EZGİ MEMNUNE DOĞAN

EFFECT OF COLOR ON MEMORY THROUGH SIGNAGE SYSTEMS IN TRAIN STATIONS

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EFFECT OF COLOR ON MEMORY THROUGH SIGNAGE SYSTEMS

IN TRAIN STATIONS

A Master's Thesis

by

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Department of

Interior Architecture and Environmental Design

İhsan Doğramacı Bilkent University

Ankara

September 2020

To my parents

EFFECT OF COLOR ON MEMORY THROUGH SIGNAGE SYSTEMS

IN TRAIN STATIONS

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

by

EZGİ MEMNUNE DOĞAN

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF FINE ARTS

THE DEPARTMENT OF
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ANKARA

September 2020

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

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ABSTRACT

EFFECT OF COLOR ON MEMORY THROUGH SIGNAGE SYSTEMS IN TRAIN STATIONS

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MFA, Department of Interior Architecture and Environmental Design
Supervisor: Assoc. Prof. Dr. Nilgün Olguntürk

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In complex buildings, it is important to remember the color of information while finding the way with correct identifications. The purpose of the study is to understand the relationship between misleading information and color with the wayfinding process in train stations to compare different colors in terms of recognition. Recognition of color is tested according to false memory studies with misinformation paradigm. The experiment was conducted with six different colors; orange, magenta, turquoise, purple, white, and black. The participants were a total of ninety people of various ages and professions. The study was conducted in two phases. Firstly, they answered questions about the viewing conditions of their devices (smartphones, pad, laptop, and desktop). Secondly, they watched the first and the second videos that consisted of different sign colors in a virtual train station and answered questions that included images of the signage. It was found that there was no difference between different colors on remembering the sign color, misleading information, color scheme, location of the signage, color order, and color pairing. The colors included in the study were remembered in all considerations.

The findings of the experiment can guide architects, interior architects and graphic designers who may be interested in sign design.

Keywords: Color, Memory, Signage, Train Stations, Virtual Environment

ÖZET

TREN İSTASYONLARINDAKİ İŞARETLEME SİSTEMLERİ ÜZERİNDEN RENGİN HAFIZA ÜZERİNE ETKİSİ

Doğan, Ezgi Memnune

Yüksek Lisans, İç Mimarlık ve Çevre Tasarımı Bölümü
Tez Yöneticisi: Doç. Dr. Nilgün Olguntürk

Eylül 2020

Karmaşık binalarda yön bilgisinin rengini doğru hatırlamak yön bulmak için önemlidir. Bu çalışmanın amacı tren istasyonlarında yanıltıcı bilginin farklı işaret renkleriyle yön bulmaya çalışırken renklerin hatırlanmaları arasındaki ilişkiyi anlamaya yöneliktir. Rengin hatırlanması *sahte anı* (İng. *false memory*) çalışmalarında kullanılan yanlış bilgi paradigmasına göre test edilmiştir. Deney, altı farklı renk ile gerçekleştirilmiştir; turuncu, çingene pembesi, turkuaz, mor, beyaz ve siyah. Çalışmaya farklı yaş ve meslek gruplarından olmak üzere doksan kişi katılmıştır. Çalışma toplam iki aşamadan oluşmaktadır. İlk olarak, katılımcılardan cihazlarının (akıllı telefon, tablet, dizüstü bilgisayar ve masaüstü bilgisayar) görüntüleme koşulları ile ilgili soruları cevaplamaları istenmiştir. İkinci olarak, sanal ortamda oluşturulan tren istasyonunun, farklı işaret renklerinden oluşan birinci ve ikinci videolarını izledikten sonra işaret renklerinin görsellerinin yer aldığı soruları cevaplamaları istenmiştir. Farklı renklerin; işaretlerin hatırlanması, yanlış bilgilendirme, renk şeması, işaretlerin yeri, renklerin sırası ve tek renkler ve renk çiftleri çerçevesinde birbirlerinden farklılıkları gözlenmemiştir. Çalışmada kullanılan renklerin, her değerlendirme göz önüne alındığında hatırlanmış olduğu saptanmıştır. Bu çalışmanın sonuçları, işaret tasarımıyla ilgilenen mimarlar, iç mimarlar ve grafik tasarımcılar için yol gösterebilir.

Anahtar Sözcükler: Hafıza, İşaretler, Renk, Sanal Ortam, Tren İstasyonu

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CHAPTER I

INTRODUCTION

Train stations are complex environments where people encounter some difficulties while finding their train (Arthur & Passini, 1992). Good wayfinding system should provide information about the current position of the user, give directions about the transport modes and routes, and inform the users after reaching the destination (Transport Design Manual, 2019). Signs can improve legibility of spaces by assisting wayfinding processes. Especially, locating signage improves the usability of large buildings (Nassar, 2011). Also, in the design process, designers should take into consideration the signs to improve the wayfinding process.

Color has an impact on memory by increasing the level of attention so that the information is remembered (Dzulkifli & Mustafar, 2013). However, people cannot remember the information because of forgetting or because of the distortion of the memory. These affect remembering the events accurately. False memory described in the psychological literature on memory distortion (Loftus, 1996) has two paradigms. These are Deese- Roediger- McDermott (DRM) paradigm and misinformation paradigm. In this study misinformation paradigm, which is remembering a situation that never occured or differently from the way they occurred (Roediger & McDermott, 1995), is studied.

It is important to understand the effect of misinformation on sign color in train stations in order to observe the influence of given information on directions for wayfinding. In order to perceive the space and provide legibility, accurately remembering the colors on a sign is significant. Thus, healthy wayfinding processes are conducted with decreased confusion and reduced possibility of being lost and missing the train (Wang et al, 2019).

1.1 Aim of the Study

The main aim of the study is to understand the effect of misleading information on remembering different colored signs in the train station. It is important to understand how color influences the train station users while finding the destination. Recognizing and recalling the first encountered color can ease the wayfinding process by guiding the user who follows the color of indicated direction. The findings of the study can be beneficial for architects, interior architects, graphic designers and those who are interested in memory, color and signs.

1.2 Structure of the Thesis

The thesis consists of five chapters. The first chapter is the introduction, in which the approach of memory, wayfinding and how they can be influenced by color are briefly mentioned. Moreover, the aim of the study and the structure of the thesis are mentioned in this chapter.

The second chapter consists of color and memory. Basics of color that includes the characteristic of the color, and color order systems which are Munsell Color System, Natural Color System (NCS), CIELAB and RGB Color Model are defined. Also, it captures expression of memory. Firstly, memory is defined in general to acquire information about the distortion of memory. Secondly, false memory and its paradigms are explained with the literature review. Thirdly, in order to understand the effect of color on memory, color memory is clarified with experimental studies.

The third chapter analyzes the definition of wayfinding. The significance of wayfinding is explained in order to understand the perception of built environment through the wayfinding process. The wayfinding studies in virtual environments (VE) are including explanations and beneficial features. Additionally, advantages and restraints of experimental studies in virtual reality (VR) are indicated. Individual differences which are familiarity, age and gender are clarified. Graphic components of wayfinding design that maps and signage are defined. Afterwards, signage design,

sign types and the sign design emphasizing the font, color and material are examined in detail. Studies on the impact of color in wayfinding are included. Lastly, characteristics of train stations affectin wayfinding are explained. Train station types and wayfinding behavior in train stations are included through the urban scale to the interior scale of stations. Besides, signage design in train stations with legibility and design requirements are indicated.

The experiment is clarified in the fourth chapter. First, the aim of the study, research questions and hypotheses are explained. Then, the method of the study is defined with the description of the site, identification of the sample group and the procedure of the experiment including the phase 1 and phase 2, sets of the experiment, preparing the questionnaire and phases of the experiment. The findings of the experiment are statistically analyzed and evaluated. The results are discussed and compared in relation to the preceding studies.

In the last chapter, the conclusion of the thesis and limitations are included. Visual and written documents of the experiment and charts of the statistical analysis are involved in the appendices.

CHAPTER II

COLOR AND MEMORY

2.1 Definition of Color

Color impacts every part of our lives which surrounds us (Fehrman & Fehrman, 2000). Meervein, Rodeck and Mahnke (2007) explained the common definition of the color which is “a specific visual sensation produced by visible radiation, or “color stimulus" (p.18). They stated that if natural light or artificial source of light is interrupted by an object or a dust particle, color stimulus occurs. Color has an impact on lots of are in design. Dalke et al. (2005) indicated that color is an intrinsic property of all materials and surfaces. It is included in lots of area in design. Fairchild (2005) defined color as a visual perception characteristic which consists of any combination of chromatic and achromatic color.

Color sensation has three attributes which are hue, saturation and brightness. Hue is the quality that provides differentiating one color from another like red from yellow, green from blue or purple. It is a distinctive feature of coloring in an object or on a surface that equal luminosity and chroma may differ (Munsell, 1988). According to the consideration of the hue, white, gray and black are achromatic colors which are lack of hue (Raskin, 1986) and apart from these colors are defined as chromatic colors. Besides, color can be classified as warm colors (Chijiiwa, 1987). Warm colors are hues from red to yellow and cool colors are hues from green to violet. Saturation is the quality of color that provides to “difference between strong and weak colors, the degree of color sensation from that of white and gray; the intensity of a distinctive hue; color intensity” (Munsell,1988, p.16). Fehrmen and Fehrman (2000) defined saturation as the amount of pigment in a color which is strength or vividness of that hue. Saturation reduces when adding white to a color that produces a tint (Raskin, 1986). Value or brightness is about a light color differing from a dark one (Munsell, 1988). Adding black to a color reduces its brightness that produces a shade (Raskin, 1986).

2.2. Color Order Systems

When a large number of colors are necessary and intermediate colors between samples are considered, a system is required. These systems are known as color order systems (Hunt, 1988). It provides us to communicate to each other (Fehrman & Fehrman, 2000).

2.2.1. Munsell Color System

In Munsell Color System surface colors are identified by three quantities which are hue, chroma, and value (Agoston, 1987) (see Figure 2.1.). There are five principle hues which are red (5R), yellow (5Y), green (5G), blue (5B), and purple (5P). The intermediate hues are yellow-red (5YR), green-yellow (5GY), blue-green (5BG), purple-blue (5PB), and red-purple (5RP) (Hunt, 1987). Hue range includes 11 hue radii from 0 to 10, the value indicates the lightness of the color from 0 to 10 scale (Agoston, 1987). He defined that chroma is the difference from a gray of the same lightness that measured along the hue radius which is zero at the center.

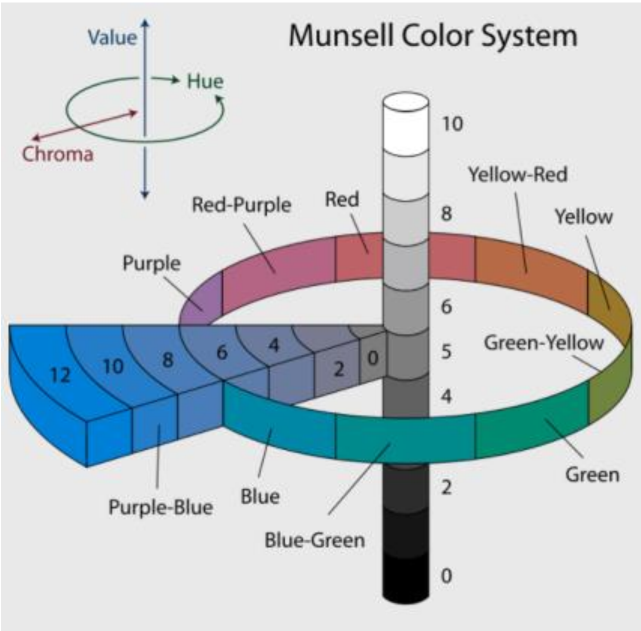

Figure 2.1.: The Munsell color system (https://en.wikipedia.org/wiki/Munsell_color_system#/media/File:Munsell-system.svg)

2.2.2. Natural Color System

The Natural Color System is the relative amounts of the basic colors expressed as percentages, which are perceived to be present (Hunt, 1978). It is the "recognition of the six psychological primaries which are white, black, yellow, red, blue and green" (Agoston, 1987, p.95). The unitary hues which are Y, R, G, and B are systematically located on the NCS color circle. The dashed lines demonstrating hues of 50/50 mixtures: YR (yellow-red), RB (red-blue), BG (blue-green), and GY (green-yellow) and hue ranges (Agoston, 1987) (see Figure 2.2.).

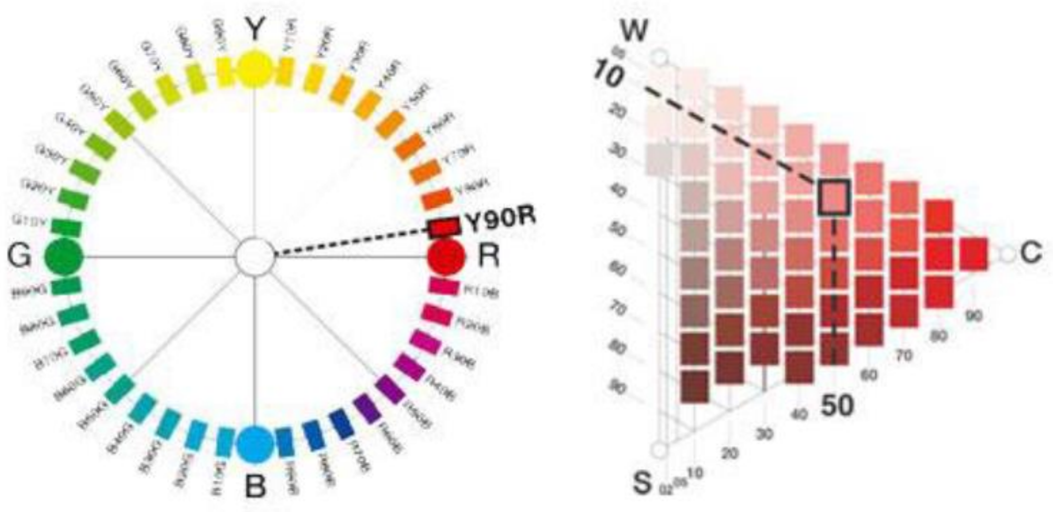

Figure 2.2.: NCS color circle (left hand side), NCS color triangle (right hand side) (Akbay & Avcı, 2018, p. 144)

2.2.3 CIELAB

CIELAB is a system that is "based on spectrophotometric measurements of color samples illuminated by specific types of lighting and related to the visual response of a *standard observer*" (Fehrman & Fehrman, 2000, p. 209). Tri stimulus values of X, Y, Z can be converted to three quantitates L, A, B, with simple calculations. These three quantitates supply a different color space. Moreover, it is developed to maintain a standardized color scale to discriminate the industrial color differences (Agoston, 1987) (see Figure 2.3).

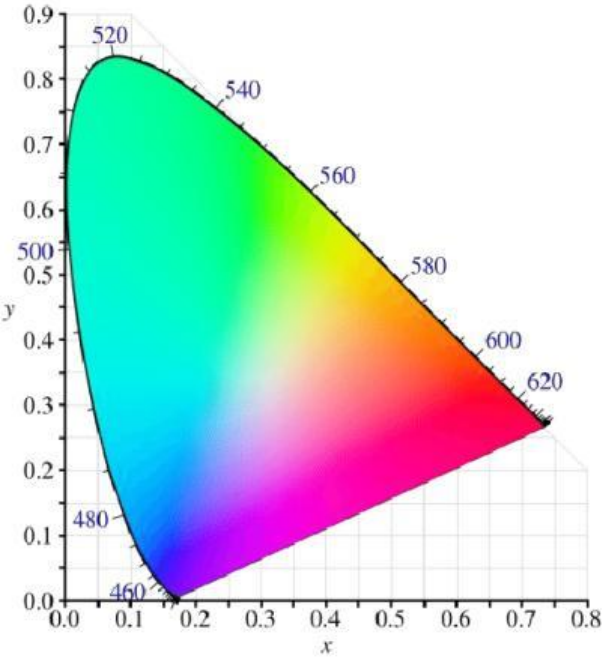

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Figure 2.3: CIE chromaticy chart (Ghazijahani et al., 2016, p.20).

2.2.4 RGB Color Model

In this study RGB color system is used on arrangement of the colors. Also, it is preferred because of displays on the devices' screen. RGB color model constitutes of mixing various proportions of colored light which is called "additive color mixture"(see Figure 2.4). Mixture of three primary light colors which are red, green and blue produces white light (Raskin, 1986). Mixture of the red and green light constitutes yellow light, red and blue lights produce magenta and blue and green lights create cyan (Eiseman & Herbert, 1990).

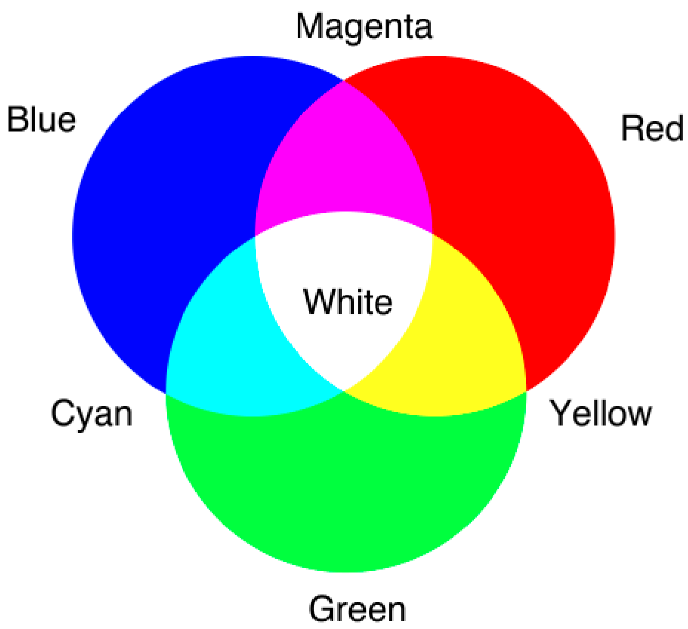


Figure 2.4: Additive colors

(https://marketingaccesspass.com/what-colors-make-red-what-two-colors-make-red/)

2.3 Definition of Memory

Memory is the capability to achieve and maintain new information and retrieve it in a conscious or unconscious way, when required that consists of a set of independent systems acting collectively (Squire & Kandel, 1999, as cited in Guarnieri, Bueno and de Souza Silva Tudesco, 2019). It is a method which provides people with past experiences and thoughts to advance from one idea to the next (Bower, 2000). Also, it is defined as encoding, storage and retrieval of the past experiences in human mind (Memory, n.d.). Tulving (2000) stated that memory is a neurocognitive resource to encode, store and retrieve information, a hypothetical store that information is held and memory as a property of information, componential process of retrieving information and people's exceptional awareness of remembering something.

Memory has two types which are explicit memory and implicit memory. Explicit memory is consciously remembered knowledge or experience that consists of firsthand experiences which is episodic memory and semantic memory, knowledge of facts and concepts about the world (Stangor & Walinga, 2014). Implicit memory is the impact on current perceptions and behavior that individual is unconscious of the influences (Einstein & May, 2013). It has three types that procedural memory is often unexplainable awareness of the way things are done, classical conditioning effects that creating a naturally occurring response with correlation of neutral stimuli (like a sound or a light) with another stimulus (like food) and priming is the alter in behavior resulting from the experiences that happened frequently or recently (Stangor & Walinga, 2014) (see Figure 2.5).

