higher brightness perception due to the higher illuminance levels is an accurate result. So, results of the studies related with the effect of both illuminance and CCT levels on brightness perception are affected the difference of experimental design which is a determinant factor. Experiment setting, application of the experiment and the way brightness perception is measured may affect the obtained results.

For the comfort perception it was hypothesized that comfort perception increases with the decrease of the color temperature for red colors while for the neutral and blue colors the hypothesis was comfort perception increases with the increase of the color temperature. The results of the comfort perception support the hypothesis. According to the findings of comfort perception, while in red paintings the tendency of decrease was towards 3000 K to 6000 K, it was 6000 K to 3000 K for blue and neutral paintings. Color and CCT affect the comfort perception together. For warm colors, comfort perception needs lower CCTs, while achromatic and cool colors comfort perception can be supplied with higher CCTs according to the results. In other words, for obtaining comfort perception CCT should be comply with the existent dominant color scheme of the painting. In previous studies, comfort perception was not found associated with color differentiation. Although in this study red painting was most comfortable under 3000 K a warm white, and neutral and blue paintings were most comfortable under 6000 K, previous studies have different results. Baniya et al. (2015) stated that for visual comfort the preferred lighting conditions was 750 lux with 4000 K CCT of light in office environments. In Manav's study experimented in office environment resulted that 4000 K was chosen for comfort. In the study of Vienot et al. it was concluded that in case of comfort lower CCTs were preferred more. According to Chen et al. (2016), comfort were related with the illuminance not the CCT. According to the results of Zhai et al. (2015) with the rise of CCT comfort perception was negatively affected. For comfort perception related with lighting condition, chosen experimental activity is important and determinant. For example, in case of office environments, comfort of task performance and attention of the employees is the major concern while in museum spaces comfort perception is related with viewing conditions of the art object. So, differences and similarities with the literature for comfort basically due to the difference of the activity.

Pleasantness state of the visitors was hypothesized as pleasantness increased with the decrease of the color temperature for red colors and increased with the increase of the color temperature for neutral and blue colors. According to the results, all three color paintings were found to be the most pleasant under 4000 K. But among colors, there are different tendencies from mean scores. Red colors differentiate from neutral and blue colors with respect to mean scores. Although pleasantness state was mostly favored in 4000 K CCT for all colors, visitors found 6000 K least pleasant for red paintings while for neutral and blue paintings 3000 K was found to be the least pleasant. Therefore, color have a relatively small impact on the pleasantness perception. There are different results about the pleasantness perception in the literature. Baniya et al. (2015) indicated that for pleasantness the preferred lighting conditions was 750 lux with 4000 K CCT in office environments. According to Vienot et al. (2009) for pleasantness lower CCTs were preferred more. Similar to these results Zhai et al. (2015) stated that with the rise of CCT pleasantness perception was negatively affected. Different from current study, previous studies related with the pleasantness perception did not deal with the effect of color. If they used color as an independent variable for assessing pleasantness, they could indicated different results with the changing color scheme. Also, for stating pleasantness activity and experimental study are crucial factors.

Naturalness state was hypothesized as naturalness perception increases with the decrease of the color temperature for red colors and increases with the increase of the color temperature for neutral and blue colors. According to the results, for the naturalness perception of the visitors 4000 K had the top ranked mean scores for all colors. Therefore for all colors, a neutral white CCT is the most pleasant. However, among colors there were slight differences. While for red color paintings visitors perceive 6000 K least natural, for blue and neutral paintings the fewest mean scores were through 3000 K. In the literature, there was not found naturalness perception according to color differentiation. There are studies that contradicted with and in line with the current study about naturalness perception. Baniya et al. (2015) had a similar result about naturalness and found 4000 K as most natural. Masuda and Nascimento (2013) concluded that 6040 K was found to be most natural contradicted with the current study. Zhai et al. (2015) indicated that with the rise of CCT naturalness perception was negatively affected. Used objects, color and environment can be very influential on the difference of naturalness perception results.

Relax state of visitors in museum environment was hypothesized as relax perception increases with the increase of the color temperature for all colors. According to the results, 4000 K has the top ranked score for relax perception for all colors. The graph tendencies here did not differ from each other for different colors. For all three colors top ranked CCT was 4000 K while 3000 K was found to be least relaxing by participants. It can be concluded about relaxation perception that, color does not have an effect and natural and cool white lights are more preferable instead of warmer color temperatures. Current study mostly contradicted with previous studies about relaxation perception. Manav (2007) stated that 2700 K a warm white light was preferred for relaxation. Wang et al. (2016) indicated that lower CCTs were preferred for relaxing activities. Vienot et al. (2009) stated that in case of relax lower CCTs were preferred more. In the study of Zhai et al. (2015) conducted in a museum environment resulted that with the rise of CCT relaxation perceptions were negatively affected. For the relaxation perception of the visitors 4000 K had the top ranked mean scores for all colors. Different from contradicted studies, in current study, a fixed illuminance level was used and participants might found 4000 K at 200 lux as the most relaxing. Experimented activity and experiment setting may also have an effect on different results. Besides, as a limitation of placing the LED spot fixtures a fixed order, 4000 K was always at the middle, may affect the relaxation results. Participants may tend to choose the medium CCT both for location and also visibility for relaxation.

CHAPTER IV

CONCLUSION

The effect of color and style of art paintings on CCT preferences of visitors and the effect of color and CCT on evaluative emotional states (warmth, brightness, comfort, pleasantness, naturalness and relaxation) were explored in an experiment room that was set up as a small exhibit. The results of the statistical analysis of this study indicated that the most preferred CCT for illuminating art paintings in museum environment is 4000 K, a neutral white light. The general indication that could be done about the CCT preference results is visitors want to see warm color paintings under lower CCTs while in the case of cool color paintings the choice of visitors are towards higher CCTs. It can be stated about style of the paintings that choosing CCTs harmonious with the nature of the painting color is most obvious in the contemporary figurative art paintings with facial depictions. According to the evaluative emotional states results, for all bipolar adjectives both color and CCT had an impact. For warmth perception, visitors perceived a painting warmer when the CCT is lower and color of the painting is warmer. For brightness state, results of the study showed that brightness perception increases with the increase of the CCT level. Brightness perception of visitors was also affected from color of the paintings and had a more positive relation with cool colors than achromatic and warm colors. For warm colors, comfort perception needs lower CCTs, while achromatic and cool colors comfort perception can be supplied with higher CCTs according to the results. For all colors, pleasantness perception was mostly favored at 4000 K CCT. There were slight differences between colors about pleasantness perception as visitors found 6000 K least pleasant for red paintings while for neutral and blue paintings 3000 K was found to be the least pleasant. While for red color paintings visitors perceive 6000 K least natural, for blue and neutral paintings the fewest mean scores were through 3000 K. For all three colors top ranked CCT was 4000 K while 3000 K was found to be least relaxing by visitors.

This study is important because there are not any works integrating both color and style of the art objects on CCT preference. Also for the evaluative emotional states although there were studies about effect of CCT on bipolar adjectives, there are not any studies combining effect of color and CCT. Therefore, the results of this study fill the gap in the literature about the effects of color and style on CCT preference and effects of color and CCT on evaluative emotional states.

The findings of the study can be useful for administrative staff of museums and art galleries, museum curators, lighting designers and interior architects while designing a museum gallery or exhibit environment. It is also beneficial for museum visitors getting pleasure from the exhibition and specially exhibited objects. Visitors are most concerned with object form and perception of true color. Thus, to recognize the relation of color and style of the art paintings with the CCT of light, it is essential to create proper and beneficial museum environments.

The study is conducted in an experiment room that was set up as a small exhibit and with university students. One limitation for this research is not being able to use a real museum or gallery space and real museum visitors. The psychological situation and responses of participants might be affected from the real environment. Nevertheless, it is believed that this study would be reliable for answering basic perceptual preferences between people and complex objects in terms of lighting. Another limitation is purposefully fixing the illuminance level of the lighting fixtures for analysis concerns. More results can be derived for display lighting with the usage of combinations of different CCT and illuminance levels.

In future studies, a similar experiment can be conducted in real environments and more color and painting options and differentiated illuminance levels can be used. Items and number of participants could be increased for future studies. Also, the effect of demographic state of the visitors which can be age, gender, having design base professional or not on the preference of display lighting can be investigated in detail.

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APPENDIX A

THE QUESTIONNAIRE

APPENDIX A.1. Questionnaire (in Turkish).

Ad-Soyad:
Yaş:
Cinsiyet: □ K □ E
Okul:
Bölüm:
Sınıf:
Göz bozukluğunuz var mı? Varsa ne olduğunu belirtiniz.
………………………………………………………..

RESİM-1

A) Karşınızdaki duvarda birbirinin aynısı ve 3 farklı ışık ısısı(CCT) ile aydınlatılmış aynı renk yoğunluğunda resimler bulunmaktadır. Bu resmi bu ışıklardan hangisi altında görmeyi tercih edersiniz?