Figure 2.5: Types of memory (Stangor & Walinga, 2014, p.338).

Memory comprises three stages. These are sensory memory, short-term memory and long-term memory. Sensory memory is a short-lived memory that includes sensory details of events how things look, sound, feel, smell and taste (Cowan, 2008). Short-term memory is “a number of memory systems with limited capacity, concerned with the temporary (in the range of seconds) retention of a variety of materials” (Vallar, 2002, p. 367). It is a short term interval that keeps information 30s or less (Healy, 2001). Working memory and short-term memory can be confused. Working memory is the process of using the information to make sense of, modify, interpret, and store (Stangor & Walinga, 2014) information that lasts 2 to 18 seconds (Einstein & May, 2013). Long-term memory stores the information a long time with learning and repetition that obtains the information by using triggers or cues (Clarkson, 2008) (see Figure 2.6).

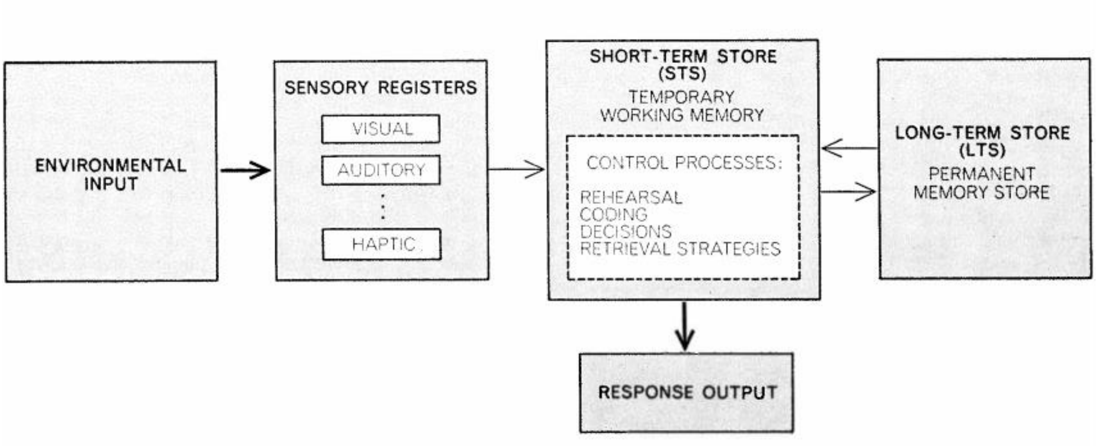


Figure 2.6: This flowchart indicates the differentiation between short-term and long-term memory (Atkinson & Shiffrin, 1971, p.3).

Memory has three processes; encoding which is converting a physical and sensory information into a kind of identification that takes place in memory. Storage holds encoded information in memory and retrieval is recovering the information stored in memory (Sternberg & Sternberg, 2011). Okado and Stark (2005) stated that forgetting is a well-accepted behavior because through passage of time or through building new information, memories can be lost. Poor encoding, failure to consolidate or store memories like reactivation or rehearsal, lack of adequate hints for remembering and interference of information with the cues to the target information (with different event or interpretation of the original event) are the reasons for forgetting (Johnson et al., 2012). Nevertheless, it is thought that memories are stored in a secure location in our head, from which accurate

recollections of the past events can be extracted. However, it is also unreliable and deeply susceptible to incorrect information or misinformation chasing an event (Benedict, Richter & Gast, 2019).

2.4 False Memory

Loftus (1996) stated that false memory originated from the psychological literature on memory distortion. Schacter et al. (2003) explained memory distortion in seven sins that transience reducing of memory accessibility over time, absent-minded lapses of attention that result in forgetting to do things, blocking information that has not faded out of memory but is temporarily unavailable for a variety of reasons. Misattribution is a lack of source when people could not remember where they have got information, suggestibility is guiding questions or suggestions that direct people to believe something has never happened, bias is current knowledge and beliefs that change memories about the past, persistence is undesirable recollection that people cannot forget (like traumatic experiences) (Schacter et al., 2003).

True memory is the real retrieval of an event of any nature, be it visual, verbal, or otherwise (Guarnieri, Bueno & de Souza Silva Tudesco, 2019, p. 50). On the other hand, false memory is remembering a situation that never occured or differently from the way it occurred (Roediger & McDermott, 1995). Johnson (2001) described false memory as a mental experience that erroneously was taken as a veridical

representation of an incident of individuals' past occurrence. Memories have profound impacts on oneself and others like believing falsely someone is the originator of an idea in major ways and remembering the keys are in the kitchen while they were in the living room in minor ways (Johnson, 2001). False memories are the remembrance of occurrence by a witness that indeed did not happen (McGrath & Turvey, 2014). False memories occur in different ways, from changes in the meaning of a memory (e.g. thinking that you saw something imagined or thinking that you heard about an incident on television news rather than from a friend) to changes in the substance of the memory itself (e.g. believing that a suspect held a weapon rather than a knife), making it possible that there are several mechanisms by which these distortions occur (Okado and Stark, 2005).

Two paradigms are used specifically to analyze the false memory. These are Deese-Roediger- McDermott (DRM) paradigm and misinformation paradigm.

2.4.1 Deese, Roediger and McDermott (DRM) Paradigm

The Deese, Roediger and McDermott (DRM) paradigm was built by Deese (1959) and revitalized by Roediger and McDermott (1995). In the DRM paradigm participants learn a list of related words (e.g. “bed, rest, awake, dream”, etc.). After learning the words each of them semantically closely related words items which correspond to a critical non-studied word (so called lure, e.g., “sleep”) and unknown control items are presented falsely in a recognition test (Roediger & McDermott,

1995). In this paradigm “in a recognition test with a subset of encode words which are the critical lure words and irrelevant lure words are demonstrated to participants. They have to make simple judgements whether they remember each word or not. In a recall test, they have to write down all the words they are able to remember” (Pardilla-Delgado & Payne, 2017, p.1).

A false memory occurs when participants report the non-studied words on tests of recall or recognition test, even those words were demonstrated (Eslick, Kostic & Clearly, 2010). In the recognition phase participants identify objects which seem merely familiar. They recognize preceding stimuli (words or images) when compared with the items presented (study phase) in a list which are not demonstrated before (recognition phase). Familiarity appears to operate faster than the recollection when the concerned the quick decision of recognition. (Guarnieri, Bueno & de Souza Silva Tudesco, 2019).

In this paradigm impact of false memory on color is evaluated with the words related to the color names. Roediger and McDermott (1995) studied a list of words correlated with the "black" but only for one color name, list of words associated with the color names may evoke another color name which increases the possibility of false memory (Eslick, Kostic, & Cleary, 2010). Eslick, Kostic, & Cleary (2010) conducted a study in order to understand the impact of false memory for color variation in color names. For example, if the color- related words are displayed in

different font colors compared with the actual font color would participant remember the actual color name or show false memory with remembering the font color. They reported that participants falsely recall the word of color among the related word list when compared to the seeing the color (e.g. red) in different font colors. Moreover, colored fonts reduce the impact of false memory when compared the standard non-color related lists. Impact of false memory on color was also studied by the misinformation paradigm.

2.4.2 Misinformation Paradigm

Misinformation paradigm is described by Loftus, Miller and Burns (1978). Exposing misleading information causes memory impairment which is called the isinformation effect (Loftus, 2005). In this paradigm, participants watch videos or slides showing crimes or criminal plots. After that in a distractor or retention phase, misinformation concealed in a narrative text or a list of questions about the represented event (Volz et al., 2019). The majority of the information presented were accurate, but one or more pieces of information were consciously presented false. After that participants take a recall test. The effect of misinformation arises when participants accept encountered misinformation. The participant who encountered with the misinformation have more tendency to remember falsely compared to the people who did not have a misinformation (Moore & Lampinen, 2016).

Misinformation paradigm has three phases. In the first phase participants watch an event, secondly, misinformation is given by questions or narrative, lastly participants are asked to recall or recognize the original event. According to the misinformation, participants' results may be influenced or not (Challies, 2011). Misinformation paradigm is usually introduced by indirectly hiding them in the questions about the event and post-event that narrative describing the event. Also misinformation is introduced directly with face to face interaction between people who witnessed an event. Another way is that participants discuss the observed event with a co-witness (experimental confederate), who inserts misleading information on conversation, before the memory test which effects individual's memory performance (Blank et al. 2013).

Memory tests concentrate on the two impacts of misinformation. These are participants who are misled about the information, having poor performance for original event details compared with the no-misinformation control group who evaluate with forced-choice recognition, yes-no recognition or cued recall tests (Blank & Launey, 2014). Another concentration is about participants who strongly accept the misinformation in the cued recall test and yes- no tests that in source monitoring test they mistakenly claim that they encountered misinformation in the original event (Blank & Launey, 2014).

One of the well-known experiments that Loftus (1977) conducted had two stages. In

the first experiment, participants watched a series of color slides of a car accident between a red Datsun and a green car on one scene. Half of the participants answered questions with misinformation that the color of the car was blue and the other half of the participants without this written misinformation (blue). After that, they read an unrelated story to answer questions. In the color recognition test, participants selected the color of ten objects including the car. After seven days, the control group answered new questions without a demonstration of the slides. The control group was divided into two to observe the impact of misinformation with new color recognition test. They indicated that participant who had misinformation about the color (green) of the car remembered the color as blue. In the second experiment, the same as the first experiment, initial color recognition test was not given. According to the two experiments, participants who had misleading information answered questions according to that misinformation (Loftus, 1977).

There are two other studies concerned about the correlation between misinformation and color. One of them is Braun and Loftus (1998) demonstrating an advertisement about a chocolate bar in a green wrapper divided into four experiments. In the first experiment they tried to observe the impact of difference, presenting misinformation (blue wrapper) visually and verbally. Misinformation had an impact on participants’ responses more with visually than verbally. In the second experiment, participants were warned about the color that it was not accurate. Comparison between the

warned and unwarned participants indicated that warning was not an effect on the results. In the third experiment, impact of color on consumers' decision making was evaluated. Color had a huge impact on searching grocery rather than a chocolate bar. In the last experiment, alteration of color had an impact on participants' subjective assessment of the product. Misinformation about the color that correlated with less contamination and higher safety had favorable decisions and high tendency to buy that chocolate in the future (Braun & Loftus,1998).

Another study was conducted by Belli (1988) with slides. It demonstrated to the participants that misinformation about color of a green plastic pitcher displayed in one slide changed in the question either yellow or blue or no color information. According to the results of the study, among the range of options of a color wheel, misled participants selected the color of misinformation. These studies give common results about the misinformation impact with restricted colors. Even though color memory studies are not scope of the study. It gives more detailed information about the memory and color.

When comparing DRM paradigm with the misinformation paradigm, DRM paradigm is simple in several respects. Its encoding includes the quick depiction of the list of words either visually or aurally (Pardilla-Delgado & Payne, 2017). Volz et al. (2019) identified differences of DRM paradigm from misinformation paradigm that DRM

paradigm has a different method which is schematic activation method and types of false memory which is false recognition of new information to evoke false memory. However, the misinformation paradigm has misleading information method and false recognition of mislead information rather than original information. In the present study, the experiment was conducted according to the misinformation paradigm.

2.5 Color Memory

Burnham and Clark (1954) defined that people encounter recognitive memory for color in occupational and daily life activities. They exemplified that artists used color memory when looking back and forth between the canvas and the landscape and, housewives used color memory when choosing a curtain to match the trim of the kitchen, and that the examples can be increased.

The “color memory” is relating colors with familiar objects which an individual has frequent visual experience (Bartleson, 1960). Witzel and Hansen (2015) stated that color memory is memorizing a specific color over time. They exemplified that people recalled orange more accurately than other colors when demonstrated Halloween pumpkin. Because its color is typically orange. It is a successive color matching by comparing colors after a certain time lapse required to use memory, matching the present with the remembered (Pérez-Carpinell et al. 1998a). Witzel and Gegenfurtner (2013) stated that memory color is the relation between objects and

colors taking place with familiarity, idea about the typicality among colors and association between the object and its typical color.

Color makes a contribution to memory. Borges, Stepnowsky and Holt (1977) investigated performance of recall and recognition in three different modes of demonstration (written words, black and white pictures of objects and color pictures of the same objects). They found that color pictures and names of objects had better recognition performance than the black and white pictures of objects. Spence et al. (2006) experimented with color and gray scale images indicated that color supported remembering the natural scenes.

Memory is related with attention. Attention is a cognitive process of selecting information involved in an environment (Dzulkifli & Mustafar, 2013). Color allows a person to memorize the information by increasing the attention level (Dzulkifli & Mustafar, 2013). Pan (2010) conducted a study in which participants had to memorize the color and shape of the object. He found that color is more effective on the attention rather than shape.

People restore information in short-term memory and long- term memory. Short-term memory for monochromatic hues indicated that violets, green-blues and yellow-oranges were correctly remembered (Nilsson & Nelson, 1981). The consideration of

long term memory in color constancy for matching a test color demonstrated that long and medium wavelengths (reds and greens) have more tendency to be remembered accurately than shorter wavelengths (blues) (Jin & Shevell, 1996).

Pérez-Carpinell et al. (1998a) conducted a study with the color wheel in which participants had to remember the demonstrated colors on the wheel. According to the results of the study, orange was the easiest color to recall among ten tested colors. Yellow, light green, blue and pink were the hardest to recall. Another study of memory for color chips indicated that yellow was most accurately remembered, followed by purple and orange and the least accurately classified colors were green (Bynum, Epps & Kaya, 2006).

Another study Pérez-Carpinell et al. (1998b) was conducted among familiar objects to find the impact of familiarity on color memory in physics (PHY) and School of Fine Arts (ARTS) students with two illuminants. These illuminants are “Illuminant D65 which is the daylight illuminant and Illuminant A which represents the spectral power distribution of a typical tungsten incandescent lamp” (Goodman, 2012, p. 424). Results indicated that the best remembered color in illuminant D65 are purple aubergine and green lettuce for PHY; green water-melon and red tomato for ARTS.

Under illuminant A the most remembered objects were red tomato and purple aubergine and green water-melon for PHY; green water-melon and red tomato for

ARTS. The worst remembered colors in illuminant D65 were brown chestnut and orange. Under illuminant A the worst remembered objects were yellow melon and pink rose for both of the students.

Color memory studies showed that differed among the age range and gender. Pe´rez-Carpinell et al. (2006) conducted a study of simultaneous and successive color matching with a comparison of a set of five Munsell color samples. The age range is between 64 to 80 years of 50 older adults. They found that younger adults matched the target color and remembering the original color of better than elderly adults. Also, gender did not have a significant effect on memory. However, men matched the colors poorly than the women, especially for bluish green, violet and pink. Another study, conducted by Pe´rez-Carpinell, Camps, and Trottini (2008), comprised of 50 children whose ages ranging from 9 to 11. The method of simultaneous and memory color matching with a set of five Munsell color was analyzed. According to the results of the study, children performed better in matching orange, bluish, and yellow green color than young adults. Women remembered violet better than men, girls remembered orange and pink better than boys. Moreover, in short-term memory boys remembered bluish green better than girls and women remembered yellow green better than girls. These studies indicated that remembering the target colors differs with age and gender.

In the color memory studies, color was compared according to the hue differences

(Pérez-Carpinell et al., 1998a, Nilsson & Nelson, 1981), familiar objects (Pérez-Carpinell et al., 1998b) and different illuminant conditions (Pérez-Carpinell et al., 1998b). Also, age range and gender had some different effects on remembering the colors. These studies did not include the method of false memory but gave information about the recalled colors with the comparison of the colors. In the study, the purpose is to identify the color difference in memory. In order to select the colors for the study and compare the results, these studies were taken into consideration.

CHAPTER III

WAYFINDING

3.1 Definition of Wayfinding

Lynch (1960) analyzed the characteristics of the city plan and people's perception of the environment. According to his studies the term "wayfinding" was revealed. Lynch (1960) analyzed environmental setting in five type of elements. One of them is the paths which are the channels people move through like streets, walkways, transit lines, canals, railroads; edges are linear elements that defines the boundaries between two phases. Walls are an example of the built environment. Districts are medium to large sections of the city, also described as regions that specify it with their recognizable characters. Nodes are the points, the strategic points that are primarily are junctions between different places. Landmarks are a type of point-referencing physical objects such as building, sign, store or mountain. These elements have been considered on the designing process by urban planners, architects and interior architects who adapted work inside of the buildings (Hidayetoğlu, Yıldırım & Akalın, 2012).

There are five building attributes which help the construction of mental maps (Pollet

& Haskell, 1979). These are; clearly defined path and circulation systems, markers which stand out from the general background stimuli, identifiable nodes where paths converge, strong edges such as walls and landscape features and easily identified the zones/districts (Pollet & Haskell, 1979). Including these building facilities contributes to the perception of space.

Arthur and Passini (1992) defined wayfinding as problem solving of making a journey and reaching a destination. It provides ease of circulation, accessibility and building safety in emergent situations (Passini, 1996). It is the process of deciding and following a path or route between starting point and the destination (Golledge et al., 2000). Three categories of wayfinding are; travelling between two familiar places labeled as *commute*, travelling into unfamiliar territory for learning the surrounding environment named as *explore* and traveling from familiar place to the origin of the unfamiliar destination is called as *quest* (Allen, 1999a).

Golledge et al. (2000) divided human movement into two which are navigation and wayfinding. They explained that navigation is the process of spatial information concerning position and rate of travel between origins and destinations, shortly following a path. Wayfinding is defined as selecting and linking path segments from an established network as one travels along a specific route (Golledge et al., 2000). People feel disoriented if they cannot position themselves and cannot develop a place to reach the destination (Arthur & Passini, 1992). In an unfamiliar environment,

people requires information to make decisions which are about the setting to find their destination, information to execute decisions, information about the destination and information to conclude the decision-making/executing process (Arthur & Passini, 1992).

Arthur and Passini (1992) stated that wayfinding has three specific but interrelated processes. These processes are; "*decision making* and the development of a plan of action; *decision execution* which transforms the plan into appropriate behavior at the right space; *information processing* understood in its generic sense as comprising of environmental perception and cognition, which, in turn, are responsible for the information basis of the decision-related processes" (Arthur & Passini, 1992, p.25).

Being in an unfamiliar place of feeling that it is difficult to find a place has some psychological impacts on people. The frustration and stress that people are exposed to while getting around in the built environment are as bad as being lost (Arthur & Passini, 1992). Having difficulties with wayfinding might have negative impacts like loss of time, decreased safety, stress, or discomfort (Doğu & Erkip, 2000). Vilar, Rebelo and Noriega (2014) indicated that having difficulties with wayfinding made visitors avoid places like shopping malls, hospitals, museums, airports, train stations and convention centers. However, easy wayfinding provokes positive feelings that make people want to visit it again (Çubukçu, 2003).