1) □ 2) □ 3) □

B) Aşağıdaki her bir sıfat çifti için en soldaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

C) Aşağıdaki her bir sıfat çifti için ortadaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

D) Aşağıdaki her bir sıfat çifti için en sağdaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

RESİM-2

A)Karşınızdaki duvarda birbirinin aynısı ve 3 farklı ışık ısısı(CCT) ile aydınlatılmış aynı renk yoğunluğunda resimler bulunmaktadır. Bu resmi bu ışıklardan hangisi altında görmeyi tercih edersiniz?

2) ☐ 2) ☐ 3) ☐

B) Aşağıdaki her bir sıfat çifti için en soldaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

C) Aşağıdaki her bir sıfat çifti için ortadaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

D) Aşağıdaki her bir sıfat çifti için en sağdaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

RESİM-3

A) Karşınızdaki duvarda birbirinin aynısı ve 3 farklı ışık ısısı(CCT) ile aydınlatılmış aynı renk yoğunluğunda resimler bulunmaktadır. Bu resmi bu ışıklardan hangisi altında görmeyi tercih edersiniz?

1) ☐ 2) ☐ 3) ☐

B) Aşağıdaki her bir sıfat çifti için en soldaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

C) Aşağıdaki her bir sıfat çifti için ortadaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

D) Aşağıdaki her bir sıfat çifti için en sağdaki ışık kaynağı ile aydınlatılan resmi nasıl bulduğunuza dair size en uygun olan değeri işaretleyiniz.

	5	4	3	2	1	
sıcak						soğuk
doğal						yapay
gevşetici						yorucu
hoş						hoş değil
etkileyici						etkileyici değil
aydınlık						karanlık

APPENDIX A.2. Questionnaire (in English).

Name-Surname:
Age:
Gender: F M
School:
Department:
Class:
Do you have any eye deficiencies? If yes, state below.
………………………………………………………..

PICTURE -1

E) On the wall across to you, there are same pictures with same color scheme illuminated by three different correlated color temperatures. On which lighting condition, do you prefer to see the picture?

3) ☐ 2) ☐ 3) ☐

F) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the leftmost light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

G) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the central light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

H) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the rightmost light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

PICTURE -2

A) On the wall across to you, there are same pictures with same color scheme illuminated by three different correlated color temperatures. On which lighting condition, do you prefer to see the picture?

4) ☐ 2) ☐ 3) ☐

B) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the leftmost light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

C) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the central light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

D) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the rightmost light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

PICTURE -3

A) On the wall across to you, there are same pictures with same color scheme illuminated by three different correlated color temperatures. On which lighting condition, do you prefer to see the picture?

5) ☐ 2) ☐ 3) ☐

B) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the leftmost light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

C) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the central light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

D) For each adjective pair below, please mark the most appropriate value for how you found the picture illuminated by the rightmost light source.

	5	4	3	2	1	
warm						cool
natural						unnatural
relaxing						tense
pleasant						unpleasant
comfortable						uncomfortable
bright						dark

APPENDIX B

WORD PAIRS FROM THE LITERATURE

Table 11. Adjective pairs from Zhai et al (2015).

Appearance	**Atmosphere**
High Contrast- Low Contrast	High Quality-Low Quality
Warm-Cool	Active-Negative
Bright-Dark	Relaxed-Tense
Clear-Unclear	Soft-Hard
Colorful-Dull	Artistic-Business
Natural-Artificial	Lively-Boring
	Comfortable-Uncomfortable
	Pleasant-Unpleasant

Table 12. Adjective pairs from Chen et al. (2015).

Colorful-Dull	Natural-Unnatural
Bright-Dark	Active-Passive
Clear-Blurry	Classic-Modern
Warm-Cold	Comfortable-Uncomfortable
Relaxing-Tense	High Visibility-Low Visibility
Soft-Hard	Lively- Boring
Pleasant-Unpleasant	

Table 13. Adjective pairs from Vienot et al. (2009)

Non Glaring- Glaring	Dull-Cheerful
Dark-Bright	Tiring-Relaxing
Cold-Warm	Uncomfortable-Comfortable
Artificial Color Rendering-Natural Color Rendering	Unpleasant-Pleasant
Crepuscular-Clear	

Table 14. Adjective pairs from Luo et al. (2013)

Pleasant-unpleasant	Warm-cool
Comfortable-uncomfortable	Colorful-dull
Active-passive	Bright-dark
Relax-tense	Clear-crepuscular
Soft-hard	Natural-unnatural
Modern-classic	

APPENDIX C

PHOTOGRAPHS OF THE EXPERIMENT SETTING WITH DIFFERENT STYLES AND COLORS

Figure 47. Example participant in the experiment setting observing blue drip paintings.

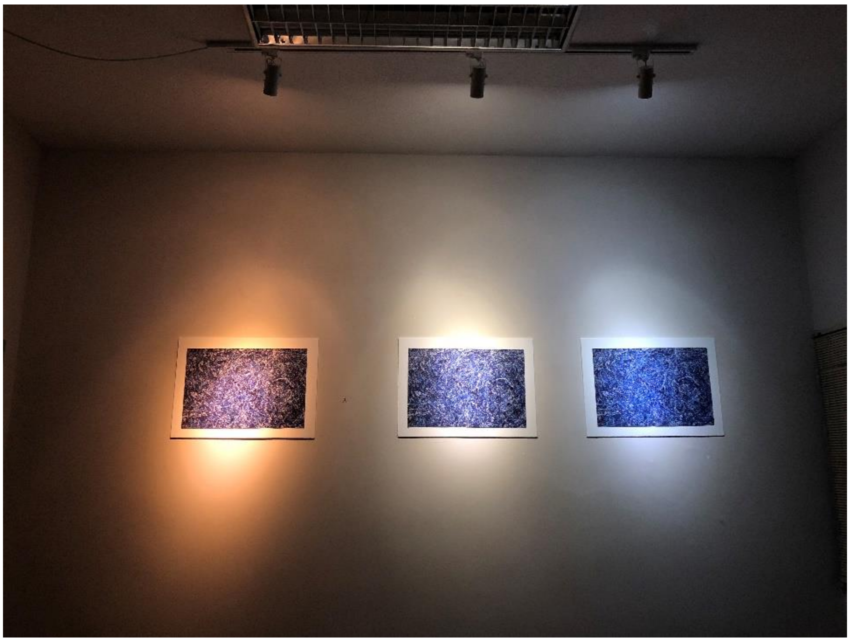

Figure 48. A view from experiment with blue drip paintings.

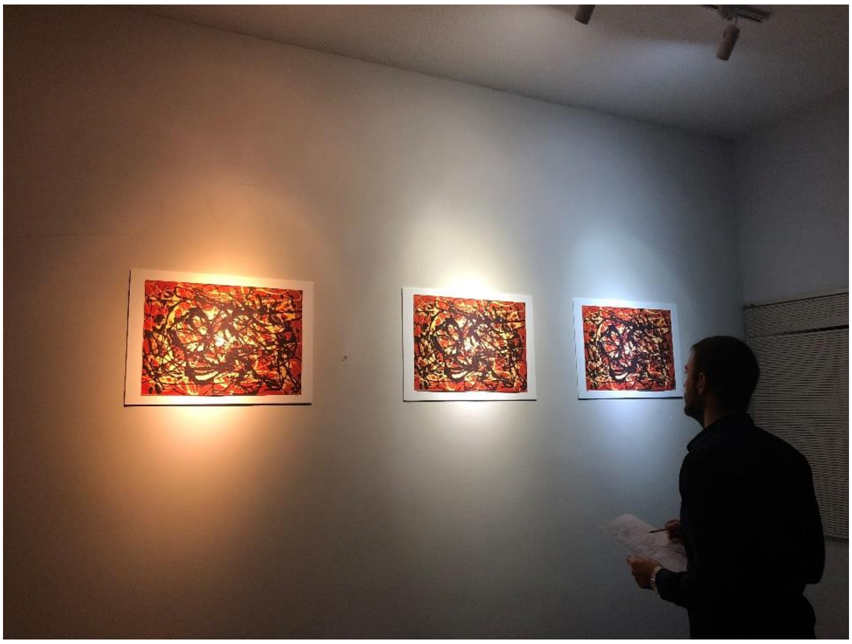

Figure 49. Example participant in the experiment setting observing red drip paintings.

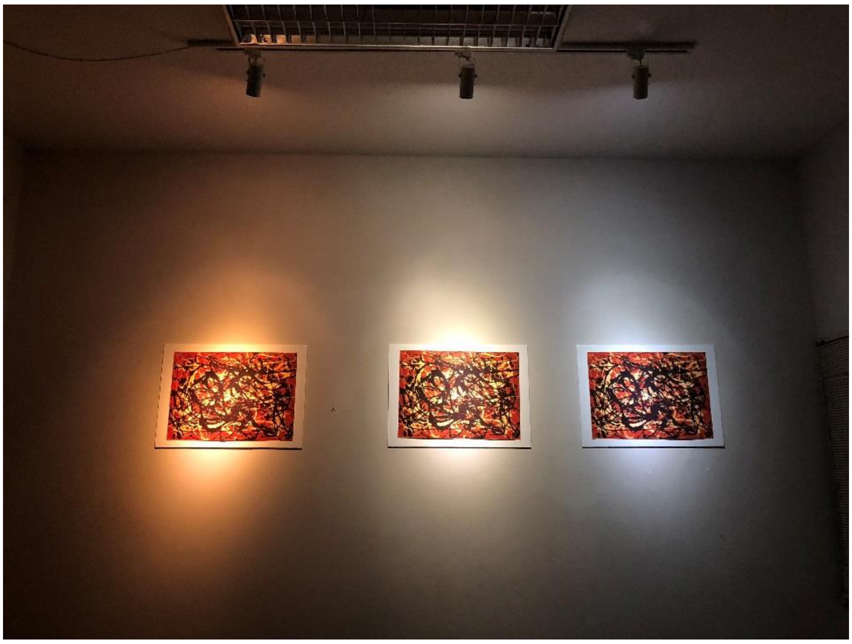

Figure 50. A view from experiment with red drip paintings.

Figure 51. Example participant in the experiment setting observing neutral drip paintings.

Figure 52. A view from experiment with neutral drip paintings.

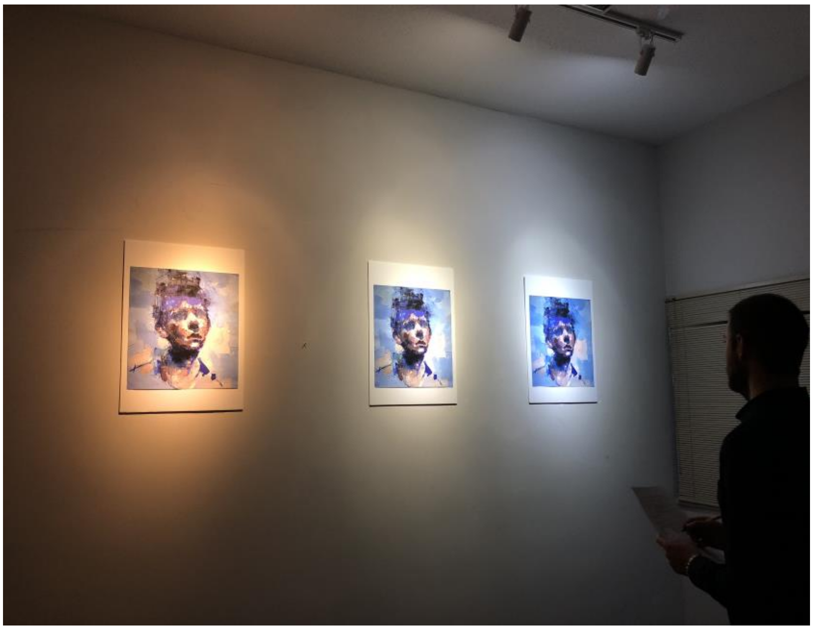

Figure 53. Example participant in the experiment setting observing blue contemporary figurative art paintings.

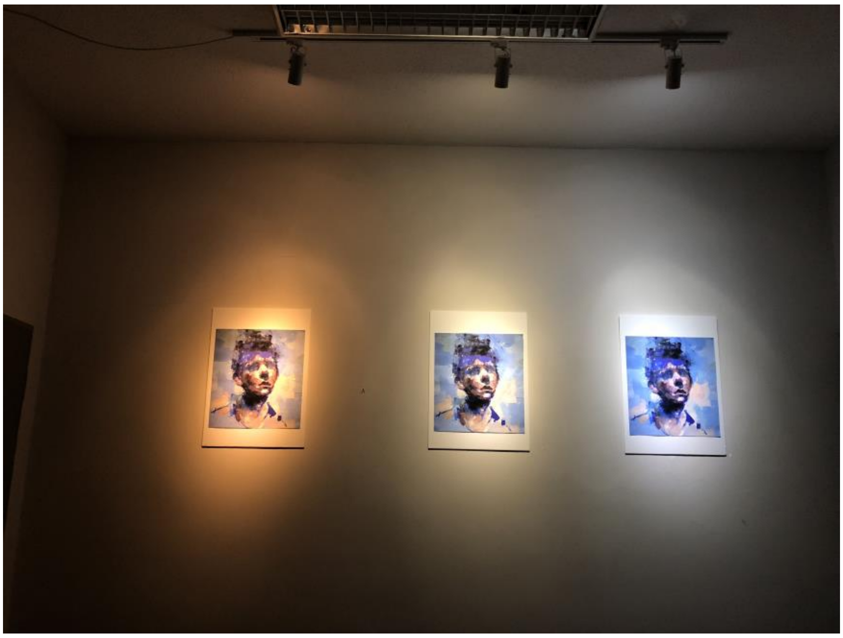

Figure 54. A view from experiment with blue contemporary figurative art paintings.

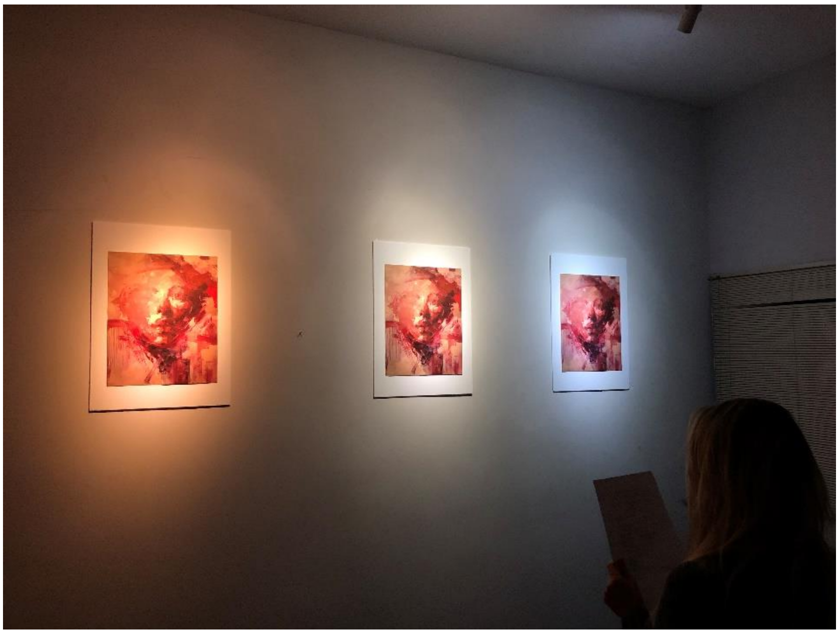

Figure 55. Example participant in the experiment setting observing red contemporary figurative art paintings.

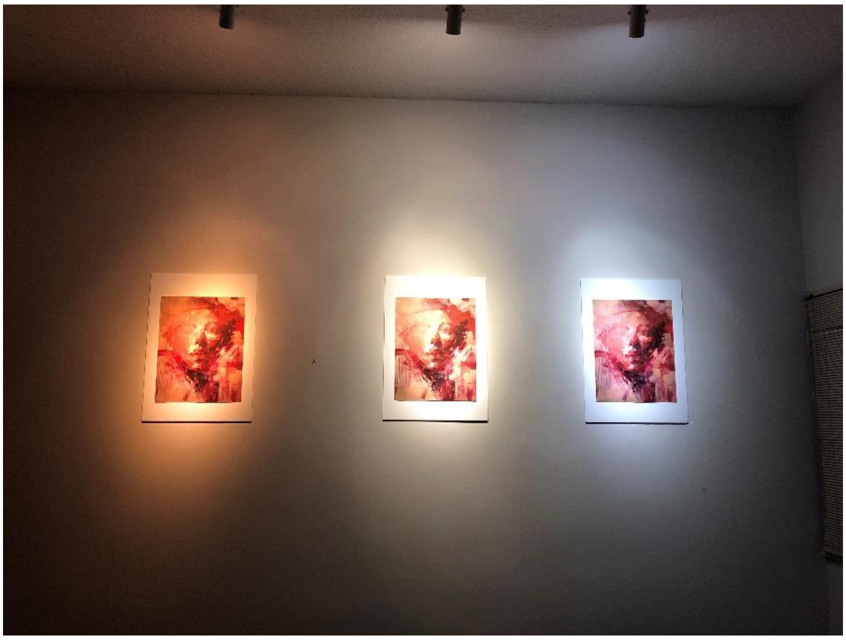

Figure 56. A view from experiment with red contemporary figurative art paintings.

Figure 57. Example participant in the experiment setting observing neutral contemporary figurative art paintings.

Figure 58. A view from experiment with neutral contemporary figurative art paintings.