Working memory takes part in recognition of the places. Davis, Therrien and West (2009) defined working memory as attending, selecting and remembering appropriate environmental information. Balaban et al (2017) claimed that navigationally relevant data such as landmarks must be stored in long-term memory and later accessible in the working memory in order to avoid getting lost. Legibility of typographic information provide with distance, angular distortion and background contrast are significant for wayfinding (Passini, 1996). Common identifying property of legibility and orientation is recognition (Doğu & Erkip, 2000). Legibility contributes to the recognition of space and the identification of users from their visual qualities (Wang et al., 2019).

Spatial cognition enables people to represent, arrange, understand and navigate the environment to take part in specific objects, to control them and transmit knowledge about the objects and the environment to others (Spence & Feng, 2010). Visuospatial perception and memory maintain to perceive and retain the size, proportion, layout and localization of spaces and objects (Min & Lee, 2020). According to the concern of relation of cognition and environment, spatial orientation gains importance.

Spatial orientation is the ability of individuals identify themselves in an area that is entirely based on creating an adequate cognitive map of the space (Arthur & Passini, 1992). People need to perceive the space to find the paths or alternative ways to reach the destination. According to the spatial orientation, cognitive map should be considered. Cognitive map is a whole mental image or representation of the area and

the environmental layout (Arthur & Passini, 1992). It differs from the cognitive mapping, which is the process of mental structuring, which incorporates what has been perceived in parts into the whole (Arthur & Passini,1992).

3.2 Virtual Environment in Wayfinding Studies

People can visualize and interact three dimensional spatial environment of real spaces in virtual environment technologies (Çubukçu & Nasar, 2005). Blascovich et al. (2002) defined virtual environment (VE) as “synthetic sensory information that leads to perceptions of environments and their contents as if they were not synthetic” (p. 105). Virtual reality (VR) is advanced computer technology. It can give users several intuitive sensations, when simulating mechanisms in a physical or imagined environment (Guo et al. 2020).

Flexibility is essential aspect of virtual reality (VR) that researcher can design according to the requirements of the study objectives and have higher variable control that is very difficult to accomplish when used in real-world settings (Vilar, Rebelo & Noriega, 2014). Preferring VR in navigation training has significant benefits on performing exercises rather than real environments (Claessen et al., 2016).

Virtual environment technology systems are categorized into two which are desk-top

systems and immersive-display terms. Desk-top systems demonstrate the virtual environment on a fixed computer screen while immersive-display systems demonstrate it from two small scenes of a head-mounted display (Pe´ruch, Belingrad, & Thinus-Blanc, 2000). These technologies advantages are possibility of designing environments in varying complexity, allowing online measurements during navigation, monitoring several spatial learning parameters like amount of exposure to the environment and number, position and nature of landmarks (Pe´ruch, Belingrad, and Thinus-Blanc, 2000). They indicated the advantages of the VR that provide control of environmental factors such as noise, light, materials and presence, gain time and financial cost from the production and installation which can be hard in the real environment. VR makes observations in real world become possible in virtual worlds (Conroy, 2001).

3.3 Different Aspects in Wayfinding Behavior

There are some individual differences that influence the efficiency of wayfinding.

Familiarity, age and gender are the main aspects of the differences. Familiarity is one of the issues of wayfinding. Passini (1996) stated that spatial orientation is the ability of the individuals to reflect the special characteristics of an environment and placing themselves in it. It can be hard for them to be familiar if they could not place themselves in the environment. O'Neill (1992) stated that complexity of the floor

plans impact wayfinding performance negatively. He added that low level of familiarity is affected from the plan complexity. Chebat, Gélinas-Chebat and Therrien (2005) stated familiar people use information in their long-term memory however unfamiliar people use maps, signs and other people. Hölscher et al. (2006) indicated that familiar participants rely on their knowledge while unfamiliar participants consult information from the building and outside. According to the results they found that familiar participants performed better in achieving a target. Armougum et al. (2019) conducted a study to examine the cognitive load (reservoir of cognitive resources for various tasks to perform) in real- life situations with travelers in train stations. They compared the cognitive load in real-life environmental condition and virtual reality simulation of train station. Performance of the regular (experts) and ocassional (novice) travelers were compared. The results demonstrated that experts have higher performance than novices. These studies indicated that familiarity improves the wayfinding performance.

Another determinant on the individual differences is the gender. Galea and Kimura (1993) found that males were more effective than females at learning the road. Males are better when considered the Euclidean measure that refers to parameters of the map studies. Females, on the other hand remembered more landmarks than males. Schmitz (1999) reported that when concerning the route direction in maps and descriptions, men performed better than women. However, women were better than men in the use of landmarks to route directions. In the studies of Çubukcu and Nasar

(2005), it was found that in comparing directions and navigation errors males are better than the females. Lin et al. (2012) conducted a study with locating targets in grid-like virtual environments. When they compared the performance of females and males, they found that males moved quicker than females. However, males could not navigate the spatial surrounding more efficiently than females. According to the evaluation of the wayfinding performance, gender efficiency differs.

Age is another point in wayfinding studies. Çubukcu and Nasar (2005) reported that younger respondents had better performance on navigation errors than the older ones, performance decreased as the age increased. According to Osmann and Wiedenbauer's (2004) report, participants learned a route from the slide presentations after they had to remember the landmarks in order to find their way in a virtual environment. When comparing the results according to age, second graders relied more on the landmarks than the six graders and adults remembered fewer landmarks. Six graders and adults had close recognition in landmark rates.

Head and Isom (2010) conducted a study between young and older adults who completed wayfinding and route learning tasks in a virtual environment. There were age differences in the wayfinding process with recalling landmarks and recognizing environmental scenes. When concerned the route learning conditions, older adults had some difficulties with the landmarks.

3.4 Graphic Components of Wayfinding Design

The memory of spaces may be distinguished relying on whether it comes from direct or indirect sources. Direct sources include the navigational experience of space by walking or standing and indirect sources involve maps and navigational aids that provide an external description of the environment (Willis et al., 2009). There are two graphic component of wayfinding design. These are the maps and the signage in building orientation.

3.4.1 Maps

Maps provide nearly complete route planning in advance (Hölscher et al., 2007). Having a map even in simple buildings is beneficial for orientation purposes. It supplies information for people to understand where they are and the whole of the building (Pollet & Haskell, 1979). The interpretation of maps requires understanding a “stand for” relationship between environmental characteristics and cartographic conventions used to symbolize and creating a relationship between the map user and the environment with “you are here” (Allen, 1999b). You-Are-Here maps may theoretically serve to help self-locate and track one's progress toward the target (Hölscher et al., 2007). You- Are- Here maps are solidly installed vertically on walls or signposts (Richter & Klippel, 2002). It needs to be located near decision points. Also, they should be positioned on the entrances that visitors can orient themselves at these points, decide their destination and the route (Richter & Klippel, 2002).

3.4.2 Signage

Signage systems are visual information systems that use graphics and characters to convey direction, identification, safety and regulations of environmental information (Calori & Vanden-Eynden, 2015). By simplifying the apparent complexity of a building, an effective signage system may indicate quick and efficient evacuation routes (Zhang, Jia & Qin, 2017).

3.4.2.1 Signage Design

Signage has significant effect on the safety and usability in public spaces when concerned wayfinding in open urban spaces or large indoor building spaces (Nassar, 2011). Nowadays, smartphones have an advantage on locating the position and finding the best route for the destination in outdoors (Motamedi et al., 2017). Nevertheless, low accuracy of indoor positioning technologies and outdated floorplans affects indoor navigation that maps and signage provide to reach the destination (Motamedi et al., 2017). Good signage is important to help traveler in their journey by including essential information (Greenroyd et al., 2018). Zheng

(2020) stated that regardless of the type of map used, signage is the most commonly used landmark for finding the way.

Signage is the primary wayfinding attribute considered to assist individuals achievetheir way to a desired destination (Vilar et al., 2015). Signage includes visual

indicators for the mental picture of the environment by increasing the user's knowledge of the space with map, signs and other aids (visual or otherwise) to reach the destination (Jalees, 2020). People who used the signs reached the destination more quickly than people who used the You- Are- Here map (Butler et al., 1993).

Readable signs decrease the incidents of confusion, tension and danger. Designers associate readability with the color that enhance interior signage and effectiveness in interior spaces (Lomberski, 2008). "Signage must often be read at a distance by pedestrians walking quickly or passengers in moving cars, letterform legibility is critical to the success of a wayfinding program" (Gibson, 2009, p.80). Legibility is a visual property of a character or symbol which determine how easily it is recognized (Humar et al., 2014). The changes in visibility resulting from improvements in sign and print size, luminance and interactional effect of visual angle should be considered all in signage design (Rousek & Hallbeck, 2011). According to the study of the Shi et al. (2020), achromatic color combinations was more legible than chromatic color combination. In addition, they found that different types of signs and set a different height was not influence the legilbility.

3.4.2.2 Signage Types

Arthur and Passini (1992) indicated that in unfamiliar places people requires orientation and general information to make decisions about the place, where they

are and where their destination lies, directional information to execute decisions that guide them along their destination, identification to conclude the decision-making/executing process.

There are four sign categories which are:

- Orientation Signs; inform the visitor about an overview of their surroundings. Its design needs to be coordinated with the identification signs and directional signs to ease the circulation of the route (Gibson, 2009).
- Identification Signs; located at destinations to identify destination or place, the first impression of the destination that demonstrates the name and function of the places (Gibson, 2009).
- Directional Signs; positioned for guiding the way from the destination to direct people to various destinations (referred as wayfinding signs), circulatory system of wayfinding that provides cues about the place (Gibson, 2009). Also it includes the information which is demonstrated at destinations like signs with names or pictographs at entrances to the destination (Arthur & Passini, 1992).

- Regulatory Signs; manage peoples' behavior or forbidding certain activities like Authorized Personnel Only and No Smoking (Calori and Vanden-Eynden, 2015)

3.4.2.3 Sign Design

Signs are a symbol or message that provides information or directions in a public place (Sign, n.d.). Signs are the most prevalent aspect in information systems (Pollet & Haskell, 1979). It has only one aim that communicates information about its environment to people (Calori & Vanden-Eynden, 2015). Sign should indicate three distinct types of information which are generic search words, instructive symbols and anticipatory phase (Corlett, Manenica & Bishop, 1972). They explained that generic search words provide direction for finder in order to identify their objective within the system. Instructive symbols include arrows and symbols to select appropriate direction-finding. Lastly, anticipatory phase supplies visitors to anticipate their next route choice and remember it upon arrival.

Analysis of arrival, departure, and decision points which are circulation paths and signing opportunities should be considered when planning the location of the signage (Gibson, 2009). Direction of traffic and space configuration lead on deciding the location of the signage as concerned designers experience (Nassar, 2011).

All signs should be located in order to see it in each choice point and positioned perpendicularly in relation to the flow of traffic (Corlett, Manenica & Bishop, 1972). Corlett, Manenica and Bishop (1972) claimed that it decreases the feeling of being lost in direction-finding situation. Signs should be located in decision points, when

concerned the vehicular signage reaction time is a factor that give people enough time to maneuver, place the identification signs at the destinations in order to confirm their arrival to place (Calori & Vanden-Eynden, 2015).

While designing the sign there are some accessibility features that need to be considered (Pollet & Haskell, 1979). These are;

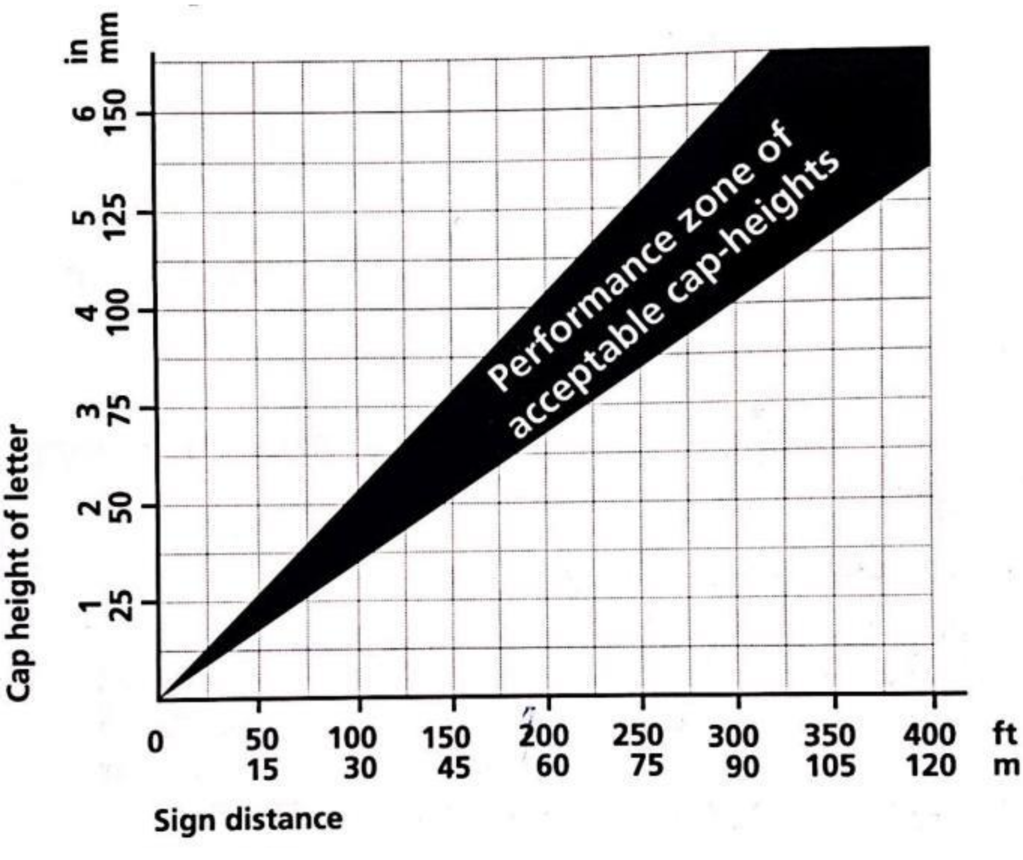
- Prevent obstruction of signs with building features like lights and air vents
- In a single directional sign, prevent more than five messages and five line of text
- Reinforcing text with the familiar pictograms
- Directional signage put emphasis on architectural indicators (wall graphics or landscaping) that lead to the destination
- Signs located on the transitional areas should provide people to be on correct route

- Floor levels and their uses (e.g., entrances to the complex, offices, concourse, parking) clearly identified in elevator lobbies and at the tops of ramps, stairs, and escalators
- Signs installed at intersections to ensure the information can be noticed by those coming from all directions

Type of the sign should be decided according to the purpose and the included information. Arthur and Passini (1992) constructed a sign in three categories. These are the "*self-supporting* on a post, a slab or a plinth; *wall mounted*, either flat on a vertical surface or projecting and *suspended* from a soffit or ceiling" (Arthur and Passini, 1992, p. 147).

Content defines the type of the signage and form has an impact on accessibility that consists of color, shape, font, size and space (Yuzhu, 2010). Sign messages and locations need to be hierarchically ordered and the locations of the signs need to be considered while deciding on plans (Calori & Vanden-Eynden, 2015). It should be the same in every identification and vocabulary have to be concise (Calori & Vanden-Eynden, 2015).

> "Every letterform or distinctive alphabet has its own legibility distance factor, depending upon its design characteristics. The term "legibility distance" really defines the "efficiency" of the letter (or other graphic element) in terms of use. It dictates the size that letters in a sign must be if they are to be perceived and recognized from a given distance" (Arthur& Passini, 1992, p. 165) (see Figure 3.1.).



in
mm
Cap height of letter
6 150
5 125
4 100
3 75
2 50
1 25
Performance zone of
acceptable cap-heights
0
50 15
100 30
150 45
200 60
250 75
300 90
350 105
400 120
ft
m
Sign distance

Figure 3.1: Demonstration of the relation between sign distance and cap height of letter (Arthur & Passini,1992, p. 165).

Typography, symbols and arrows need to be cooperated to successfully communicate (Calori & Vanden-Eynden, 2015). Typography is significant for sign design and typeface is the main issue of the typography that it should have formal suitability; visually compatibility with the environment, stylistic longevity, legibility and sustainability with ADA/SAD guidelines (Calori & Vanden-Eynden, 2015). Font

has an impact on legibility (Yuzhu, 2010). Basic anatomy of the roman letter forms consist of the x-height, ascender, descender, bowl, stern and serif (Gutjahr & Benton, 2001) (see Figure 3.2.). General characteristics of the fonts are bold, vertical and sans serif (Yuzhu, 2010). Common used shapes are circle, triangle and square. Language of vision utilizes shape of circle for regulations, triangles for warning and squares for identification (Arthur & Passini, 1992). Arrows can be located at sides in a way that arrows and symbols are located in line with the typography and are stacked positioning arrows and symbols above or below of the typography (Calori & Vanden-Eynden, 2015). Location of the arrows should be decided according to which way they point (Arthur & Passini, 1992).

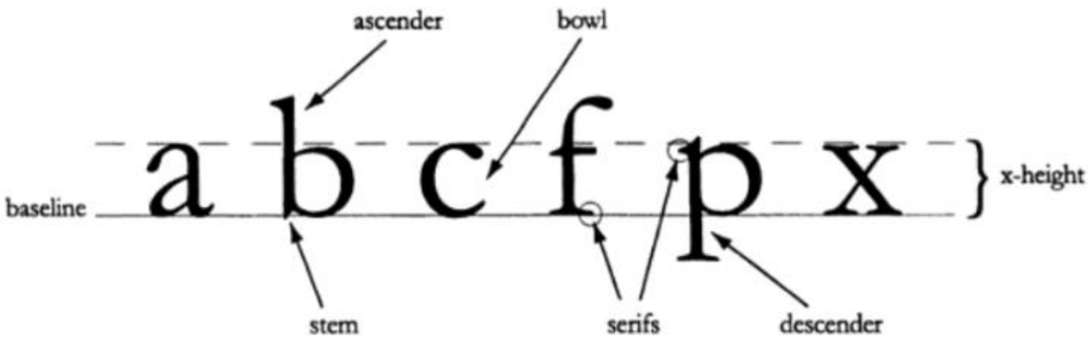


Figure 3.2.: Roman letters (Gutjahr & Benton, 2001, p.8)

Lighting and material are important when designing the signage. Location of the lighting and type of the lighting fixture need to be considered while preferring the material of the signage. Ambient light for illuminating signs is practical to use inside the buildings however position of the light source should be considered (Arthur &

Passini, 1992). Moreover, the material of the signage should be considered that it may have a shiny surface, a matte or non-lustrous finish (Arthur & Passini, 1992). Also, the type of material has an impact on the color of the sign. Material selection is important because each surface has different reflection quality and lighting condition can damage the colored surfaces of sign panels (Gibson, 2009).

Color has a universal language (Yuzhu, 2010). There are common sign colors for particular purposes (e.g., yellow for warning signs, red for emergency signs or devices, and green for safety equipment or facilities signs) (Gibson, 2009).

Passini and Arthur (1992) indicated that restriction on the selection of color on color coding is not valid for sign colors. However, contrast should be considered when combined with a second color. Color contrast has an impact on emphasizing the information on signage, attempting to convey and differentiate the information from the background (Yuzhu, 2010).

Coding the categories of information is one of the major issues of effective wayfinding (Gibson, 2009). It provides to graphically distinguish transit lines, pedestrian pathways, or urban districts on maps and signage (Gibson, 2009). Passini and Arthur (1992) stated that each color should have a purpose that link similar places to identify. For example; one color for the entrances, elevators, stairs, and another color to link different parts of departments or facilities. (Arthur & Passini, 1992). Color should stand out or be compatible with the environment, contribute to

the meaning of sign messages, distinguish the messages from one another and be decorative (Calori & Vanden-Eynden, 2015).

People may have some difficulties with the signs;

> “Ambiguity, even though the message is understandable, it can be unclear to the observer. Conflict, that not removing the old signs after installing the new ones. Deficiency, because of including too little or too much information. Excess, because of including more data that is not required on decision points. Glare, because of the location in some points where signs can be distorted by reflected light. Illegibility, that information is too small to see from the reading distance. Inaccuracy, that information has to supply all the information that must be right, up to date and accurate information, recent and accurate. Obstruction, because of blocking the view that light fixture or

> piece of HVAC is located in front of a sign. Unreliability, where people rely on the signs in an unfamiliar setting which may be disappointing for people without any reason. Us, that people do not concentrate on the wayfinding task" (Arthur & Passini, 1992, p. 184-185).

While designing the sign, location on the plan, sign type, color, shape, font, size shape, legibility, symbols, and arrows should be taken into consideration. Lighting and its location are important for the visibility of the sign. Lighting and material are compatible that increase the effectiveness of the signs. Another issue is the color that emphasizes the information from the background with the color contrast. Grouping similar places with one color has an impact on following the route while wayfinding.

Some of the studies were compared using map and signs demonstrated that signs compared to map support the people to find the destination. Cliburn and Rilea (2008) conducted a study that compared the map and sign conditions concerned in

wayfinding. Signs were hung from the ceiling in the virtual environment and the map was demonstrated on the corner of the screen. They reported that participants who navigated the world with the aid of signs were substantially faster than those that were given a map. Huang et al. (2018) conducted a study in virtual environment in a city layout under four different wayfinding conditions that no sign, mini-map, full signs are placed at every node along each path, and finally, refined signs that were signs located strategically. They reported that under no sign condition, participants wandered around and it was not easy for them to reach the destination; under mini-map conditions, participants reached the destinations following the same path. In full signs and refined signs conditions, all participants also followed the same path. Lastly, placing signs on the route encouraged people on their wayfinding process.

3.5 Color in Wayfinding Studies

During wayfinding and orientation, color can be used as a clever, creative and inspiring method in application (Read, 2003). Well-designed color and light in indoors may have a positive effect on wayfinding and spatial perception (Hidayetoğlu, Yıldırım and Akalın, 2012). Helvacıoğlu and Olguntürk (2011) conducted a study to find the effect of the color on wayfinding in school environments. They located six landmark boxes on corridors. According to the results of the study, color has an impact on wayfinding, but different colors do not have an impact on route finding tasks. Hidayetoğlu, Yıldırım and Akalın, (2012)

studied the impact of color and light on indoor wayfinding and subjective judgements of those perceiving environments. People remembered warm colors compared to cool and neutral colors. Lastly, females preferred high brightness levels compared to males.

Color improves visual memory in a building environment with encoding and recognition process of the visual memory (Helvacıoğlu, 2007). Süzer and Olguntürk (2018) indicated that navigation performance of elderly people was better in the cool color scheme including the tones of blue and warm color scheme including the tones of red compared to neutral settings of tones of gray and beige. Min and Lee (2020) conducted an experiment in order to find the impact of contrast in neutral, warm and cool colored spaces on spatial memory. Participants performed better in warm and neutral color schemes compared to cool colors.

In wayfinding process, signage has an impact on reaching the destination. Vilar, Rebelo, and Noriega (2014) conducted a study in virtual environment for indoor wayfinding. They analyzed the impact of different signage systems, vertical condition which is wall-mounted and consists of one color, horizontal condition which has different colors on the wall-mounted sign. Also, neutral condition (no signage) was included in the study. When compared the two types of signage systems (vertical and horizontal conditions), participants spent less time in horizontal condition compared to vertical and neutral conditions. It can be interpreted that color

has an impact on wayfinding. Another study was about understanding emergencies where participants selected among the six colors in a virtual room with two doors (Kinateder, Warren and Schloss, 2019). The study indicated that people walked through the green exit signs among the red, yellow, blue, magenta, and white colors. However, the choice of magenta was close to the green.

3.6 Characteristics of Train Stations Affecting Wayfinding

The railways start to take part in worldwide central position in transportation from second half of the 19th century (Rovelli et al., 2020). It boosts to regional improvement by related land-use changes (Rovelli et al., 2020). Alexander and Hamilton (2015) stated that arguably the birthplace of the modern railway is the United Kingdom.

Railway system has significant impact on growth of the cities and development of urban systems (Pels & Rietveld, 2007). Rail transport takes an important place on economic growth of a country (Yu & Lin, 2008). Jovanović et al. (2020) remarked that railways serve modern economies, delivering safe freight, and passenger transport services. It provides improvement in regional growth and the economy and decreases the negative environmental effects of the transport sector (Jovanović et al., 2020).

Hamilton and Alexander (2013) also defined train stations as the focal point for a located city that function of the station is main entrances of community like gateways or threshold. When geographical entity concerned, train stations have two identities.

> "A node that a point of access to trains and, increasingly to other transportation networks. A place; a specific section of the city with a concentration of infrastructure but also with a diversified collection of buildings and open spaces" (Bertolini & Spit, 1998, p.9).

The node-place model was developed to describe the connection between land use policies and transport centers particularly for train stations (International Union of Railways, 2019). There is a balance between the place and the node that place value of the station (real-estate value, urban development, etc.) which is comparable with node value of the station (quality of transport activities and passengers flow) (International Union of Railways, 2019).

Main components of transportation nodes are; paths which are lines between points, transportation station is meeting point of different paths ad transport modes, supporting facilities which are housing, office and retail facilities and public open spaces are squares or parks located between the buildings or stations within a node (Mtembu, 2008).

Edwards (1997) categorized stations according to their size and function. Mtembu (2008) defined the stations as the following:

- Mainline Terminal is the biggest station typically situated in the town center. Trains start and end travelling in these stations.
- Mainline Interchange Stations are mainline stations or terminals or island stations that have a strong connection with other forms of transportation such as tram, taxis and buses
- Mainline Stations are situated in the city center close to a bus or taxi ran which do not have link with other forms of transportation.

- Suburban Station can be divided as busy (frequent daily use), quiet (occasional use) or Interchange Station (stronger connection to a taxi or bus rank) which depends on its placement.
- Rural Stations are smaller stations containing only the basic necessities of the station.
- Special/unnamed stations involve airport station and other stations which have special purpose.

Monsuur et al (2017) evaluated the types of train services in the United Kingdom which are:

- Commuter rail, which comprises of mass rail transport that serves large cities. It uses rolling stock to accommodate the transfer of passengers that runs at high frequencies.

- Rural rail is a small-scale railway operation in rural areas. It uses small rolling stock that runs at low frequency, 1 train per hour
- Interurban trains are longer distance commuting services between large conurbations with a frequency of 2 train per hour.
- Long-distance trains serve across the country with a frequency of 2 trains per hour.

- High-speed trains offer convenience that are similar with the long distance trains but they run in higher speeds

Utilizing the arch form for the canopy of Saint Pancras Station provided an exploration to requirements of larger, clear areas in station buildings (Mtembu, 2008). Over the years, stations have diversified to include other services such as stores, hotels, and restaurants which make stations became a meeting places for passengers in transit (Mtembu, 2008). In most of the cities train stations are located close to the historic centers, making them desirable entry points for central business areas and for tourists recreational or shopping trips (Pels & Rietveld, 2007). It is not just a nodes of the transportation as Coppola and Silvestri (2020) emphasized with the examples that train stations are where journeys begin and end, people get together, organize meetings and spend their time, eat a meal, shop or just read a book while waiting a departure.

Train stations are not only the nodes for the passenger as the transport flow to change

from one vehicle to any other but also spatial concentrations of the activities has an improving effect on the cities (Pels & Rietveld, 2007). It encourages the growth of the city by concentrating on sustainability, technology, heritage, safety& security, social equity, and economic growth (International Union of Railways, 2019).

Rediscovering the role of train stations as “urban centrality” directs urban planners, transport engineers and architects to design stations according to the need and requirements of the user (Coppola & Silvestri, 2020). Nowadays designers focus on the sustainability that prefer glass roofs, rainwater tanks and solar panel which are becoming the standard practice of the transportation hubs (International Union of Railways, 2019). Traffic pattern, station infrastructure and interlocking systems are determinants on the capacity of stations (Jovanović et al., 2020).

Train stations are complex transportation buildings that consists of large number of hallways and subspaces that people (Wang et al., 2019). Passengers can easily lose their way (Wang et al., 2019). Wayfinding scheme for train stations consists of identifying major paths that can be taken from the pedestrians and survey in order to understand comprehensively; devising a wayfinding scheme with considering the major paths to determine the location of the wayfinding signs; designing, fabricating and placing signs, and evaluation, maintenance and update to replace the outdated signs (Huang et al., 2018). Satisfaction of passengers has an impact on promoting the growth of railway use. A good signage that includes the information about the arrival

and departure times has an impact on travel effectively (Ghazali, Ramli & Abidin, 2017).

3.7 Signage Design in Train Stations

Train stations are characterized as a combination of confusion, apprehension, and disorientation that passengers can be anxious of being wrongly directed and missing the trains due to the misdirected and the bigness of the station (Athur & Passini, 1992). Purpose of the train station design is to provide a seamless trip for travelers and an enjoyable experience, safety and security for visitors (International Union of Railways, 2019). People need to perceive the space and follow the destination interruptedly. Wang et al. (2019) sated that legibility is a major issue for indoor spaces such as train stations and airports used for commuting. If the legibility is provided, it becomes easy for the people to remember and identify the space which decreases confusion and improves perception of the space (Wang et al., 2019).

Good wayfinding systems should be recognizable, consistent, functional, accessible, seamless and interesting, including the information of

- “where they are (position and context),
- what transport modes and routes they can use to reach their destination and
- when they have reached their destination in order to reach the destination conveniently and quickly” (Transport Design Manual, 2019, p.9).

Wayfinding system should be inclusive that provides information accessible to people, be modular that can be used for a variety of applications, be sustainable that materials need to be long-lasting for environmental factors, clear and concise with short, simple words and keeping messages simple, consistent that how it was mentioned once, it should be mentioned in the same way (Transport Design Manual, 2009).

Good wayfinding decreases stress level, encourages passengers onto the rail network and increases income, supports passengers to select the appropriate route to reach destination, maintains the flow of passengers, decreases station crowding, saves time for passengers, minimizing the mistakes while finding the correct train, reduces platform dwell times and decreases staff enquiries (Rail Safety and Standard Board, 2006).

Placement of the signage has an impact on usability of the buildings and impact on wayfinding characteristic of the pedestrians in large buildings like airports, train stations and large academic buildings (Nassar, 2011). People rely on information to understand and control the environment like trying to find the right information to reach their destination in train stations (Armougum et al., 2019).

Signage is guaranteed to assist passengers in the station (International Union of Railways, 2019). Location of the sign should be considered based on the visibility

that the user may overlook a sign or have some difficulties during the navigation process (Huang et al., 2018). Placement of the sign is important that placing too high causes people to miss the information or too low causes a hazard (International Union of Railways, 2019). The text and pictogram signs’ height should be between 140 cm to 160 cm. Where a sign may be temporarily hidden in a crowd, for example, the sign should be positioned at a height no less than 200 cm above the finished floor plane (Signage Manual, 2016). Typeface need to be preferred sans serif or one of the limited serifs like Helvetica, Arial, Brunel or Rail (Rail Safety and Standard Board, 2006).

Gupta (2008) explained design considerations of sign system in public places as;

- It should provide clear designation of places, warnings, and route information.
- In order to be useful for everyone, it can be clearly seen from eye level and well-lit for detection of nighttime.
- It should be clearly understood, messages must be consistent, as short as possible, claimed positively and signified the same for all viewers.
- It should combine letters with graphic symbols to illiterate people.
- The signage should be more pictorial to prevent the language be an obstruction.
- Using light-colored characters or symbols on dark background increase the readability of the sign

- Background material of the sign should be eggshell, matte or non-glare.
- Mainly preferred colors for sign are white, black, red, blue and green.
- When it is conducted with the colorful walls, intensity of light and color can create some emotional warmth, clarification of orientation and safety for crime and accidents.

Wayfinding studies pointed out the impact of color on wayfinding in train stations. Van Hagen et al. (2008) conducted a study in a Dutch train station with changing colors and lighting of the station with virtual environment. They reported that participants on blue platform with high intensity of light had better orientation. Shi et al. (2020) studied a wayfinding sign in metro stations with two color combinations of signs regarding the legibility. These are achromatic that white target on a black background and chromatic that yellow target on black background. They analyzed that achromatic color combination is more legible than chromatic color combination. Lloyd, Rodgers and Robert (2018) conducted a study about the impact of color coding on usability of metro map. They had three schemes, a route-colored map that each route had a distinctive color, a trunk-colored map that each trunk (bundle of the routes) had as distinctive color and a shaded color map that each trunk had a different color and routes were in different shades of that color (see Figure 3.3). Destinations on the route were selected by a software. After that, participants had to indicate whether they could travel from station <S1> to station <S2> without changing trains or not. This question indicated the accuracy of the answers.

According to the results of the study, route coloring scheme has been significantly accurate than trunk and shaded- color maps. As mentioned in this paper, navigational task of tracing a route could be easy with the route coloring however, it could also create visual clutter that would make it difficult to carry out a complex journey planning (Lloyd, Rodgers and Robert, 2018).

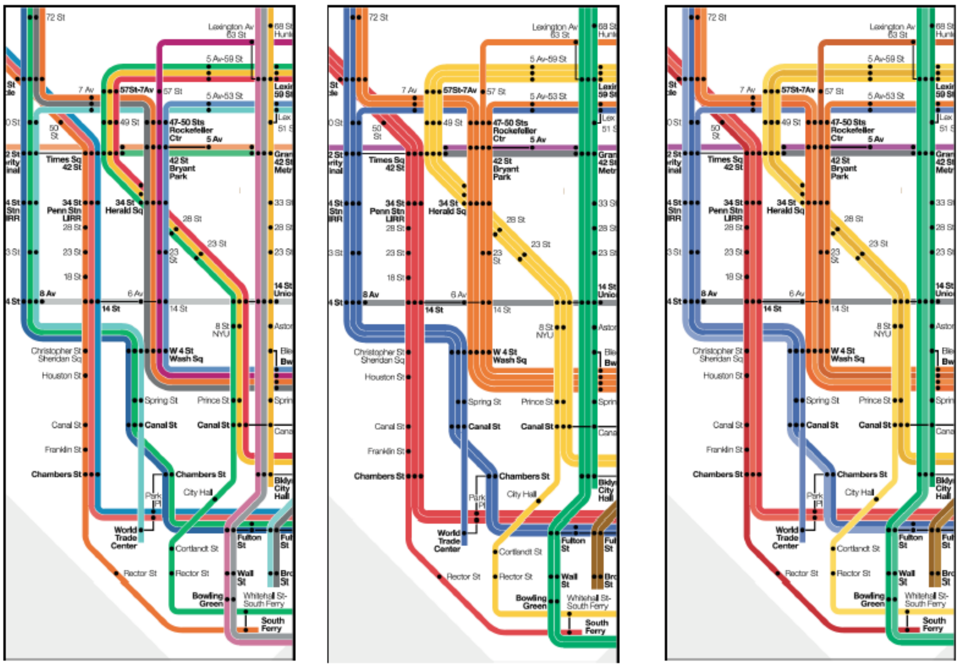


Figure 3.3: Image on the left demonstrates route- colored map, second image is trunk-colored map and image on the far right illustrates the shaded color map. (Lloyd, Rodgers and Robert, 2018, p. 413)

False memory studies were conducted with limited colors which were blue, yellow and green. Color memory studies were indicated that orange and purple were mainly

remembered colors. Also red, yellow, green and blue colors had universal language in sign design. Different colors which were orange, magenta, purple, turquoise, black and white colors were selected to understand the effect on memory. In the Ankara YHT railway station, there was a gap in signage that information was not adequate to find the way. Also, not having enough information and wrong directions such as not renewing the information on the signage and not putting the signage on the decision points may be decreased the wayfinding performance. Railway stations were huge and complex structure which can be hard for travelers to remember the first encountered information on the signage. In order to understand the effect of sign color in the railway stations misinformation paradigm was used.

CHAPTER IV

THE EXPERIMENT

4.1. Aim of the Study

In Ankara Yüksek Hızlı Tren (YHT) railway station, there is no information indicating any directional signs. It can be hard for visitors to find the correct platform that may cause waste of time, which is crucial for visitors. However, in train stations, people can be misled because of the old directions and changing the locations which are not included on signage. Lack of signage in Ankara YHT railway station provides to understand the relationship between memory and color in railway stations. The aim of the study is to investigate the relationship between misleading information and remembering different colored signs in train stations. The misinformation effect is memory impairment which occurs because of exposing misleading information (Loftus, 2005). This study comprehends whether changing the color of the signs have an influence on remembering the first demonstrated colors. This provides information about influence on variations in color on recognition.

4.1.1. Research Questions:

Q1: Is there a significant relationship between different colors on remembering the sign color?

Q2: Is there a significant relationship between the misleading information and remembering the sign color?

> **Q2.1:** Is there a significant relationship between the misleading information and color scheme on remembering the sign color?
>
> **Q2.2:** Is there a significant relationship between the misleading information and the location of the signage on remembering the sign color?
>
> **Q2.3:** Is there a significant relationship between the misleading information and the order of the color on remembering the sign color?
>
> **Q2.4:** Is there a significant relationship between the misleading information and single and paired colors on remembering the sign color?

4.1.2. Hypotheses:

H1: There is a significant relationship between different colors on remembering the sign color.

H2: There is a significant relationship between misleading information and remembering the sign color.

H2.1.: There is a significant relationship between misleading information and color scheme on remembering the sign color.

H2.2: There is a significant relationship between misleading information and the location of the signage on remembering the sign color.