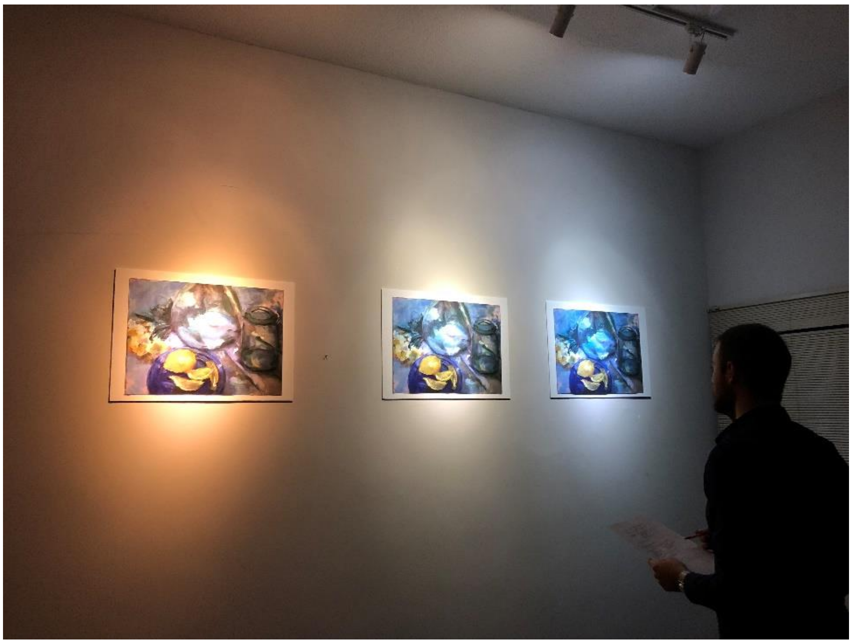

Figure 59. Example participant in the experiment setting observing blue still life paintings.

Figure 60. A view from experiment with blue still life paintings.

Figure 61. Example participant in the experiment setting observing red still life paintings.

Figure 62. A view from experiment with red still life paintings.

Figure 63. Example participant in the experiment setting observing neutral still life paintings.

Figure 64. A view from experiment with neutral still life paintings.