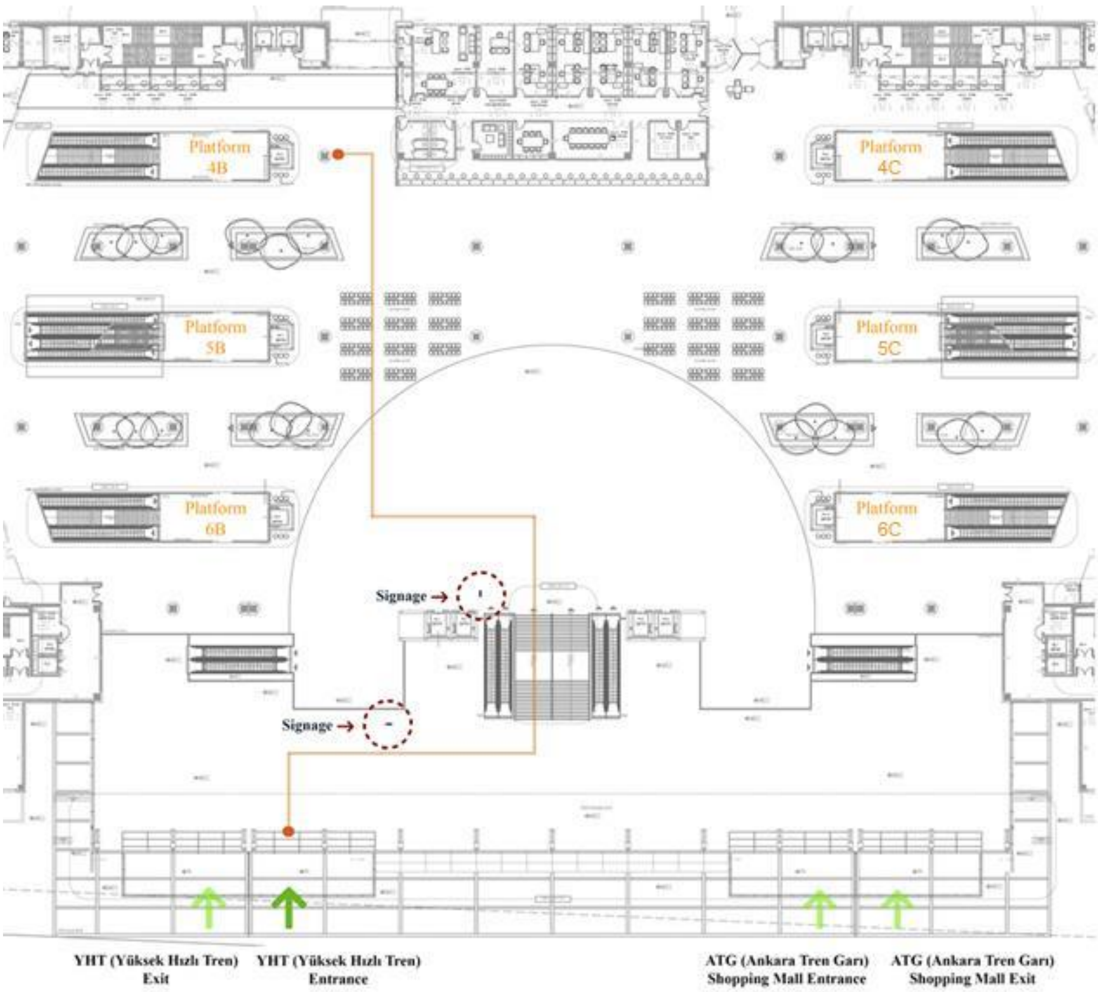
H2.3: There is a significant relationship between misleading information and order of the color on remembering the sign color.

H2.4: There is a significant relationship between misleading information and single and paired colors on remembering the sign color.

4.2 Method of the Study

4.2.1 Description of the Site

Before the experiment, Ankara YHT railway station and its drawings were analyzed. Ankara YHT railway station is located next to the Ankara railway station. Also, people can enter from Ankara railway station. Thus there are two entrances. The entrance is restricted with the main entrance which is the YHT Entrance. According to the drawings; 4B, 5B, 6B platforms are departure platforms and 4C, 5C, 6C platforms are arrival platforms. Platform 4B is for Eskişehir, platform 5B is for İstanbul and platform 6B is for Konya passengers. In order to investigate the influence of color on signs from entrance to the departure platform, arrival platforms are not included. The route started from the YHT entrance, going through the



platform 4B (see Figure 4.1).

Figure 4.1: Ankara railway station plan demonstrates route from Yüksek Hızlı Tren (YHT) entrance to platform 4B (not to scale).

4.2.2 Sample Group

The sample group consisted of 90 people for this study. The study was sent to randomly selected participants. The link of the study was shared on social media accounts (Facebook, Instagram and WhatsApp). Participants who are architects, interior architects and people who have a profession related to design was not included in the study. In the curriculum of the universities, color lectures are included for interior architects. Also, it can be included for the architects. Thus the possibility of having color lectures, people who had a design background was not included. Participants should not have theoretical information about color because they can answer biased. Participants did not have any color vision deficiency. There were 57 females (63,3%) and 33 males (36,7%) whose age range was from 20 to 59. Participants whose ages were under the 20 years and over 65 years were not included in the experiment. The attention and concentration of participants under 20 years is not reliable and for those over 60 years, they might have troubles remember things. Participants' age range was divided in four groups (see Table 4.1.). The percentage of participants who had been in train station is 71,1% (64 people), but 28,9% (26 people) of them had not been in station (see Table 4.1). The percentage of their frequency differs that 2,2% of the participants indicated that they very frequently, 12,2% of them occasionally, 56,7% of them rarely and 28,9% very rarely utilized the train station (see Tables 4.2., 4.3). Due to the circumstances, it was not possible to get an equal number of participants to compare age, gender and familiarity. Thus the experiment did not concentrate on the familiarty, gender and age differences.

Table 4.1: Frequency and percentages of participants' demographic information

Demographics		Frequency	Percentages
Gender	Females	57	63,3%
	Males	33	36,7%
Age	20-29	38	42,2%
	30-39	28	31,1%
	40-49	6	6,7%
	50-59	18	20%
Familiarity	Familiar	64	71,1%
	Unfamiliar	26	28,9%
Profession	Student	11	12,2%
	Employee	74	82,2%
	Retired	5	5,6%

	Familiar	Unfamiliar
Female	37	20
Male	27	6

Table 4.2: Number of the participants' familiarity

Table 4.3: Number of the participants' familiarity frequencies.

	Always	Very Frequently	Occasionally	Rarely	Very Rarely
Female	-	1	6	30	20
Male	-	1	5	21	6

4.2.3 Procedures

4.2.3.1 Phase 1

In this study a web-based experiment is preferred because of the COVID-19 pandemic. It was not permitted to go outside except for emergency conditions. In order to find participants for the study, the experiment was conducted on the Google Forms. Participants' attendances were provided by the link of the experiment. They attended study with the shared or sent links via social media accounts. Web-based research enables the analysis of a broad variety of software and hardware components that influence the reproduction of color stimuli (Mylonas & MacDonald, 2010). The variability of appearance of color stimuli can be controlled with the viewing conditions. In order to control experimental conditions, participants had to follow similar steps of the online color naming experiment (Mylonas & MacDonald, 2010, 2014, Paramei, Griber, & Mylonas, 2018). They had to adjust the brightness until they can see the differences between all 11 steps of the grayscale clearly on the display properties task and continued. Color naming test is not within the scope of this experiment. In addition, participants were asked to report for any color

deficiencies before the start of the experiment. Thus, color naming test and color vision tests were not included in this study. Viewing conditions questions consisted of only the questions related to the device description, lighting, and environmental circumstances. In the questions, they indicated their display device (smartphones, pad, laptop, and desktop) and white graphic elements on the screen. After that, they described the lighting conditions of their environment and the surrounding environment behind their device and selected the viewing distance.

4.2.3.2 Phase 2

The study was conducted in a virtual environment. The 3D model provides to experience the same space without going to the train station. It helps to try lots of possibilities where different colors could be applied to the same model. It is more convenient to conduct an experiment in a desktop VE. It facilitates the control of environment and the path that participants experienced each color with the same scenario. This can contribute to understanding the effects of color on remembering the sign in train stations. Also, it saved the time as the experiment was conducted in a short time. However, participants did not feel the stress of being lost, missing train, finding the location of the train etc. Participants attended the experiment from the screen of their devices in a simulated environment which does not include the psychological conditions of real environments. It may influence the efficiency of the participants. Ankara YHT railway station was modeled using “3ds Max” by the

Autodesk program. Videos of the virtual environment were prepared in 3D rendering software using Lumion Pro 5 since it is compatible with 3ds Max. The train station 3D model was drawn in Lenovo Thinkpad S440. Videos of the model were prepared on Philips 220VW9 monitor.

In the Ankara YHT railway station, there is not any informative signage including whole platforms to guide people. Platform numbers and capitals are designed to put in front of the elevators’ and the defined entrance areas’. Hanging signs that define the city names are not visible and people need to come closer to see them. In the experiment location of the signage are decided in order not to interrupt people while they are trying to find their platform. It should be located in accessible places to inform passengers. Participants encounter the same signage twice on the ground floor and first floor. After passengers enter and pass the security detection, they encounter with the first signage on the ground floor. After passing the stairs, they encountered the second signage (see Figure 4.2).

In the second phase of the experiment, participants read the instructions about the first video set, second video set, and questions. The first videos’ instruction is; “You are going to watch videos of the 3D drawings of the Ankara Yüksek Hızlı train station. In each video you are going to watch the passenger's, who is going to Eskişehir, walking through the platform 4B. You are going to watch the first videos. Please watch videos once". After watching the first videos they have to watch

misleading second videos. Instruction of the second video is; "You are going to watch videos of the 3D drawings of the Ankara Yüksek Hızlı train station. In each video you are going to watch the passenger's, who is going to Eskişehir, walking through the platform 4B. You are going to watch the second videos. Please watch videos once. After watching the videos, you can answer the questions". Before starting to answer the questions participants have to read the instructions. "Answer the following questions according to the first videos. Whether you saw that image in the first videos click "Yes" or not click "No"" (see Appendix A). After answering the questions, they have to submit them. All the answers were saved by the Google Forms.

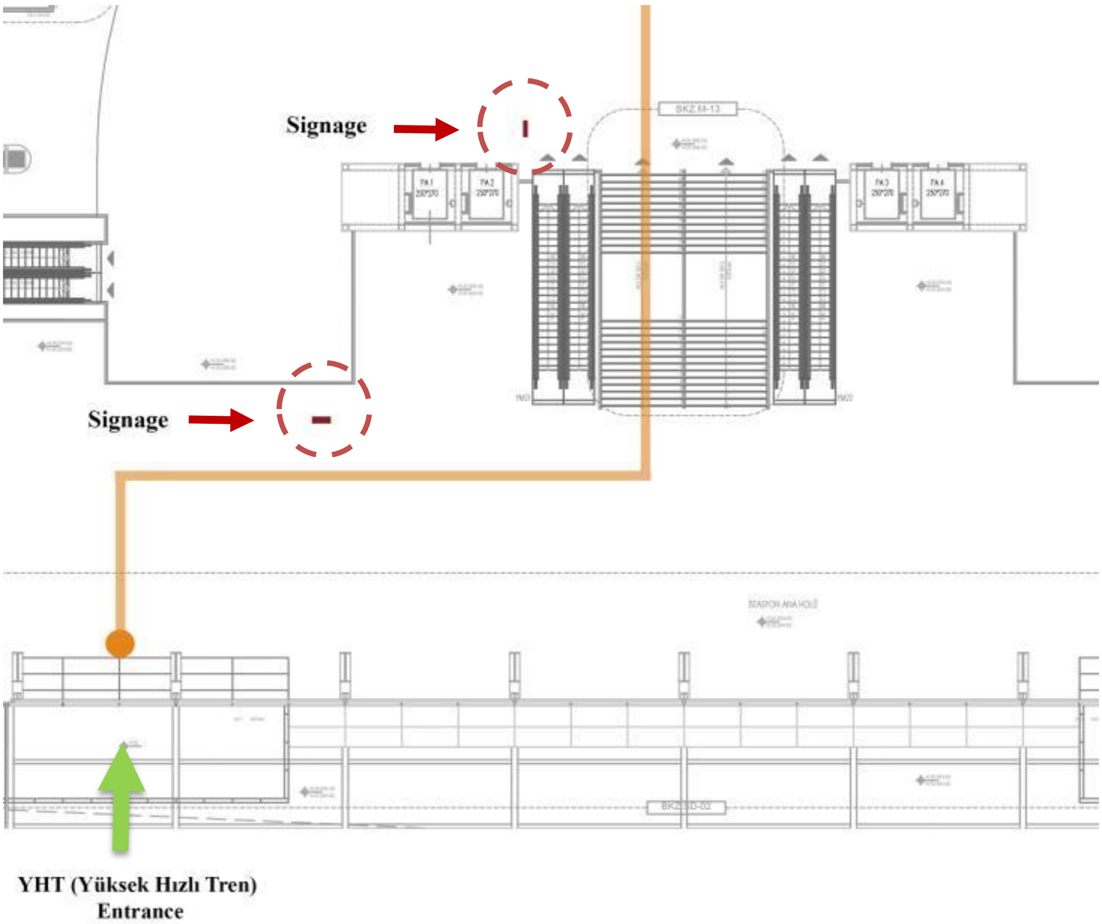


Figure 4.2: Location of signage on decision points (not to scale)

Dimensions, font sizes, and colors were designed according to the railway station signage guidelines (Rail Safety and Standard Board, 2006; Signage Manual, 2016; Transport Design Manual, 2019). Sign and the signage are designed according to the Signage Manual (2016) (see Figure 4.3.). This manual aims to provide instructions for those who are preparing tender document for arrangement of signs at stations within the Queensland Rail City Network, Australia. It consists of procedural information and technical details of sign types (Signage Manual, 2016). Sign type of

the present study is the “Directional Sign” which is freestanding. It is located on the main decision point in both of the floors. Height of the signage is designed according to a standing person eye level. It has 160cm height, 60 cm width and 10 cm depth. The font type of signs is Arial. The size of the signs is 40 mm cap X height. All city names were separately placed in the center with 15 cm height (see Figure 4.4). Arrows were placed on the right side of the information because they demonstrated right and above directions. Information about the cities were located on both sides of the signage.

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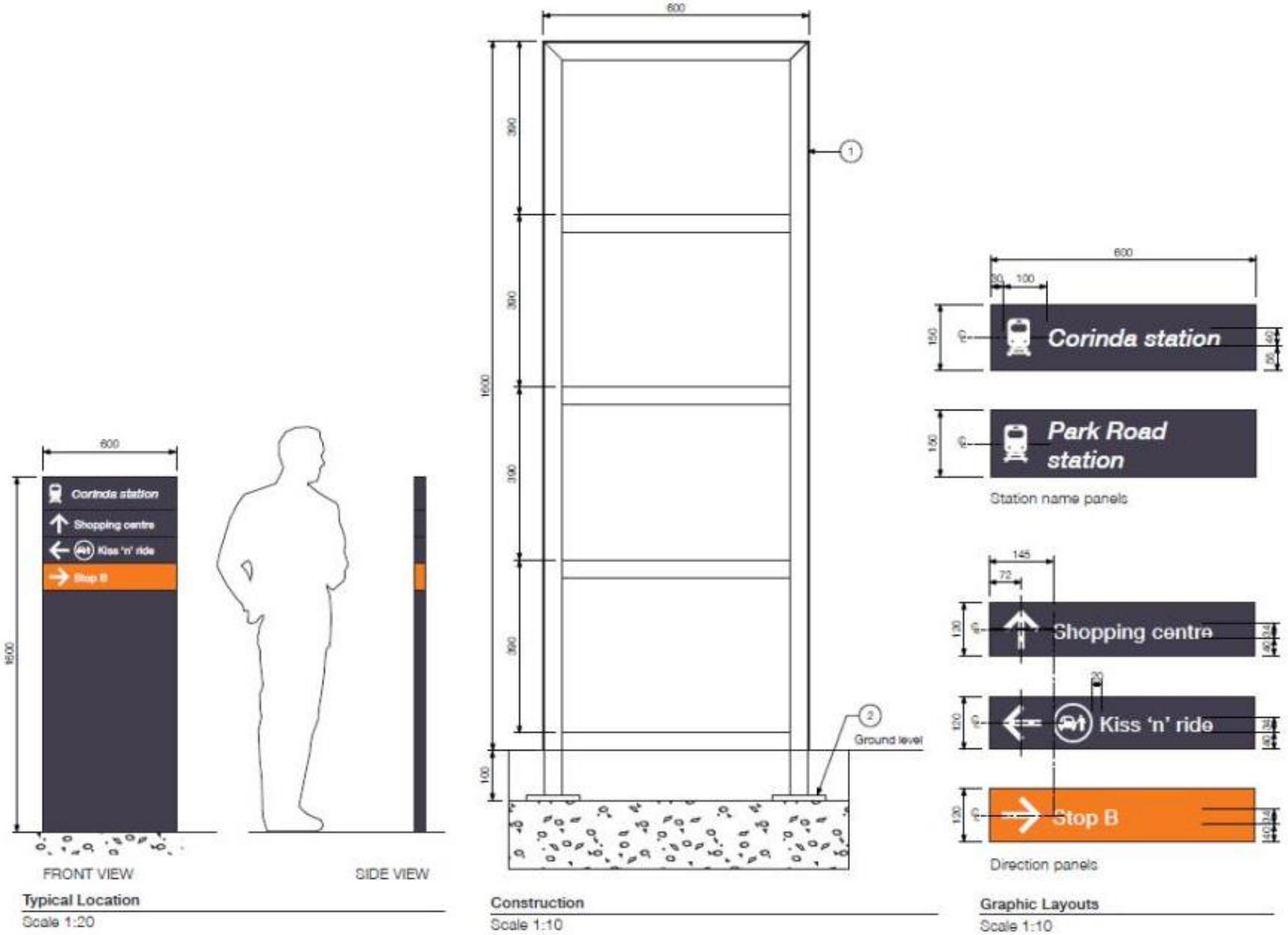


Figure 4.3: Demonstration of the typical location and graphic layout of the directional sign (Signage Manual, 2016, p.36).

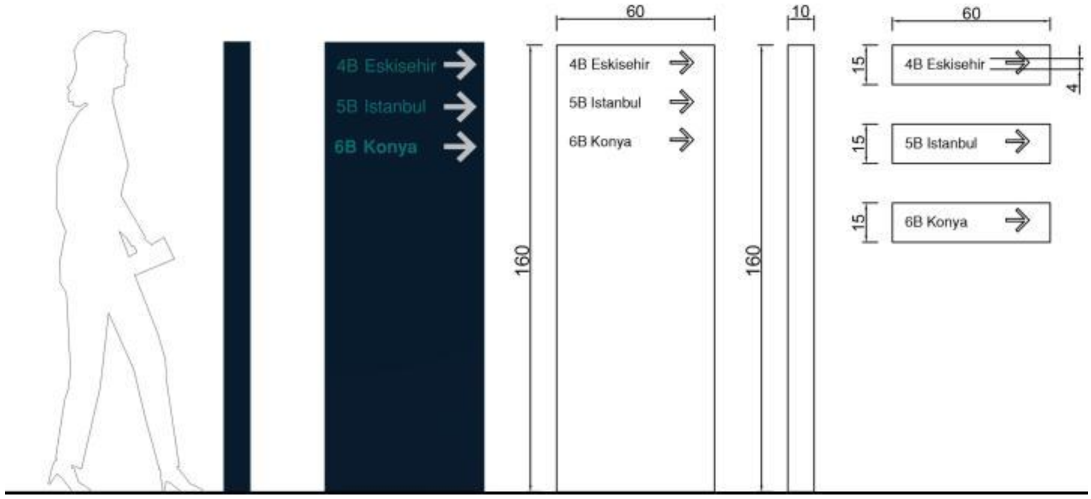


Figure 4.4: Dimensions of the signage design for this study (not to scale).

Each participant attended the study from their own devices (smartphone, tablet, desktop, and laptop). Computers' monitors and other devices' screens (tablets and smartphones) are compatible with the RGB color model. In this study, it was preferred to determine the colors' value. Pictures and videos renders were prepared in Philips 220VW9 monitor; the structure of the questionnaire was prepared on the Lenovo Thinkpad S440 screen. However, colors can differ in different computers. While preparing the videos' renders, the value of the purple which is R:255 G:0 B: 255 seemed purple in LENOVO but differed in the Philips monitor. So, the value of the purple was changed to the R:99 G:0 B:166 value which was also preferred in one of the previous studies (by Farran et al., 2012). Also, R: 255 G: 191 B:0 value of the orange differed. It was changed to the R:255 G:120 B:25 values which is the same as the study by O'Connor (2011).

Colors are selected in this study with universally known colors and the requirements of the signage design standards. Berlin and Kay (1969) indicated that universally eleven basic color categories are similar for most of the languages. These are white, black, red, green, yellow, blue, brown, pink, orange, and grey. Most of the universally known colors are accepted by the population of Turkey. Ekici, Yener and Camgöz (2005) explained that majority of people in general population are aware of the basic color names that are the same as the rainbow. These are red, orange, yellow, green, blue, indigo, and violet. When these commonly known colors are compared with the signage design guidelines in train stations, the signage seem to has a common color language. Mainly; red signifies important safety and warning, yellow and green colors represent general safety indications and blue for demonstrating accessible places. Thus; red, yellow, blue, and green colors are not included for information communication. All the main colors were assigned some purposes like warnings, safety indications and accessible places. There is no color left for locations other than white and black. Red, yellow, green and blue are reserved for the specific designation. In the study, black and white colors are used but also orange, magenta, turquoise and purple colors are included to investigate the different colors. Each color has a pair to make the group. Also in coding information, it is hard for people to remember more than five colors (Rail Safety and Standards Board, 2016) (see Table 4.4). The background color for the signage is Pantone 539C. It is the same with the signage background color in Transport Design Manual (2019). In order to emphasize departure platforms, arrival platforms (4C, 5C, 6C) were colored grey.

Table 4.4: RGB, HSB (Hue, Saturation and Brightness) and Hexadecimal codes of the colors used.

COLORS		RGB Values			HSB Values			Hexadecimal Code
		R	**G**	**B**	**H**	**S**	**B**	
Orange		255	120	25	255	90	100	ff7819
Magenta		255	0	255	300	100	100	ff00ff
Turquoise		0	128	128	276	100	65	008080
Purple		99	0	166	180	100	50	6300a6
White		255	255	255	0	0	100	ffffff
Black		0	0	0	0	0	0	000000
Grey		173	173	173	0	0	68	adadad
Pantone 539C		0	38	58	201	100	23	00263a

4.2.3.3 Sets of the Experiment

The experiment is consisted of a total of twelve videos in two sets of six videos. All videos are the same but the colors of signs on the signage differ. Scenes of the videos start from the YHT (Yüksek Hızlı Tren) entrance and go through the platform 4B. The duration of the videos is arranged according to the distance from the entrance of the train station to the platform 4B (117,60 m) which was measured according to the pedestrian walking speed of 1.2m/s (Manual of Uniform Traffic Control Devices for Canada, 1998 as cited in Montufar, Arango, Porter, and Nakagawa, 2007). The time duration is the same for each video (98 seconds). While travelers are going through the 4B Eskişehir platform, they encounter with the platform 5B and 6B. That's why only the platform 4B was preferred.

The first video set comprised of six videos where in each video, sign colors of the city names were the same (4B Eskişehir, 5B İstanbul and 6B Konya). On the other hand, the second video set comprised of another six videos which were the misleading videos. In these videos only the color of 4B Eskişehir differed from the 5B İstanbul and 6B Konya city names. Totally participants watched twelve videos in random order. Magenta and orange colors were grouped as warm, turquoise and purple color as cool and, black and white colors as neutral colors. Sign colors changed according to their color scheme that magenta changed with orange, orange changed with magenta, turquoise changed with purple, purple changed with turquoise, black changed with white and white changed with black (see Table 4.5).

Table 4.5: Demonstration of changing colors in the first and the second videos

	First Video Set			Second Video Set		
	4B	5B	6B	4B	5B	6B
Warm Colors	Magenta	Magenta	Magenta	Orange	Magenta	Magenta
	Orange	Orange	Orange	Magenta	Orange	Orange
Cool Colors	Turquoise	Turquoise	Turquoise	Purple	Turquoise	Turquoise
	Purple	Purple	Purple	Turquoise	Purple	Purple
Neutral Colors	White	White	White	Black	White	White
	Black	Black	Black	White	Black	Black

4.2.3.4 Preparing the Questionnaire

The questionnaire consists of two phases (see Figure 4.7). The first phase consists of demographic questions which are gender, age, and profession, participants' familiarity with the train station. They indicate whether they had been in Ankara YHT railway station or not and its frequency. Moreover, viewing conditions that provide information about managing the participants' display. Viewing conditions' questions consists of only the questions related to the device description, lighting, and environmental circumstances. In the questions, they indicated their device and white graphic elements on the screen. After the description of the lighting conditions of their environment and the surrounding environment behind their device, they selected the viewing distance.

In the second phase, participants answered questions about the images of the signs. The questionnaire consisted of the 48 images which were 4 sets of 12 images. The first set of twelve images which have the same colored signs are related to the first video set (see Table 4.6.). These are also grouped as single colors. All signs color of the city name (4B Eskişehir, 5B İstanbul, 6B Konya) was the same. Also, in the first set which consisted of 12 images are seperated as two groups. Six images are from the ground floor and other six images are from the first floor. In the second set, twelve images are from the second video set that only the color of the 4B Eskişehir differed from the 5B İstanbul and 6B Konya (see Figure 4.5). Again six images are from the ground floor and six images are from the first floor (see Table 4.7). These are also grouped as paired colors. In the third set of 12 questions, which are distractor images not included in the videos, only the color of 5B İstanbul was changed (see Table 4.8). These are also grouped as paired colors. Also, the half of the images were from the ground floor and other half were from the first floor. In the fourth set, 12 questions are also distractor images not included in the videos, color of 6B Konya differed from the other city names (see Figure 4.6). These are also grouped as paired colors. As previous sets of 12 images, six images are from the ground floor and other six images are from the first floor (see Table 4.9). Participants answered questions in random order. Participants click "Yes" or no "No" whether they saw that image on the first set of videos or not (see Appendix A).

Table 4.6: Demonstration of the questions from 1 to 12 which are related with first video set (The first set of the 12 images which are true memory and single colored images) (see visual drawings in Figure 4.5).

		Differentiation in Colors			**Floor**	
Questions	**Defined color for the questions**	**4B**	**5B**	**6B**	**Ground Floor**	**First Floor**
1	Orange	Orange	Orange	Orange	_	
2	Orange	Orange	Orange	Orange		_
3	Magenta	Magenta	Magenta	Magenta	_	
4	Magenta	Magenta	Magenta	Magenta		_
5	Purple	Purple	Purple	Purple	_	
6	Purple	Purple	Purple	Purple		_
7	Turquoise	Turquoise	Turquoise	Turquoise	_	
8	Turquoise	Turquoise	Turquoise	Turquoise		_
9	Black	Black	Black	Black	_	
10	Black	Black	Black	Black		_
11	White	White	White	White	_	
12	White	White	White	White		_

Table 4.7: Demonstration of the questions from 13 to 24 which are related with second video set (The second set of the 12 images which are false memory and pair colored images) (see visual drawings in Figure 4.5).

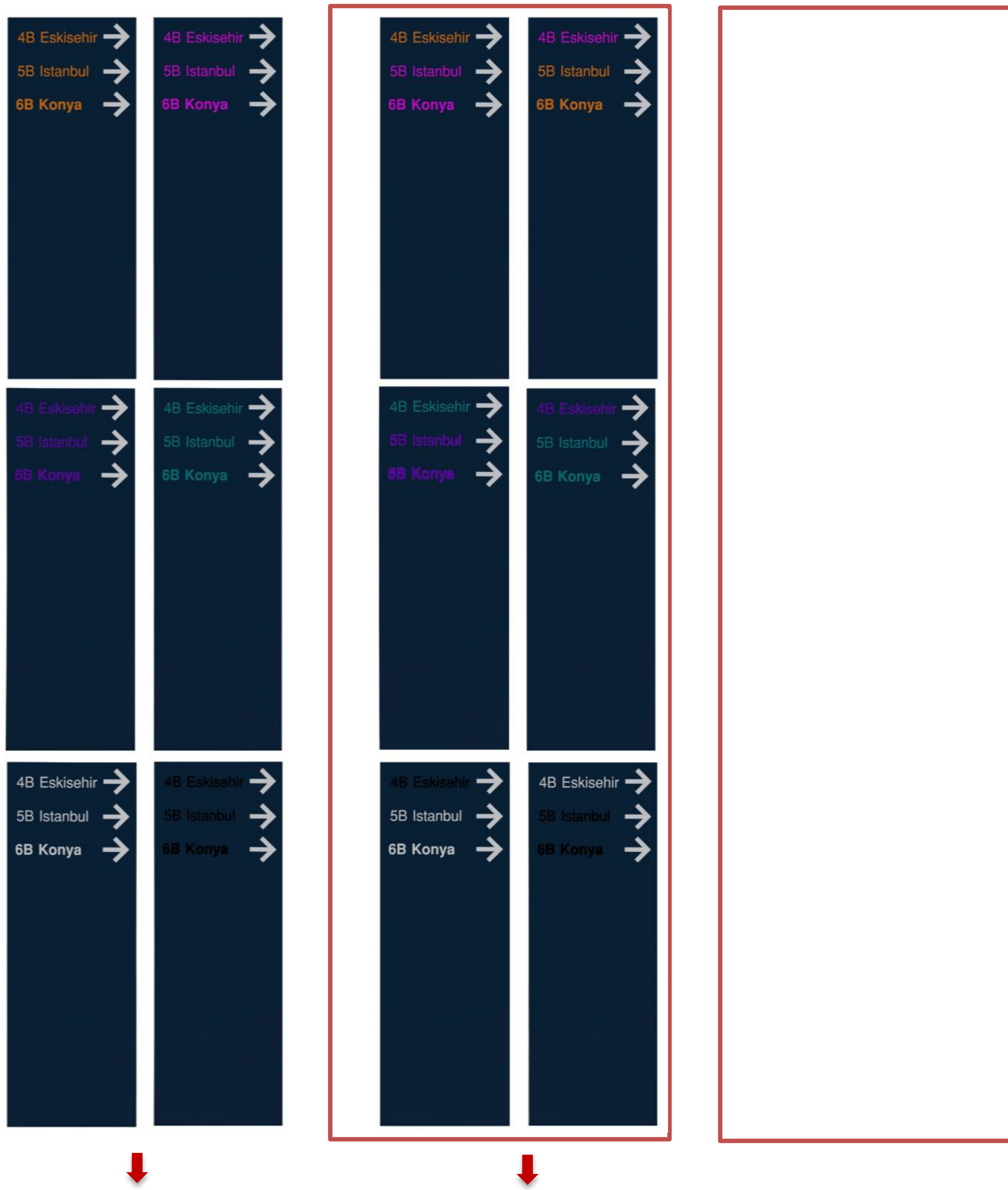
		Differentiation in Colors			**Floor**	
Questions	**Defined color for the questions**	**4B**	**5B**	**6B**	**Ground Floor**	**First Floor**
13	Orange	Orange	Magenta	Magenta	_	
14	Orange	Orange	Magenta	Magenta		_
15	Magenta	Magenta	Orange	Orange	_	
16	Magenta	Magenta	Orange	Orange		_
17	Purple	Purple	Turquoise	Turquoise	_	
18	Purple	Purple	Turquoise	Turquoise		_
19	Turquoise	Turquoise	Purple	Purple	_	
20	Turquoise	Turquoise	Purple	Purple		_
21	Black	Black	White	White	_	
22	Black	Black	White	White		_
23	White	White	Black	Black	_	
24	White	White	Black	Black		_

Table 4.8: Demonstration of the questions from 25 to 36 which are distractor images not included in the video sets (The third set of the 12 images which are false memory and pair colored images) (see visual drawings in Figure 4.6).

		Differentiation in Colors			**Floor**	
Questions	**Defined color for the questions**	**4B**	**5B**	**6B**	**Ground Floor**	**First Floor**
25	Orange	Magenta	Orange	Magenta	–	
26	Orange	Magenta	Orange	Magenta		–
27	Magenta	Orange	Magenta	Orange	–	
28	Magenta	Orange	Magenta	Orange		–
29	Purple	Turquoise	Purple	Turquoise	–	
30	Purple	Turquoise	Purple	Turquoise		–
31	Turquoise	Purple	Turquoise	Purple	–	
32	Turquoise	Purple	Turquoise	Purple		–
33	Black	White	Black	White	–	
34	Black	White	Black	White		–
35	White	Black	White	Black	–	
36	White	Black	White	Black		–

Table 4.9: Demonstration of the questions from 37 to 48 which are distractor images not included in the video sets (The fourth set of the 12 images which are false memory and pair colored images) (see visual drawings in Figure 4.6).

		Differentiation in Colors			**Floor**	
Questions	**Defined color for the questions**	**4B**	**5B**	**6B**	**Ground Floor**	**First Floor**
37	Orange	Magenta	Magenta	Orange	–	
38	Orange	Magenta	Magenta	Orange		–
39	Magenta	Orange	Orange	Magenta	–	
40	Magenta	Orange	Orange	Magenta		–
41	Purple	Turquoise	Turquoise	Purple	–	
42	Purple	Turquoise	Turquoise	Purple		–
43	Turquoise	Purple	Purple	Turquoise	–	
44	Turquoise	Purple	Purple	Turquoise		–
45	Black	White	White	Black	–	
46	Black	White	White	Black		–
47	White	Black	Black	White	–	
48	White	Black	Black	White		–



Different colored signage in the first video set

Different colored signage in the second video set

Figure 4.5: Demonstration of sign colors differentiation for the first and the second videos (sample of six images).

Figure 4.6: Demonstration of sign colors differentiation for distractor images (sample of the six images)

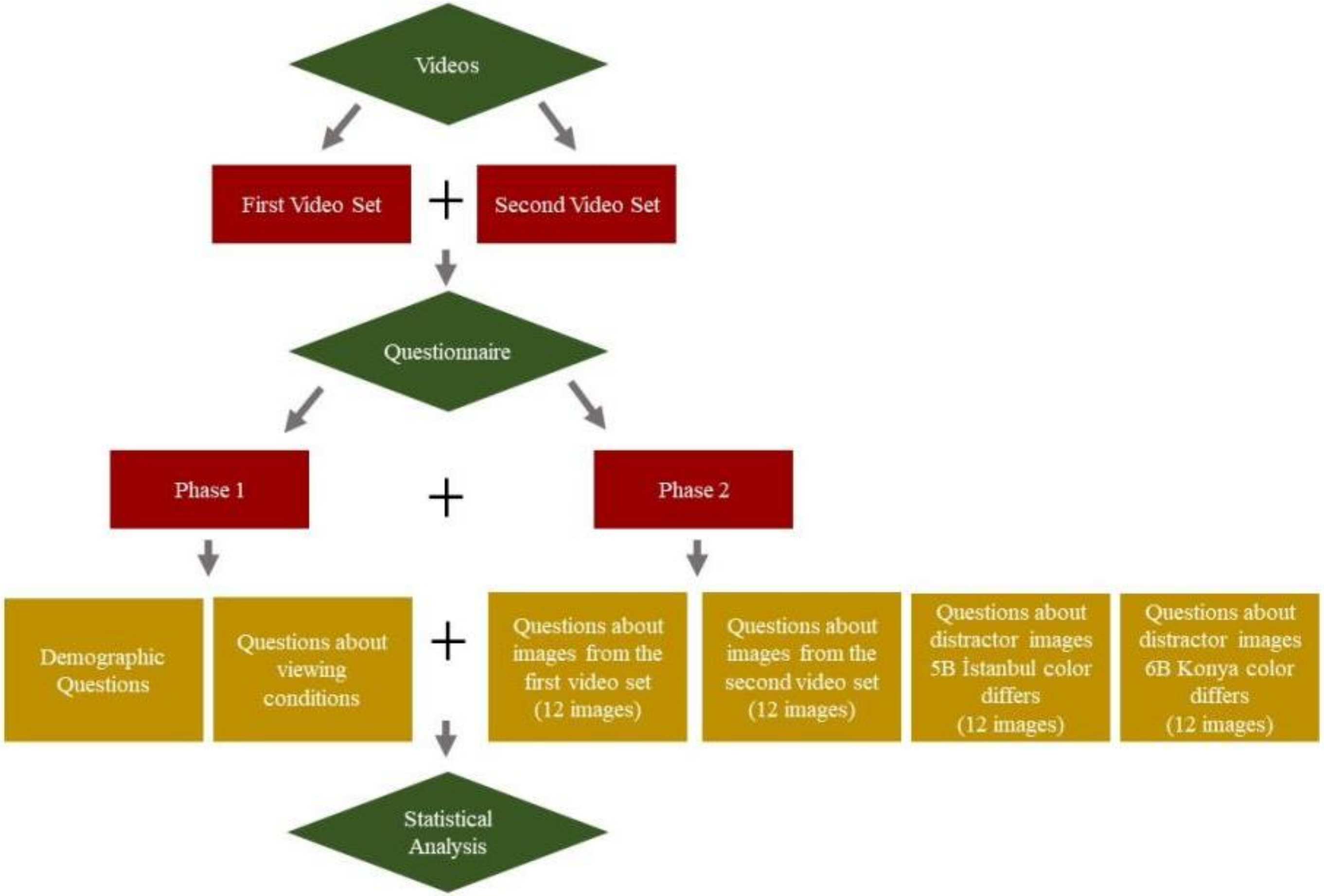


Figure 4.7: Flowchart of the experiment

4.3. Findings

Data was analyzed with the Statistical Package for Social Sciences (SPSS) 24.0. Evaluation of the data was acquired with the Chi-square test for Independence and frequency tables.

In the first phase questions about the demographic information, familiarity and viewing conditions was answered. Event hough the unequal number of participants, the relationship between the familiarity, age and gender on remembering the sign color was evaluated with the random sampling. In random sampling 26 people selected from the 64 people in order to compare familiar and unfamiliar participant's answers. The relationship between the familiar and unfamiliar participants evaluated with the Chi-square. There was no significant relationship between the familiar and unfamiliar people on remembering the sign color (χ^2=27,600, df =19, p=,091). Also gender evaluated as the same with the familiarity. In random sampling 33 people were selected out of 57 people. According to the chi-square test there was no significant relationship between the females and males on remembering the sign color (χ^2=18,000, df =18, p=,456). Moreover, age was also evaluated as the same with the familiarity and gender. Participants whose age range between the 20-29, 30-39 and 50-59 were evaluated because these are in the majority. These were calculated with the chi-square that there was no significant relationship between the age groups on remembering the sign color (χ^2=38,967, df =30, p=,126). The results of the unequal participants were demonstrated that familiarity, gender and age were not differed in remembering the sign color (see Appendix C, Table C.1., C.2., C.3.).