APPENDIX D

NCS CODES OF PAINTINGS

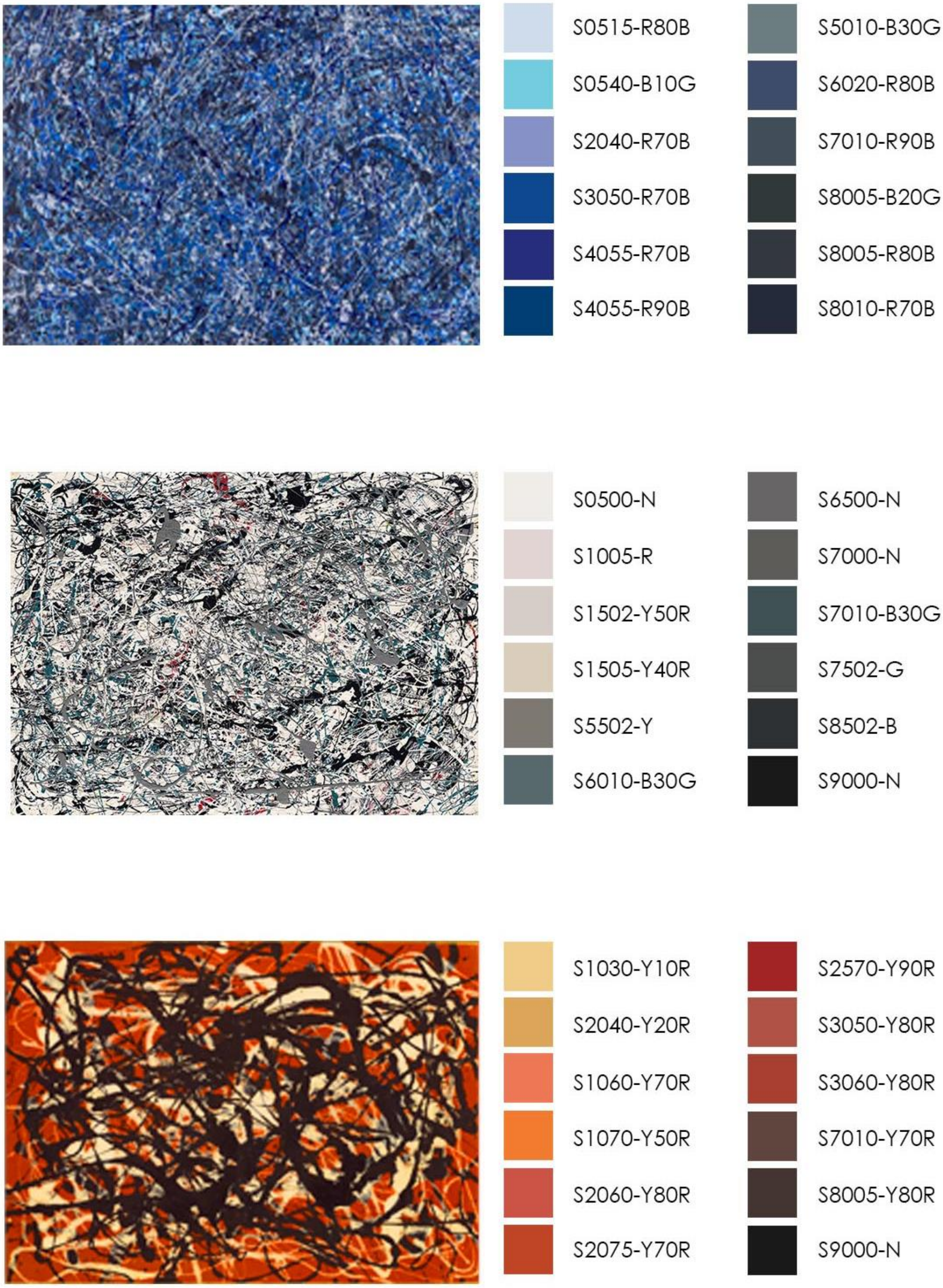

Figure 65. NCS codes for drip paintings

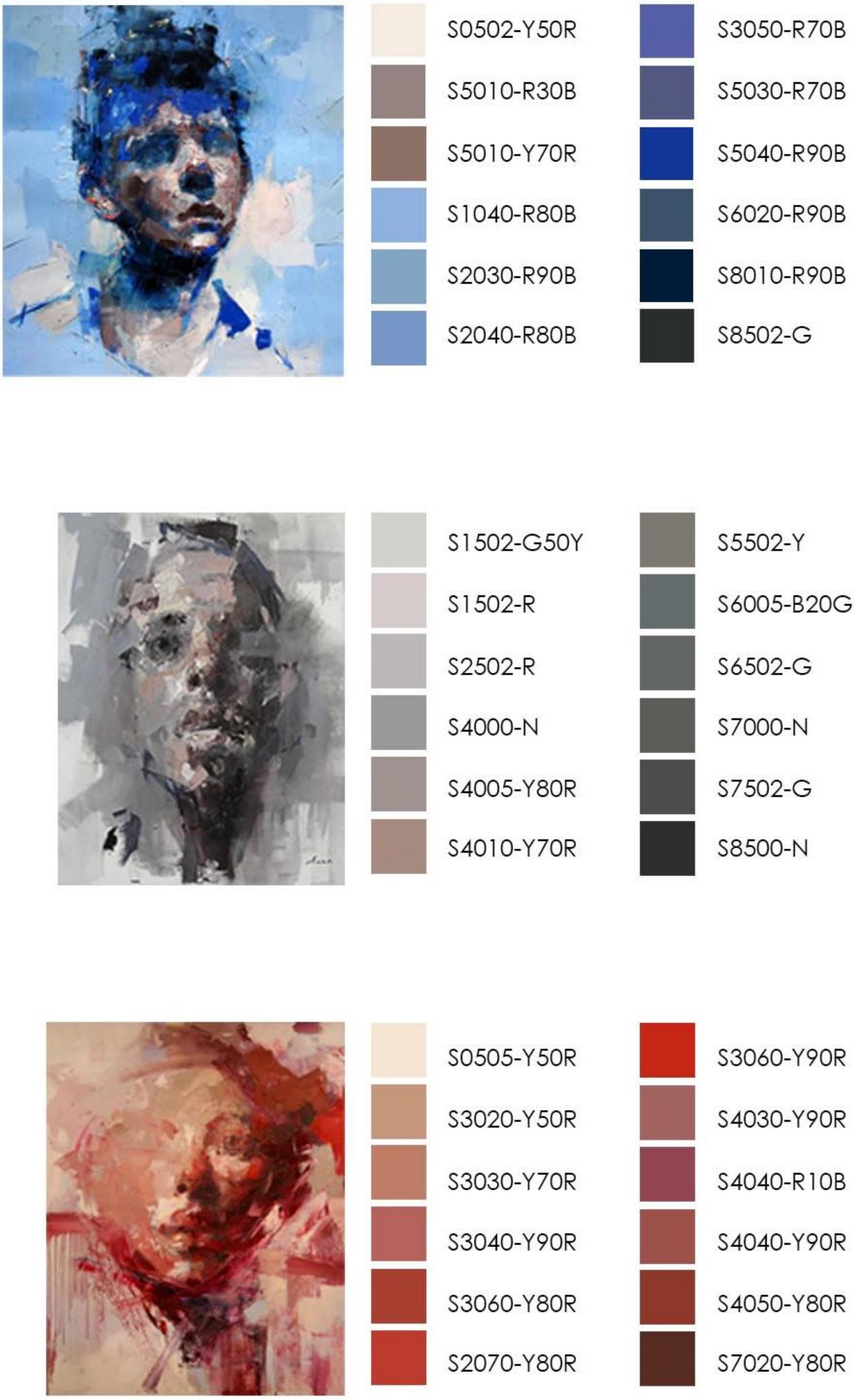

Figure 66. NCS codes for contemporary figurative art paintings

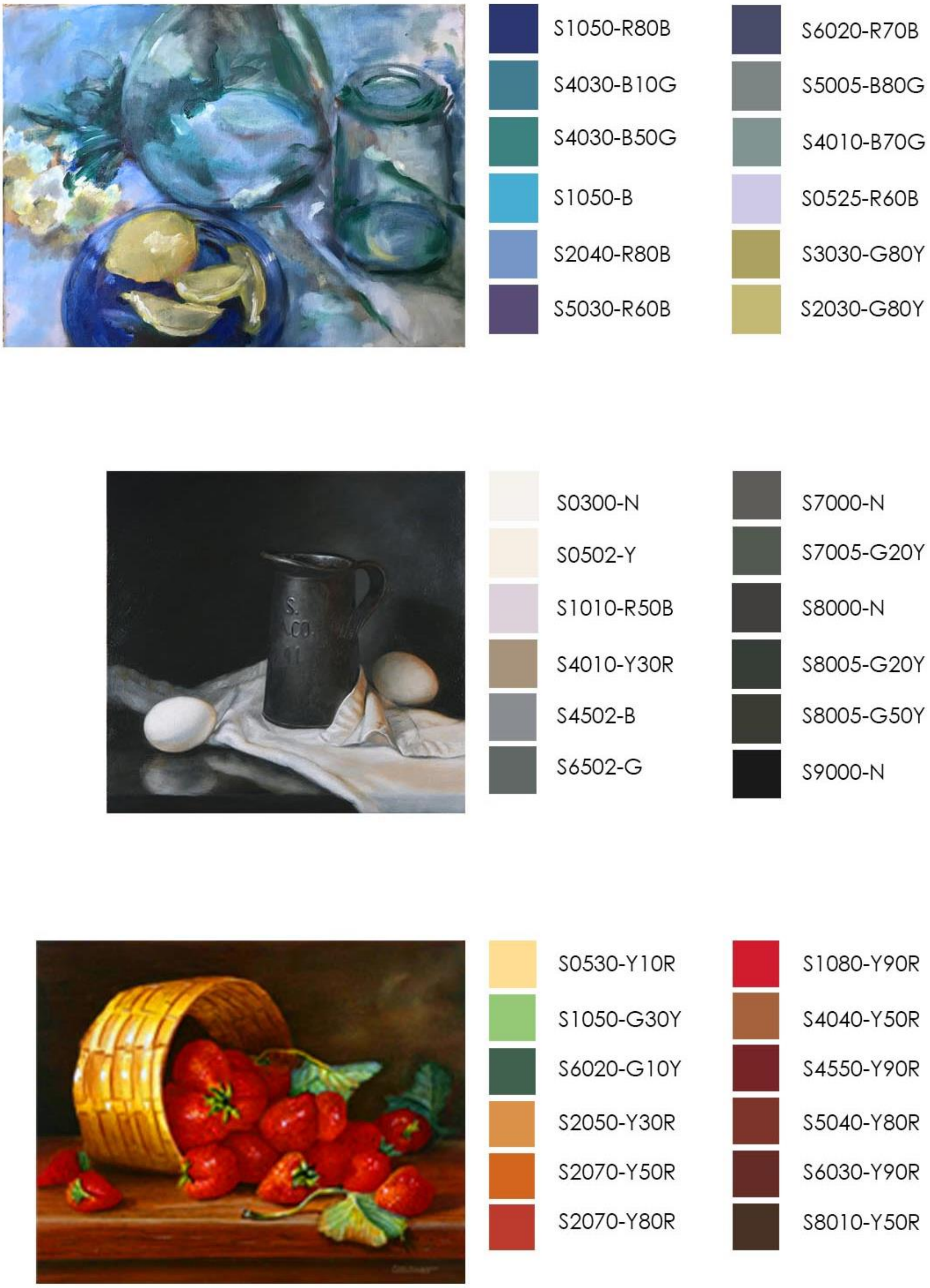

Figure 67. NCS codes for still life paintings

APPENDIX E

MEASURED ILLUMINANCE LEVELS OF PAINTINGS

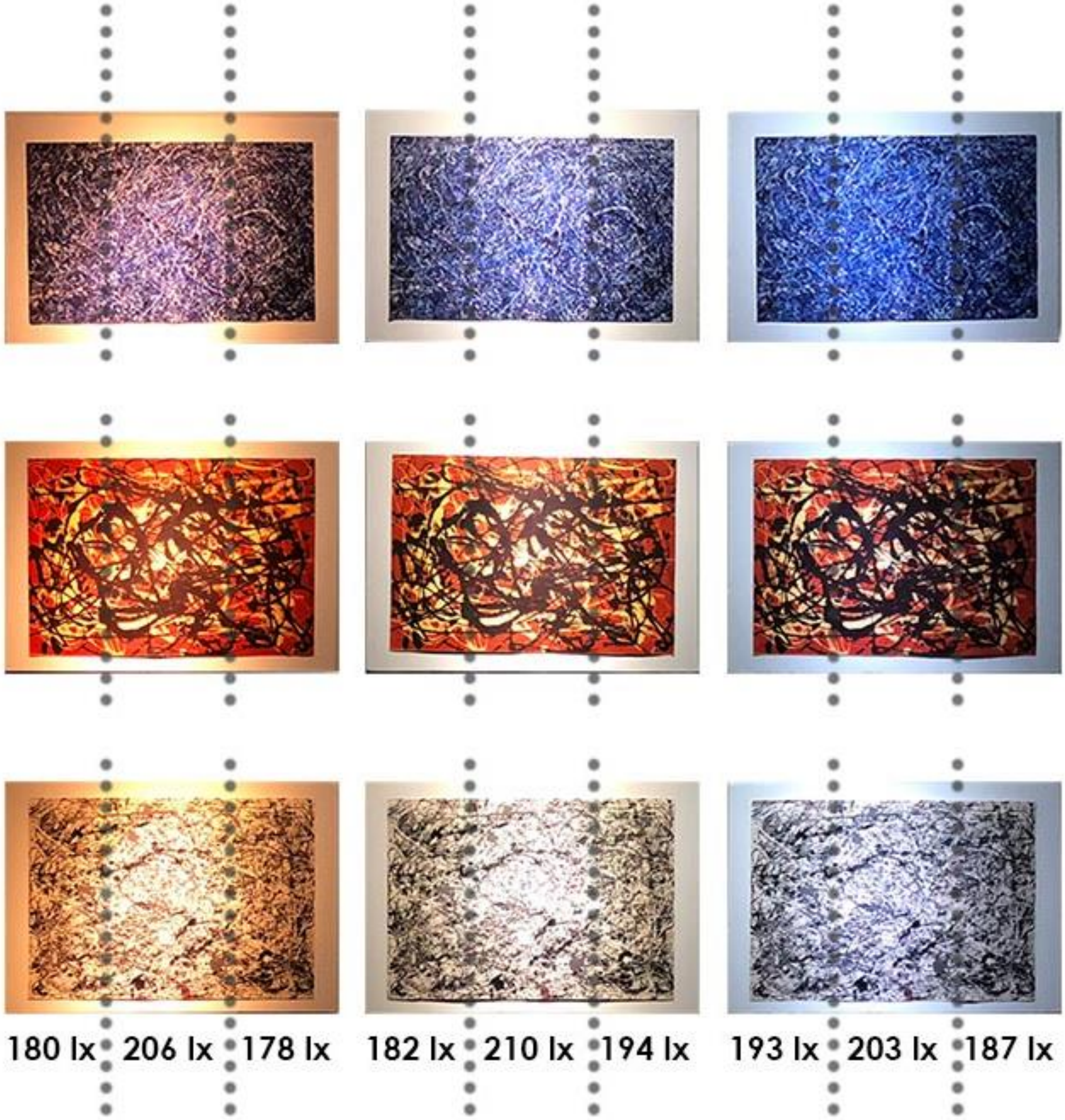

Figure 68. Measured Illuminance Levels of Drip Paintings

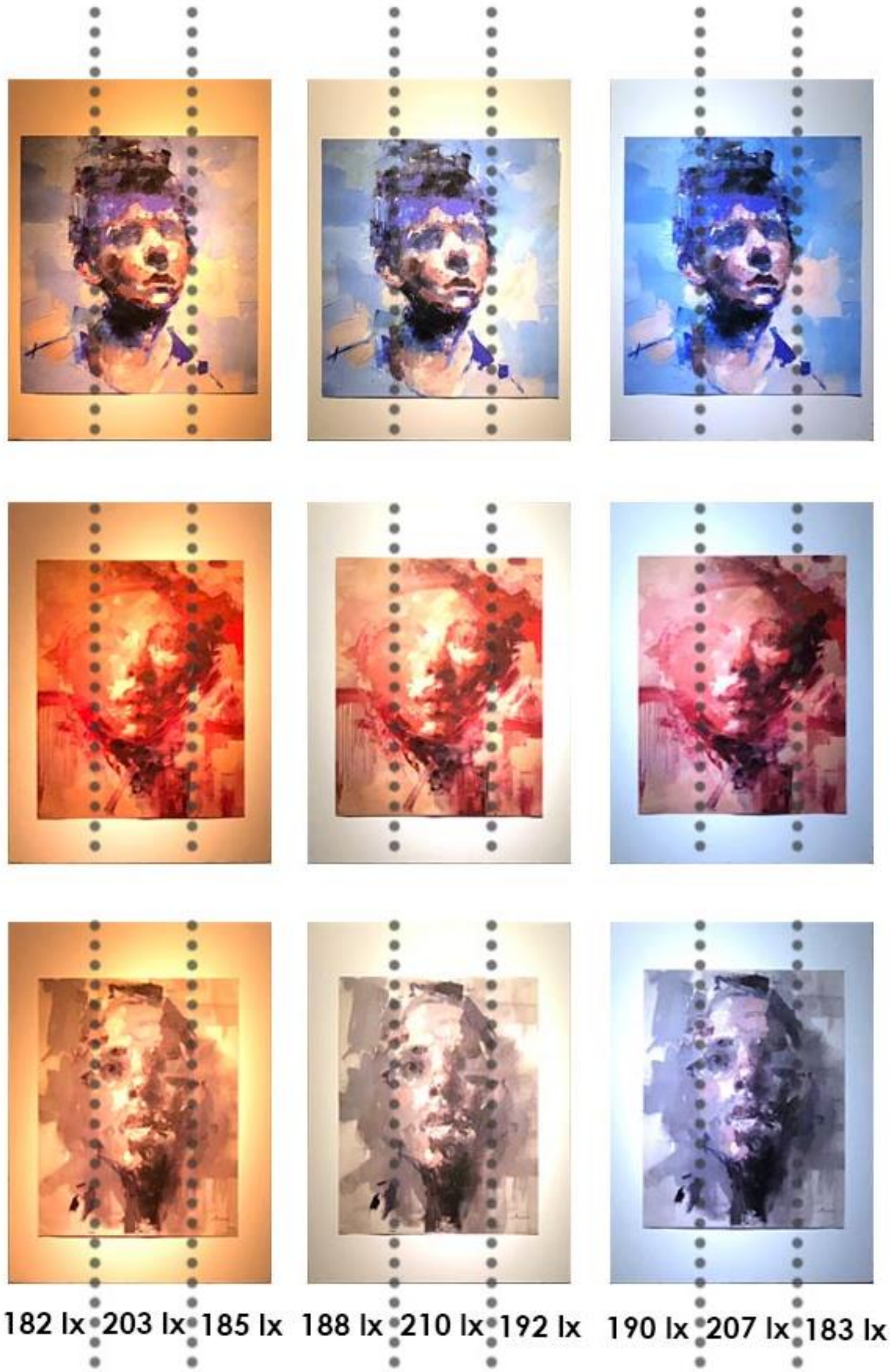

Figure 69. Measured Illuminance Levels of Contemporary Figurative Art Paintings

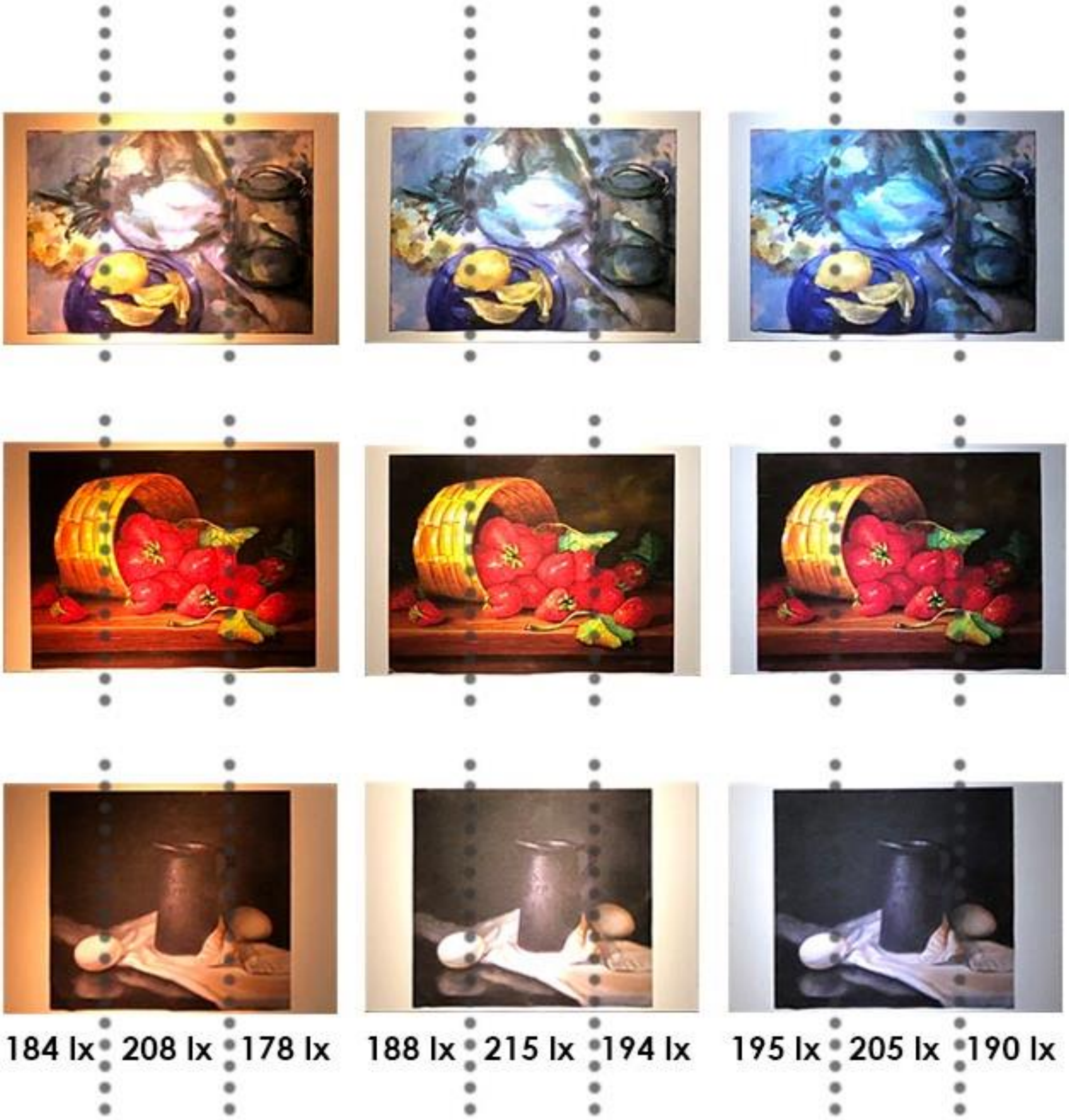

Figure 70. Measured Illuminance Levels of Still Life Paintings

APPENDIX F

STATISTICAL DATA

APPENDIX F.1. Kruskal-Wallis H Test for order effect of drip paintings

Table 15. Kruskal-Wallis H test results for order effect of red drip paintings.

Kruskal-Wallis Test					
Ranks				Test Statisticsa,b	
order		N	Mean Rank		CCT_pref_red
CCT_pref_red	rbn	9	13,56	Chi-Square	0,069
	nrb	9	14,00	df	2
	bnr	9	14,44	Asymp. Sig.	0,966
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

Table 16. Kruskal-Wallis H test results for order effect of blue drip paintings.

Kruskal-Wallis Test					
Ranks				Test Statisticsa,b	
order		N	Mean Rank		CCT_pref_blue
CCT_pref_blue	rbn	9	11,83	Chi-Square	1,627
	nrb	9	16,17	df	2
	bnr	9	14,00	Asymp. Sig.	0,443
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

Table 17. Kruskal-Wallis H test results for order effect of neutral drip paintings.