Percentages of the viewing conditions demonstrate that mainly one of the answers was preferred more than the others. 73,3% of the participants adjusted their device 11 steps of the grayscale however 26,7% indicated the number of the steps between 3 to 10. These participants' included in the study because the number of the steps after the 3 start to be close to white color. This provide the visibility of the differences between steps. 82,2% of the participants attended experiment from their smartphones, 15,6% of them from their laptops, 1,1% is from desktop and other 1,1% from tablet. The differences between the device preferences did not influence the results.62,2% of participants' graphic element were neutral white, 16,7% had warm white, 13,3% had bluish white and 7,8% had yellowish white. According to their lighting conditions preferences, participants indicated 11,1% dark, 26,7% typical domestic, 42,2% mid daylight, 13,3% full daylight and 6,7% typical office. Even though lighting conditions were differed, the answers indicated close results. The percentage of the participants described the surrounding environment behind their device as 8,9% dark, 16,7% dim, 53,3% average, and 21,1% bright. Participants attend the experiment in different lighting conditions of the situated environment which did not have an effect on the results. Selected viewing distance percentages varied between the participants. 8,9% of them had 10 cm, 28,9% of them 20 cm, 28,9% of them 30 cm, 16,7% of them 40 cm and 16,6% of the participants' viewing distance varied between 50 and 100. Some participants attend the experiment from their smartphones. Because of the screen size, they answer questions in short viewing distance.

In the second phase, questions evaluated according group of true and false memory. True memory is “the real retrieval of an event of any nature, be it visual, verbal or otherwise” (Guarnieri, Bueno and de Souza Silve Tudesco, 2019, p.50). False memory is remembering a situation that never happened or differently from the way they ocurred (Roediger & McDermott, 1995). Findings from the statistical analyses of questions are given in respect of the stated research questions.

4.3.1 Relationship between different colors on remembering the sign color

Chi square test for Independence was used to compare the relationship of different colors on remembering the color of a sign. This indicates the relationship between two variables constructed in a crosstabulation to evaluate whether they are independent of each other or not (Argyrous, 2005). The answers of the first set of 12 images, which were related to the first video set, were evaluated (Table 4.6). These images sign colors are the same for each city names (4B Eskişehir, 5B İstanbul, 6B Konya) which are the images of true memory. The same signage located on different floors that six images included from the ground floor and six images from the first floor. Each color consists of two images. Each question represents one of the colors which corresponding to the sign color on the images (Table 4.6, 4.7, 4.8, 4.9).

Calculations were made according to the total yes and no answers given in two images for each color (see Table 4.10) (see Appendix B, Table B.1). The results showed that there is not a significant relationship on remembering the sign color (χ^2=9,484, df =5, p=,091) (see Appendix C, Table C.4). There is no difference between colors on remembering the sign color.

Table 4.10: Percentage and frequency table of yes and no answers for each color.

	Answers			
Colors	Yes	Percentages of Yes Answers	No	Percentages of No Answers
Magenta	129	71,7 %	51	28,3 %
Orange	118	65,6 %	62	34,4 %
Turquoise	119	66,1 %	61	33,9 %
Purple	113	62,8 %	67	37,2 %
White	132	73,3 %	48	26,7 %
Black	110	61,1 %	70	38,9 %
Total	721	66,8 %	359	33,2 %

4.3.2. Relationship between misleading information and remembering the sign color

In the questionnaire it was indicated that participants had to answer questions according to the first video set. The first video set was the demonstration of the same sign colored videos however second video set gave misleading information with changing the city name color of the 4B Eskişehir. The relationship between misleding information and remembering the sign color were evaluated as true memory and false memory images. True memory images consisted of the first set of 12 images from the first video set (see Table 4.6) and false memory consists of the second, third and fourth sets of 12 images (see Table 4.7, 4.8, 4.9). Each color consisted of two questions. Given correct answers for true memory images were compared with the given correct answers for the false memory images (see Appendix B, Table B.1.). Chi-square test for Independence was used. According to the results, there was not a significant relationship between misleading images which are grouped as false memory and remembering the sign colors on true memory images (χ^2=5,572, df =5, p=,350) (see Appendix C, Table C.5.). Frequency table supports the statistical result (see Table 4.11). Even though there was an alteration of color, participants remembered demonstrated color on the first video set. Misleading information did not influence the remembering the color on the first video set.

Table 4.11: Percentage and frequency table of accurate answers for true and false memory for each colors.

	Memory					
Colors	True Memory	Percentages within Memory	False Memory	Percentages within Memory	Total	Total Percentages
Magenta	129	17,9 %	353	15,1 %	482	15,7 %
Orange	118	16,4 %	357	15,3 %	475	15,5 %
Turquoise	119	16,5 %	413	17,6 %	532	17,4 %
Purple	113	15,7 %	402	17,2 %	515	16,8 %
White	132	18,3 %	415	17,7 %	547	17,9 %
Black	110	15,3 %	400	17,2%	510	16,7 %
Total	721	100 %	2340	100 %	3061	100 %

4.3.3. Relationship between misleading information and color scheme on remembering the sign color.

The relationship between misleading information and color scheme on remembering the sign color was analyzed for true memory (see Table 4.6) and false memory images (see Table 4.7, 4.8, 4.9). The number of accurate answers for warm (orange and magenta), cool (purple and turquoise) and neutral (black and white) colors were evaluated with true and false memory images (see Appendix B, Table B.2.). Chi-square test for

Independence test was used. According to the results between true and false memory images, there were no significant relationship between warm, cool and neutral colored images (χ^2=4,092, df =2, p=,129) (see Appendix C, Table C.6). Therefore, evaluation of third hypothesis results, "there is a significant relationship between misinformation paradigm and color scheme on remembering the sign color" was not supported. Frequencies of the color schemes supports the results of the test (see Table 4.12)

Table 4.12: Percentage and frequency table of accurate answers for each color scheme for true and false memory

	Memory		
Color Scheme	True Memory	False Memory	Total
Warm Colors	247	710	957
Percentages	25,8%	74,2%	100%
Cool Colors	232	815	1047
Percentages	22,2%	77,8%	100%
Neutral Colors	242	815	1057
Percentages	22,9%	77,1%	100%
Total	721	2340	3061
Total Percentages	23,6%	76,4%	100%

4.3.4. Relationship between misleading information and the location of the signage on remembering the sign color.

Analysis of the fourth hypothesis was about location of the signage on the ground and the first floors. Participants encountered the same signage on different floors. Correct answers for each of the floors were assessed with the Chi-square test for Independence (see Table 4.13). True memory and false memory images were evaluated separately for each of the floors (see Table 4.6, 4.7, 4.8, 4.9) (see Appendix B, Table B.3). The test for the true memory images for different floors pointed out that there was not a significant relationship between color and location of the signage (χ^2=,723, df =5, p=,982) (see Appendix C, Table C.7). False memory images for different floors results indicated that location of the signage did not have significant relationship on remembering the sign color (χ^2=1,168, df =5, p=,948) (see Appendix C, Table C.8). Moreover, city platforms were evaluated separately for each floor. The correct answers for each city name (4B Eskişehir, 5B İstanbul and 6B Konya) demonstrated that there was not a significant relationship between the city names and location of the signage (Platform 4B Eskisehir: χ^2=,663, df =5, p=,985 (see Appendix C, Table C.9.).; Platform 5B Istanbul: χ^2=,505, df =5, p=,992 (see Appendix C, Table C.10).; Platform 6B Konya: χ^2=,722, df =5, p=,982 (see Appendix C, Table C.11)). According to the results, statistical analysis of the fourth hypothesis, locating the same signage on different floors having a significant relationship between remembering the sign color was not approved.

Table 4.13: Frequency table of accurate answers for each color in the ground and the first floor

	True Memory		**False Memory**	
Colors	Ground Floor	First Floor	Ground Floor	First Floor
Magenta	67	62	179	174
Orange	60	58	183	174
Turquoise	63	56	205	208
Purple	54	59	201	201
White	67	65	198	217
Black	55	55	198	202
Total	366	355	1164	1176

4.3.5. Relationship between misleading information and the order of the color on remembering the sign color

Order of the color differed according to its color scheme that if the whole city names color were magenta, one of the city name was changed with orange. It was also applied to orange. These were for the warm colors. If the whole city names color were turquoise, one of the city name was changed with purple. The color of purple differed with the turquoise. These were for the cool colors. One of the black colored city names were changed with white color. Also, it was applied for the black. These differentiations occurred for the neutral colors. There were three city names which were located one under another. Each of the three cities' color distinction probability was demonstrated in every in three set of 12 questions. The second set of 12 images included from the differentiation in 4B Eskişehir color see (Table 4.7). The third set of 12 images were included from differentiation in 5B İstanbul color and the fourth set of 12 images were included from differentiation in 6B Konya color (see Tables 4.8, 4.9). Every participant experienced images in random order. The number of the correct answers considered for each of the altered color of the city names (4B Eskişehir, 5B İstanbul and 6B Konya) without separating as floor (see Appendix B., Table B.4.). Chi-square test for Independence was used. Results indicated that there was not a significant relationship between order of the colors and remembering the sign color (χ^2=1,638, df =10, p=,998) (see Appendix C, Table C.12). Therefore, locating platform names in one under another and changing one of the cities color among the three city platform names were not differed on remembering the sign color (see Table 4.14).

Table 4.14: Percentage and frequency table of accurate answers for each city name.

	CITY NAMES			
COLORS	4B Eskişehir	5B Istanbul	6B Konya	Total
Magenta	114	122	117	353
Percentages	15,7%	15,3%	14,4%	15,1%
Orange	105	125	127	357
Percentages	14,4%	15,7%	15,6%	15,3%
Turquoise	124	140	149	413
Percentages	17,1%	17,5%	18,3%	17,6%
Purple	127	135	140	402
Percentages	17,5%	16,9%	17,2%	17,2%
White	128	141	146	415
Percentages	17,7%	16,9%	16,7%	17,7%
Black	129	135	136	400
Percentages	31,1%	34,1%	34,8%	17,1%
Total	727	798	815	2340
Total Percentages	100%	100%	100%	100%

4.3.6 Relationship between misleading information and single and paired colors on remembering the sign color

Single colors had the same colored signs (4B Eskişehir, 5B İstanbul, 6B Konya) and paired colors were comprised of the changed colors of the city names (4B Eskişehir, 5B İstanbul, 6B Konya were changes as separately). The relationship between the single and paired colors evaluated within three color schemes (warm, cool and neutral colors). Single colors grouped within its color sheme that orange and magenta were the warm colors; turquoise and purple were the cool colors, black and white colors were the neutral colors. Paired colors grouped within the same color scheme that orange and magenta, turquoise and purple, black and white are changed within each other. The relation between single colors, single and paired colors and paired colors were evaluated according to the alteration of the color schemes which warm, cool and neutral color schemes (see Appendix B, Table B.5.). Analysis of the accurate answers were analyzed according to the floor differences in Chi-square test for Independence (see Table 4.15). The questions are randomized that participants answered questions one after another. Statistical analysis indicated that there was not a significant relationship between single colors (see Appendix C, Tables C.13, C.14, C.15), single colors and paired colors (see Appendix C, Tables C.16, C.17, C.18, C.19, C.20, C.21, C.22, C.23, C.24, C.25, C.26, C.27) and paired colors (see Appendix C, Tables C.28, C.29, C.30). Comparison of single, single and paired and paired colors were not differed on remembering the sign color (see Table 4.16).

Statistical analysis for each color with the concern of the recognition of colors, misleading information, color scheme, location of the signage, color order and color pairing, demonstrated that different colors were not influenced by remembering the sign color.

Table 4.15: Frequency table of accurate answers for the single colors and paired colors for each floor.

			FLOORS	
COLOR SCHEME			Ground Floor	First Floor
Warm Colors	Single Colors	Magenta	67	62
		Orange	60	58
	Paired Colors	Magenta + Orange	179	174
		Orange + Magenta	183	174
Cool Colors	Single Colors	Turquoise	63	56
		Purple	54	59
	Paired Colors	Turquoise + Purple	205	208
		Purple + Turquoise	201	201
Neutral Colors	Single Colors	White	67	65
		Black	55	55
	Paired Colors	White + Black	198	217

		Black + White	198	202

Table 4.16: Demonstration of p values of Chi square test for single colors, single and paired colors and paired colors.

	Single Colors	**Single &Paired Colors**				**Paired Colors**
Warm Colors	Magenta vs Orange	Magenta vs Orange + Magenta	Magenta vs Magenta + Orange	Orange vs Orange + Magenta	Magenta vs Magenta + Orange	Magenta + Orange vs Orange + Magenta
P Values	,864	,895	,811	,938	,979	,883
Cool Colors	Turquoise vs Purple	Turquoise vs Turquoise + Purple	Turquoise vs Purple + Turquoise	Purple vs Turquoise + Purple	Purple vs Purple + Turquoise	Turquoise + Purple vs Purple + Turquoise
P Values	,433	,525	,573	,728	,678	,917
Neutral Colors	White vs Black	White vs White + Black	White vs Black + White	Black vs White + Black	Black vs Black + White	White + Black vs Black + White
P Values	,907	,542	,802	,669	,926	,609

4.4. Discussion

In this thesis, the effects of color on remembering the sign color in train stations was studied. It was hypothesized that there were differences between the effect of different colors on participants' memory. Colors were eveluated considering the relationship between memory in remembering the sign color and misleading information, warm, cool and neutral color scheme, placing signage on different floors, order of the color with the city names and color pairing.

According to the results of the study relationship between color and memory had some close results with the color studies in the literature. Nevertheless, there are some differences concerned the evaluation of the data. It was analyzed that there were no differences on remembering colors when concerned the different colors, misleading information, color scheme, location of the signage, color order and color pairing.

In the experiments, main colors could not be used because each color had a specific purpose. Red, yellow, green and blue colors related with a purpose in sign demonstration like warning, safety and accessibility issues. Other than these main colors, black and white colors were remained. As an interior designer, black and white colors were used with the magenta, orange, turquoise and purple colors to examine the relationship of different colors.

Color memory studies about the age (Pe´rez-Carpinell et al., 2006) and gender (Pe´rez-Carpinell, Camps, and Trottini, 2008) had different effects on remembering the colors. Also, familiarity (Armougum et al. 2019), gender (Lin et al., 2012) and age (Head & Isom, 2010) were differed in virtual environment studies. In the present study, the number of participants was not equal to compare them regarding age, gender, and familiarity. However, the relation between familiarity, age, gender and remembering the sign color demonstrated that they did not have a significant relationship.

Helvacıoğlu (2007) conducted an experiment in the school environment with children. The effect of the color on wayfinding was analyzed by using yellow, orange, red, blue and green colored landmark boxes. She indicated that there was no difference between the colors used on remembering the landmarks. In this study, the relationship between orange, magenta, turquoise, purple, white and black colors were tested on their contribution to memory. It was found that there is no significant relationship among colors on remembering the sign color. None of the colors were remembered more than the other one (p=,091). Findings of the study supports the results of Helvacıoğlu (2007). According to the previous studies; orange (Pérez-Carpinell et al., 1998a; Pérez-Carpinell et al. ,1998b; Bynum, Epps & Kaya, 2006), purple (Bynum, Epps & Kaya, 2006), green-blue and yellow-oranges (Nilsson & Nelson, 1981) are mostly remembered colors. Moreover, Jin and Shevell (1996) supports that remembering long and medium wavelengths were better than shorter wavelengths. There are no differences among the color on memory which indicated that people can remember orange, magenta, turquoise and purple colors.

In the study exposing misleading information indicated that it did not have an influence on remembering the original information. Misleading information on the color by changing the city colors did not differ on remembering the same colored city names ($p= ,350$). Contrary to the previous studies (Loftus, 1977; Braun & Loftus, 1998; Belli,1988), participants did not shift their answers in the direction of the misleading information.

According to the relation between warm, cool and neutral colors in wayfinding and spatial recognition studies (Hidayetoğlu, Yıldırım & Akalın, 2012; Süzer & Olguntürk, 2018; Min & Lee, 2020), people remembered warm colors better than the cool and neutral colors. In the present study sign colors are grouped as; warm colors which are magenta and orange, cool colors which are turquoise and purple and the neutral colors which are white and black. Alteration of the color is specified between the same color schemes. The evaluation of warm, cool and neutral colors demonstrated that there is no a relationship between the color schemes ($p= ,129$). Therefore, warm, cool and neutral colors do not differ on remembering the sign color.

Helvacıoğlu (2007) reported that location of the colored landmarks has an effect on route learning. In the experiment the same signage was located in two different floors to investigate the relationship of location of the signage and memory. On the contrary of the study of Helvacıoğlu (2007), remembering the sign color did not differ with location of the signage. The results of colors evaluated separately as true and false memory demonstrated that, placing the signage in different floors did not influence the recognition of sign color. Also, the comparison of recognition between the location of false memory images with altered colored city names did not differ in both of the floors. Location of the signage with changing city colors were evaluated for each city alteration. It was found that there is not a relationship between the alteration of the city names and the location of the signage.

In the experiment, the order of the color is one of the emphasized effect on remembering the sign color. Kinateder, Warren and Schloss (2019) conducted a study with red, yellow, blue, magenta and white sign colors on side by side doors. They found that participants under emergencies picked the door with the green which was followed by magenta. In the present study order of the color was evaluated by changing the color of one of the city name among three cities on signage. Comparison of the city names indicated that changing the color did not have an influence on remembering the sign color (p= ,998). Therefore, changing order of the color did not make any differences on recognizing the sign. Moreover, the relationship between single and paired colors were evaluated according to warm, cool and neutral colors. The results demonstrated that there was not a significant relationship between the single colors, single and paired colors or paired colors.

Signs should assist people when they try to reach the destination. The difference between orange, magenta, turquoise, purple, white and black colors on remembering the sign color was not found significant. There was no difference between black and white and colored one (magenta, orange, turquoise and purple) it may rely on design of signage. This study could be used for future studies with different types of signage design and wayfinding scenario. It was important to find the way on time with well-designed and adequate information which affected travelers' psychology. Supporting the memory while finding the way with the color may be improved the wayfinding behavior. While supplying directions for the travelers, the effects of the misinformation could be taken into consideration to emphasize the first encountered color of information in the wayfinding process.

CHAPTER V

CONCLUSION

People may encounter some difficulties while finding their train because of being in the complex environments of the train stations. Signs can improve the legibility of these spaces by assisting the wayfinding processes. Also, at the beginning of the design consideration designers should regard the sign for uninterrupted circulation to improve the quality of travel for users.

The contribution of color to users' recognition of sign colors in train stations, and the relationship between the colors with the concern of the recognition of colors, misleading information, color scheme, location of the signage, color order and color pairing were investigated in a virtual train station. As indicated in the literature (Bynum, Epps & Kaya, 2006; Nilsson & Nelson, 1981; Pérez-Carpinell et al., 1998a), color has an impact on memory. However, results indicated that remembering the sign color has no difference in different situations.

There is not enough study conducted in literature with the misinformation paradigm effects on color (Belli,1988; Braun & Loftus, 1998; Loftus, 1977). The studies about the misinformation and color concluded that misleading information has an impact on remembering the color. However, the results of present study indicate that there is no relationship between misleading information and different colors on remembering the color.