Kruskal-Wallis Test					
Ranks				Test Statisticsa,b	
order		N	Mean Rank		CCT_pref_nautral
CCT_pref_neutral	rbn	9	12,00	Chi-Square	1,753
	nrb	9	13,78	df	2
	bnr	9	16,22	Asymp. Sig.	0,416
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

APPENDIX F.2. Friedman and Wilcoxon Signed Rank test results of drip paintings

Table 18. Friedman test results for drip paintings.

Friedman Test								
Descriptive Statistics							Test Statistics	
	N	Mean	Std. Deviation	Minimum	Maximum	Mean Rank	N	27
red	27	1,70	0,669	1	3	1,59	Chi-Square	9,852
blue	27	2,33	0,679	1	3	2,31	df	2
neutral	27	2,15	0,602	1	3	2,09	Asymp. Sig.	0,007
							a. Friedman Test	

Table 19. Wilcoxon Signed Rank test results for drip paintings.

Wilcoxon Signed Rank Test			
Test Statisticsa			
	blue - red	neutral - red	neutral - blue
Z	-2,736b	-1,994b	-1,057c
Asymp. Sig. (2-tailed)	0,006	0,046	0,290
a. Wilcoxon Signed Ranks Test			
b. Based on negative ranks.			
c. Based on positive ranks.			

APPENDIX F.3. Kruskal-Wallis H Test for order effect of contemporary figurative art paintings

Table 20. Kruskal-Wallis H test results for order effect of red contemporary figurative art paintings.

Kruskal-Wallis H Test					
Ranks				Test Statisticsa,b	
order		N	Mean Rank		CCTpref_red
CCTpref_red	RBN	9	14,17	Chi-Square	1,126
	NRB	9	12,28	df	2
	BNR	9	15,56	Asymp. Sig.	0,569
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

Table 21. Kruskal-Wallis H test results for order effect of blue contemporary figurative art paintings.

Kruskal-Wallis H Test					
Ranks				Test Statisticsa,b	
order		N	Mean Rank		CCTpref_blue
CCTpref_blue	RBN	9	14,61	Chi-Square	0,963
	NRB	9	15,22	df	2
	BNR	9	12,17	Asymp. Sig.	0,618
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

Table 22. Kruskal-Wallis H test results for order effect of neutral contemporary figurative art paintings.

Kruskal-Wallis H Test					
Ranks				Test Statisticsa,b	
order		N	Mean Rank		CCTpref_neutral
CCTpref_neutral	RBN	9	15,22	Chi-Square	1,733
	NRB	9	11,56	df	2
	BNR	9	15,22	Asymp. Sig.	0,420
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

APPENDIX F.4. Friedman and Wilcoxon Signed Rank test results of contemporary figurative art paintings

Table 23. Friedman test results for contemporary figurative art paintings.

Friedman Test								
Descriptive Statistics							Test Statisticsa	
	N	Mean	Std. Deviation	Minimum	Maximum	Mean Rank	N	27
red	27	1,41	0,636	1	3	1,44	Chi-Square	17,416
blue	27	2,41	0,797	1	3	2,46	df	2
neutral	27	2,00	0,620	1	3	2,09	Asymp. Sig.	0,000
							a. Friedman Test	

Table 24. Wilcoxon Signed Rank test results for contemporary figurative art paintings.

Wilcoxon Signed Rank Test			
Test Statistics[a]			
	blue - red	neutral - red	neutral - blue
Z	-3,359[b]	-2,839[b]	-2,120[c]
Asymp. Sig. (2-tailed)	0,001	0,005	0,034
a. Wilcoxon Signed Ranks Test			
b. Based on negative ranks.			
c. Based on positive ranks.			

APPENDIX F.5. Kruskal-Wallis H Test for order effect of still life paintings

Table 25. Kruskal-Wallis H test results for order effect of red still life paintings.

Kruskal-Wallis H Test					
Ranks				Test Statistics^{a,b}	
order		N	Mean Rank		CCTpref_red_stiillife
CCTpref_red_stiillife	RBN	9	14,22	Chi-Square	0,054
	NRB	9	14,22	df	2
	BNR	9	13,56	Asymp. Sig.	0,973
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

Table 26. Kruskal-Wallis H test results for order effect of blue still life paintings.

Kruskal-Wallis H Test					
Ranks				Test Statistics^{a,b}	
order		N	Mean Rank		CCTpref_blue_stiillife
CCTpref_blue_stiillife	RBN	9	16,83	Chi-Square	2,920
	NRB	9	11,11	df	2
	BNR	9	14,06	Asymp. Sig.	0,232
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

Table 27. Kruskal-Wallis H test results for order effect of neutral still life paintings.

Kruskal-Wallis H Test					
Ranks				Test Statistics^{a,b}	
order		N	Mean Rank		CCTpref_neutral_stiillife
CCTpref_neutral_stiillife	RBN	9	9,50	Chi-Square	5,425
	NRB	9	15,61	df	2
	BNR	9	16,89	Asymp. Sig.	0,066
	Total	27		a. Kruskal Wallis Test	
				b. Grouping Variable: order	

APPENDIX F.6. Friedman and Wilcoxon Signed Rank test results of still life paintings

Table 28. Friedman test results for still life paintings.

Friedman Test								
Descriptive Statistics							Test Statistics[a]	
	N	Mean	Std. Deviation	Minimum	Maximum	Mean Rank	N	27
red	27	1,56	0,577	1	3	1,41	Chi-Square	18,909
blue	27	2,48	0,643	1	3	2,44	df	2
neutral	27	2,19	0,681	1	3	2,15	Asymp. Sig.	0,000
							a. Friedman Test	

Table 29. Wilcoxon Signed Rank test results for still life paintings.

Wilcoxon Signed Rank Test			
Test Statistics[a]			
	blue - red	neutral - red	neutral - blue
Z	-3,917[b]	-2,660[b]	-1,360[c]
Asymp. Sig. (2-tailed)	0,000	0,008	0,174
a. Wilcoxon Signed Ranks Test			
b. Based on negative ranks.			
c. Based on positive ranks.			

APPENDIX F.7. Kruskal-Wallis H Test for difference among all styles with respect to CCT preference

Table 30. Kruskal-Wallis H test results for effect of style on CCT preference for red paintings.

Kruskal- Wallis H Test					
Ranks				Test Statistics[a,b]	
STYLE_RED		N	Mean Rank		CCT_pref
CCT_pref	pollock	27	45,89	Chi-Square	3,398
	portrait	27	35,44	df	2
	still life	27	41,67	Asymp. Sig.	0,183
	Total	81		a. Kruskal Wallis Test	
				b. Grouping Variable: STYLE_RED	

Table 31. Kruskal-Wallis H test results for effect of style on CCT preference for blue paintings.

Kruskal- Wallis H Test					
Ranks				Test Statistics[a,b]	
STYLE_BLUE		N	Mean Rank		CCT_pref
CCT_pref	pollock	27	38,17	Chi-Square	0,747
	portrait	27	42,02	df	2
	still life	27	42,81	Asymp. Sig.	0,688
	Total	81		a. Kruskal Wallis Test	
				b. Grouping Variable: STYLE_BLUE	

Table 32. Kruskal-Wallis H test results for effect of style on CCT preference for neutral paintings.

Kruskal- Wallis H Test					
Ranks				Test Statistics[a,b]	
STYLE_NEUTRAL		N	Mean Rank		CCT_pref
CCT_pref	pollock	27	42,11	Chi-Square	1,341
	portrait	27	37,33	df	2
	still life	27	43,56	Asymp. Sig.	0,511
	Total	81		a. Kruskal Wallis Test	
				b. Grouping Variable: STYLE_NEUTRAL	

APPENDIX F.8. Kruskal-Wallis H Test and Mann Whitney U Test for difference among colors within all styles

Table 33. Kruskal-Wallis H test results for effect of color on CCT preference for all styles.

Kruskal- Wallis H Test					
Ranks				Test Statistics[a,b]	
paintingcolor		N	Mean Rank		CCTpref
CCTpref	red	81	80,78	Chi-Square	54,770
	blue	81	155,83	df	2
	neutral	81	129,39	Asymp. Sig.	0,000
	Total	243		a. Kruskal Wallis Test	
				b. Grouping Variable: paintingcolor	

Table 34. Mann- Whitney U Test results for red-blue color differences.

Mann-Whitney U Test						
Ranks					Test Statistics[a]	
paintingcolor		N	Mean Rank	Sum of Ranks		CCTpref
CCTpref	red	81	57,78	4680,00	Mann-Whitney U	1359,000
	blue	81	105,22	8523,00	Wilcoxon W	4680,000
	Total	162			Z	-6,838
					Asymp. Sig. (2-tailed)	0,000
					a. Grouping Variable: paintingcolor	

Table 35. Mann- Whitney U Test results for red-neutral color differences.

Mann-Whitney U Test						
Ranks					Test Statistics[a]	
paintingcolor		N	Mean Rank	Sum of Ranks		CCTpref
CCTpref	red	81	64,00	5184,00	Mann-Whitney U	1863,000
	neutral	81	99,00	8019,00	Wilcoxon W	5184,000
	Total	162			Z	-5,201
					Asymp. Sig. (2-tailed)	0,000
					a. Grouping Variable: paintingcolor	

Table 36. Mann- Whitney U Test results for blue-neutral color differences.

Mann-Whitney U Test							
Ranks						Test Statistics[a]	
paintingcolor		N	Mean Rank	Sum of Ranks			CCTpref
CCTpref	blue	81	91,61	7420,50		Mann-Whitney U	2461,500
	neutral	81	71,39	5782,50		Wilcoxon W	5782,500
	Total	162				Z	-3,007
						Asymp. Sig. (2-tailed)	0,003
						a. Grouping Variable: paintingcolor	

APPENDIX F.9. Kruskal-Wallis H Test of Evaluative Word Pairs for Red Paintings

Table 37. Kruskal-Wallis H test of evaluative word pairs for red paintings.

Group				Kruskal-Wallis H Test		
	CCT	N	Mean Rank	Chi-square	df	Asymp. Sig.
warm-cool	3000	81	146,94	31,822	2	0,000
	4000	81	130,44			
	6000	81	88,61			
bright-dark	3000	81	59,77	109,774	2	0,000
	4000	81	137,52			
	6000	81	168,72			
comfortable-uncomfortable	3000	81	132,90	6,404	2	0,041
	4000	81	126,23			
	6000	81	106,86			
pleasant-unpleasant	3000	81	118,14	1,364	2	0,506
	4000	81	118,72			
	6000	81	129,14			
natural-unnatural	3000	81	123,91	57,467	2	0,000
	4000	81	161,44			
	6000	81	80,65			
relax-tense	3000	81	94,59	22,396	2	0,000
	4000	81	143,66			
	6000	81	127,75			

APPENDIX F.10. Mann-Whitney U Tests of Evaluative Word Pairs for Red Paintings

Table 38. Mann-Whitney U Test results for the difference of 3000 K and 4000 K of red paintings.

3000 K / 4000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	2817,500	1018,500	3089,500	-	2196,000	1991,500
Wilcoxon W	6138,500	4339,500	6410,500	-	5517,000	5312,500
Z	-1,629	-7,825	-0,662	-	-3,783	-4,484
Asymp. Sig. (2-tailed)	0,103	0,000	0,508	-	0,000	0,000

Table 39. Mann-Whitney U Test results for the difference of 3000 K and 6000 K of red paintings.

3000 K / 6000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	1723,000	501,500	2588,500	-	2041,500	2349,500
Wilcoxon W	5044,000	3822,500	5909,500	-	5362,500	5670,500
Z	-5,392	-9,552	-2,391	-	-4,333	-3,263
Asymp. Sig. (2-tailed)	0,000	0,000	0,017	-	0,000	0,001

Table 40. Mann-Whitney U Test results for the difference of 4000 K and 6000 K of red paintings.

4000 K / 6000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	2133,500	2275,500	2746,500	-	1170,500	2815,000
Wilcoxon W	5454,500	5596,500	6067,500	-	4491,500	6136,000
Z	-3,961	-3,572	-1,851	-	-7,288	-1,639
Asymp. Sig. (2-tailed)	0,000	0,000	0,064	-	0,000	0,101

APPENDIX F.11. Kruskal-Wallis H Test of Evaluative Word Pairs for Blue Paintings

Table 41. Kruskal-Wallis H test of evaluative word pairs for blue paintings.

Group				Kruskal-Wallis H Test		
	CCT	N	Mean Rank	Chi-square	df	Asymp. Sig.
warm-cool	3000	81	176,87	90,636	2	0,000
	4000	81	113,30			
	6000	81	75,83			
bright-dark	3000	81	56,35	124,441	2	0,000
	4000	81	135,88			
	6000	81	173,77			
comfortable-uncomfortable	3000	81	99,19	48,227	2	0,000
	4000	81	101,94			
	6000	81	164,87			
pleasant-unpleasant	3000	81	105,91	8,158	2	0,017
	4000	81	136,26			
	6000	81	123,83			
natural-unnatural	3000	81	96,47	21,133	2	0,000
	4000	81	145,28			
	6000	81	124,25			
relax-tense	3000	81	83,63	50,103	2	0,000
	4000	81	159,27			
	6000	81	123,10			

APPENDIX F.12. Mann-Whitney U Tests of Evaluative Word Pairs for Blue Paintings

Table 42. Mann-Whitney U Test results for the difference of 3000 K and 4000 K of blue paintings.

3000 K / 4000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	1450,000	871,500	3196,000	2446,000	1966,500	1344,000
Wilcoxon W	4771,000	4192,500	6517,000	5767,000	5287,500	4665,000
Z	-6,333	-8,321	-0,295	-2,893	-4,558	-6,666
Asymp. Sig. (2-tailed)	0,000	0,000	0,768	0,004	0,000	0,000

Table 43. Mann-Whitney U Test results for the difference of 3000 K and 6000 K of blue paintings.

3000 K / 6000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	666,500	371,500	1517,000	2811,500	2526,500	2109,000
Wilcoxon W	3987,500	3692,500	4838,000	6132,500	5847,500	5430,000
Z	-8,974	-9,994	-6,083	-1,623	-2,610	-4,085
Asymp. Sig. (2-tailed)	0,000	0,000	0,000	0,105	0,009	0,000

Table 44. Mann-Whitney U Test results for the difference of 4000 K and 6000 K of blue paintings.

4000 K / 6000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	2155,000	1996,000	1571,500	2960,000	2709,000	2198,000
Wilcoxon W	5476,000	5317,000	4892,500	6281,000	6030,000	5519,000
Z	-3,937	-4,561	-5,906	-1,113	-2,004	-3,774
Asymp. Sig. (2-tailed)	0,000	0,000	0,000	0,266	0,045	0,000

APPENDIX F.13. Kruskal-Wallis H Test of Evaluative Word Pairs for Neutral Paintings

Table 45. Kruskal-Wallis H test of evaluative word pairs for neutral paintings.

Group				Kruskal-Wallis H Test		
	CCT	N	Mean Rank	Chi-square	df	Asymp. Sig.
warm-cool	3000	81	171,105	75,431	2	0,000
	4000	81	116,358			
	6000	81	78,537			
bright-dark	3000	81	59,259	114,735	2	0,000
	4000	81	134,093			
	6000	81	172,648			
comfortable-uncomfortable	3000	81	111,710	14,579	2	0,001
	4000	81	108,988			
	6000	81	145,302			
pleasant-unpleasant	3000	81	108,191	6,917	2	0,031
	4000	81	136,259			
	6000	81	121,549			
natural-unnatural	3000	81	106,889	13,727	2	0,001
	4000	81	144,068			
	6000	81	115,043			
relax-tense	3000	81	86,259	43,317	2	0,000
	4000	81	156,673			
	6000	81	123,068			

APPENDIX F.14. Mann-Whitney U Tests of Evaluative Word Pairs for Neutral Paintings

Table 46. Mann-Whitney U Test results for the difference of 3000 K and 4000 K of neutral paintings.

3000 K / 4000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	1713,500	1032,000	3201,000	2510,500	2261,000	1452,500
Wilcoxon W	5034,500	4353,000	6522,000	5831,500	5582,000	4773,500
Z	-5,449	-7,772	-0,279	-2,673	-3,594	-6,298
Asymp. Sig. (2-tailed)	0,000	0,000	0,780	0,008	0,000	0,000

Table 47. Mann-Whitney U Test results for the difference of 3000 K and 6000 K of neutral paintings.

3000 K / 6000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	870,000	447,000	2367,500	2932,000	3076,000	2213,500
Wilcoxon W	4191,000	3768,000	5688,500	6253,000	6397,000	5534,500
Z	-8,293	-9,729	-3,179	-1,209	-0,712	-3,694
Asymp. Sig. (2-tailed)	0,000	0,000	0,001	0,227	0,476	0,000

Table 48. Mann-Whitney U Test results for the difference of 4000 K and 6000 K of neutral paintings.

4000 K / 6000 K	warm-cool	bright-dark	comfortable-uncomfortable	pleasant-unpleasant	natural-unnatural	relax-tense
Mann-Whitney U	2170,500	2011,500	2306,000	2895,500	2512,500	2300,000
Wilcoxon W	5491,500	5332,500	5627,000	6216,500	5833,500	5621,000
Z	-3,858	-4,461	-3,399	-1,334	-2,708	-3,424
Asymp. Sig. (2-tailed)	0,000	0,000	0,001	0,182	0,007	0,001