Mainly wayfinding studies focused on the impact of signage by comparing maps and signs (Cliburn and Rilea, 2008; Huang et al., 2018). They reported that signs assist people to find their way. Previous studies considered color for the perception of space (Min and Lee 2020; Süzer& Olguntürk, 2018). These studies reported that warm colors are better to be remembered compared to cool and neutral colors. On the contrary to these previous studies, warm, cool and neutral colors did not differ on remembering the sign color in this study. It is important to investigate the effect of sign designs with font, color, material and location on the plan. The statistical results of the study demonstrated that location of the signage, color order of the signs and comparing the single and paired color did not differ on remembering the color of the sign.

This web-based experiment was conducted in the VR because of the COVID-19 pandemic. It provided reach to more people that they could attend in any place. In the study, participants attended the experiment from their devices. However, in online color surveys, color stimuli can vary because of the different viewing conditions (Won, Lee & Park, 2020). VR provides limited control to the environmental conditions and test the effect of different colors. Nevertheless, in order to decrease the differences between the conditions of the participants, viewing conditions restricted with the device description, lighting and environmental circumstances. The limitation of the study is that participants can experience the effect of color differently in a laboratory setting. Also feeling the real environment may have an effect on remembering the sign color.

This study looks into the relationship between misinformation of color and memory. In order to perceive the space and provide legibility, remembering the colors on signs is significant for healthy wayfinding processes which decreases the anxiousness and the possibility of being lost and missing the train. This study can be beneficial for architects, interior architects, and graphic designers who are concerned with the wayfinding and signage. The results of the study indicated that people remembered the first encountered colors. When they encountered the same sign with different colors they noticed the alteration in color. Even though the difficulty of selecting a color that primary colors were reserved, magenta, orange, turquoise, and purple are easy to remember which can be preferred on a signage design. Thus misleading information can be studied with different colors. Also; age, gender, familiarity, and professions can be restricted for further studies. These colors can improve the wayfinding process by providing remembering the specified colors on following the route.

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APPENDICES

APPENDIX A

Phases of the Experiment

Color and Memory

The aim of this experiment is to investigate the impact of color on memory.

This experiment consists of 3 phases. These are personal information, videos, and questions relevant to the videos.

Thank you for attending my experiment.

* Required

Phase 1

1. How old are you? *

____

2. What is your gender? *

Mark only one oval.

( ) Female
( ) Male

3. What is your profession? *

____

4. Have you ever been to the Ankara train station? *

Mark only one oval.

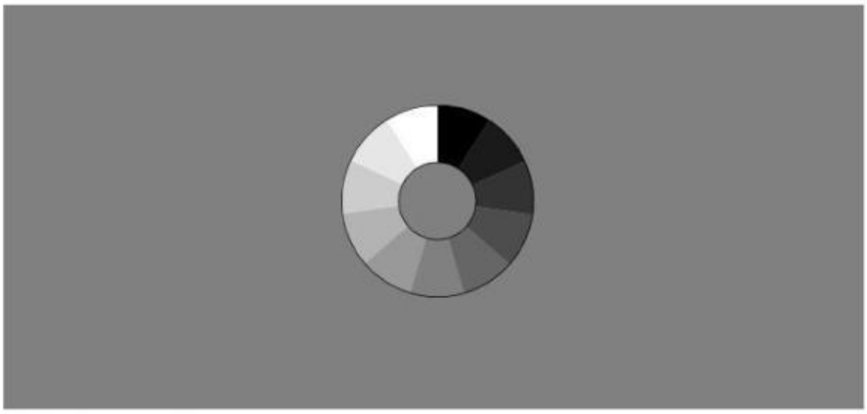
( ) Yes
( ) No

5. How often have you been in the Ankara train station? *

Mark only one oval.

- Always
- Very Frequently
- Ocassionally
- Rarely
- Very Rarely
- Never

6. Adjust the brightness of your display if necessary until you can see the differences between all 11 steps of the greyscale test image. Disable Night Shift mode or blue light filters if applicable. *



Mark only one oval.

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11

7. What is your display device? *

Mark only one oval.

- Smartphone
- Pad
- Laptop
- Desktop

8. Describe the white graphic elements on your screen. *

Mark only one oval.

- Neutral White
- Warm White
- Bluish White
- Yellowish White

9. Describe the lighting conditions of your environment. *

Mark only one oval.

- Dark
- Typical Domestic
- Mid Daylight
- Full Daylight
- Typical Office

10. Describe the surrounding environment behind your device. *

Mark only one oval.

- Dark
- Dim
- Average
- Bright

11. What distance are you from your monitor in cm? *

Mark only one oval.

- 10
- 20
- 30
- 40
- 50
- 60
- 70
- 80
- 90
- 100

Phase 2

First Video Set

You are going to watch videos about the 3D drawings of the Ankara train station. In each video you are going to watch the passenger's, who is going to the Eskişehir, walking through the 4B Eskişehir train gate. You are going to watch the first videos. Please watch videos once.


http://youtube.com/watch?v=TVsWdlnmf-k

http://youtube.com/watch?v=VP0Gh6HzCMg

http://youtube.com/watch?v=JVNz5P5i43w

http://youtube.com/watch?v=u_oS3cq23NQ

http://youtube.com/watch?v=yPouB7_e_LY

http://youtube.com/watch?v=Z_QBACgBKyc

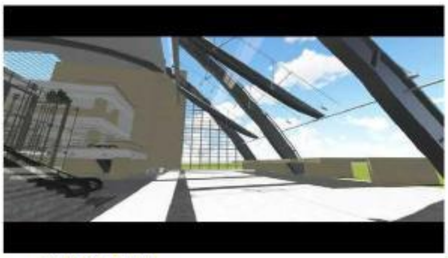
Second Video Set

You are going to watch videos about the 3D drawings of the Ankara train station. In each video you are going to watch the passenger's, who is going to the Eskişehir, walking through the 4B Eskişehir train gate. You are going to watch the second videos. Please watch videos once. After watching the videos you can answer the questions.

http://youtube.com/watch?v=lAChGg8lRoQ

http://youtube.com/watch?v=bqgpMvOZSlc

http://youtube.com/watch?v=KFw48NidDBg



http://youtube.com/watch?v=mVL7fc6MIrA

http://youtube.com/watch?v=AfDht-oi4p8

http://youtube.com/watch?v=nnnu7-4D5Yg

Color and Memory

Questions

Answer the following questions according to the first videos. Whether you saw that image in the first videos click "Yes" or not click "No".

Color and Memory

1

Mark only one oval.

- Yes
- No

Color and Memory

2

Mark only one oval.

- Yes
- No

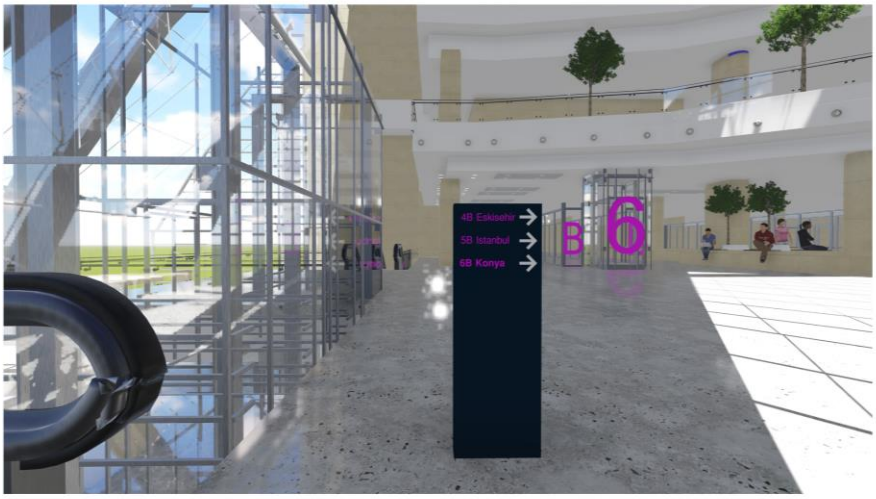
3

Mark only one oval.

- ( ) Yes
- ( ) No

Color and Memory

4



Mark only one oval.

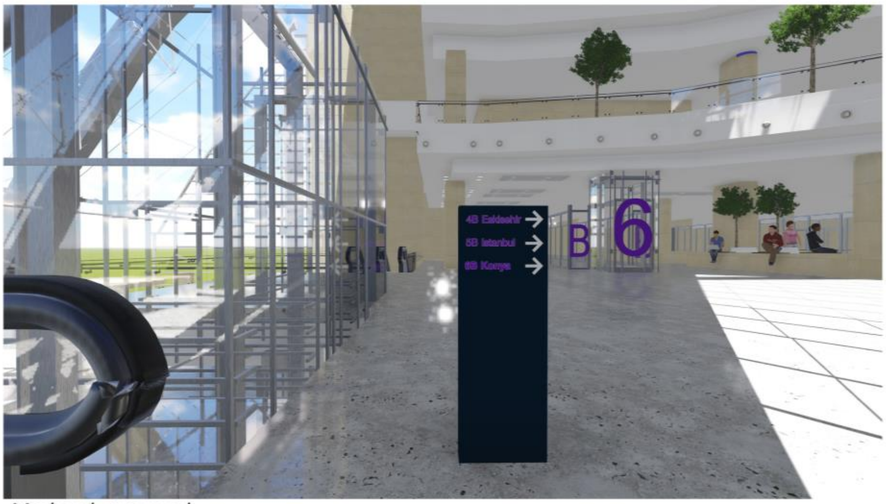
- ( ) Yes
- ( ) No

5

Mark only one oval.

- ◯ Yes
- ◯ No

6



Mark only one oval.

- ◯ Yes
- ◯ No

7

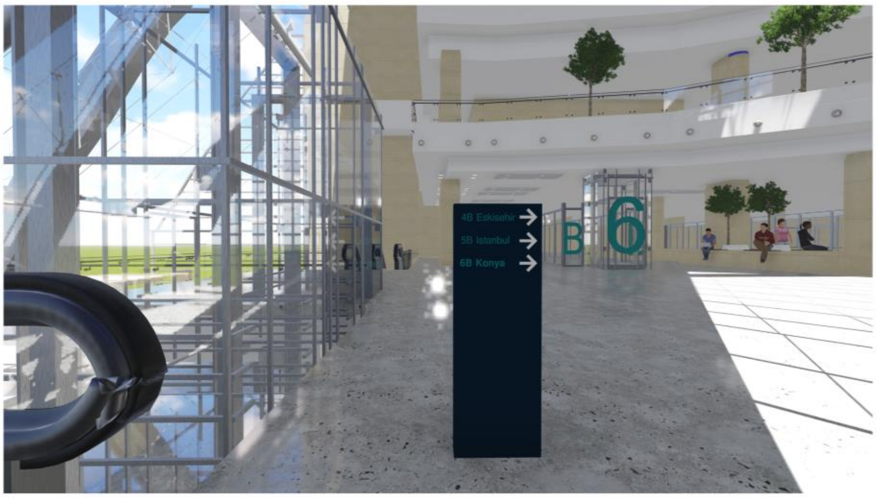
Mark only one oval.

◯ Yes

◯ No

Color and Memory

8



Mark only one oval.

◯ Yes

◯ No

9

Mark only one oval.

- ⬭ Yes
- ⬭ No

Color and Memory

10

Mark only one oval.

- ⬭ Yes
- ⬭ No

Color and Memory

11

Mark only one oval.

- Yes
- No

12

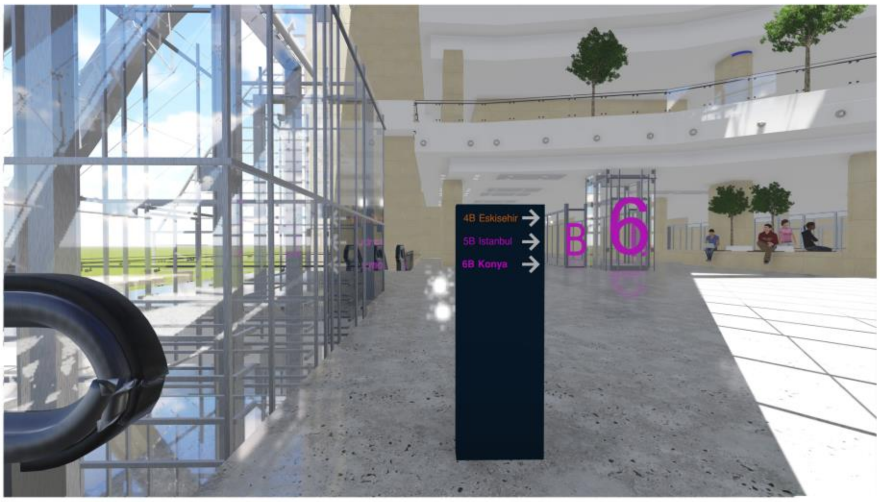
Ma

13

Mark only one oval.

- Yes
- No

14



Mark only one oval.

- Yes
- No

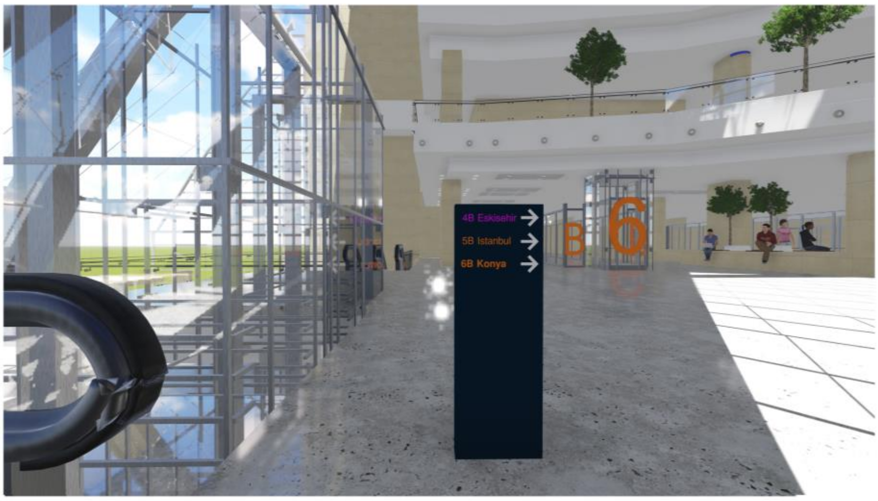
15 *

Mark only one oval.

- Yes
- No

Color and Memory

16 *



Mark only one oval.

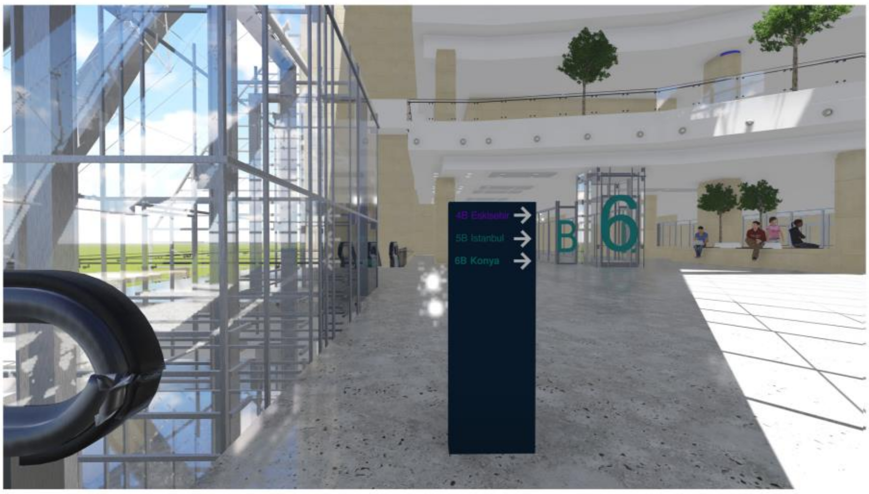
- Yes
- No

17

Mark only one oval.

- ◯ Yes
- ◯ No

18



Mark only one oval.

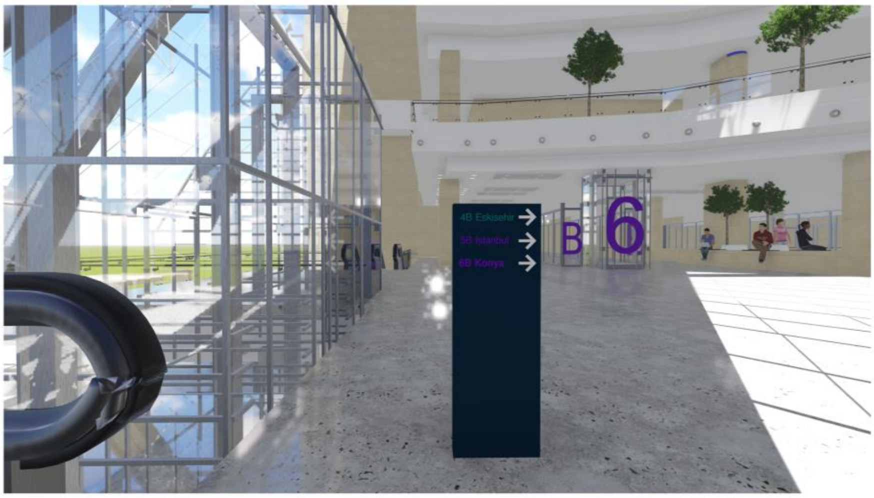
- ◯ Yes
- ◯ No

19

Mark only one oval.

- ( ) Yes
- ( ) No

20



Mark only one oval.

- ( ) Yes
- ( ) No

Color and Memory

21

Mark only one oval.

- ( ) Yes
- ( ) No

Color and Memory

22

Mark only one oval.

- ( ) Yes
- ( ) No

23

Mark only one oval.

- Yes
- No

24

Mark only one oval.

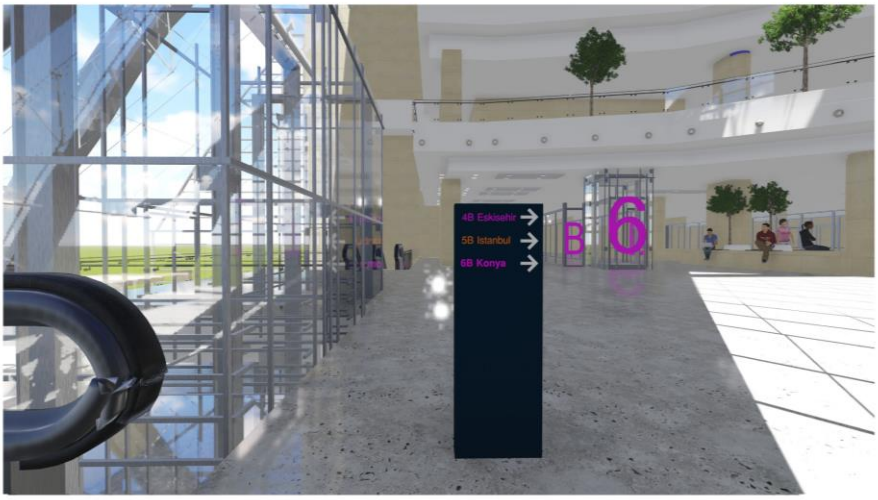
- Yes
- No

25

Mark only one oval.

- ( ) Yes
- ( ) No

26



Mark only one oval.

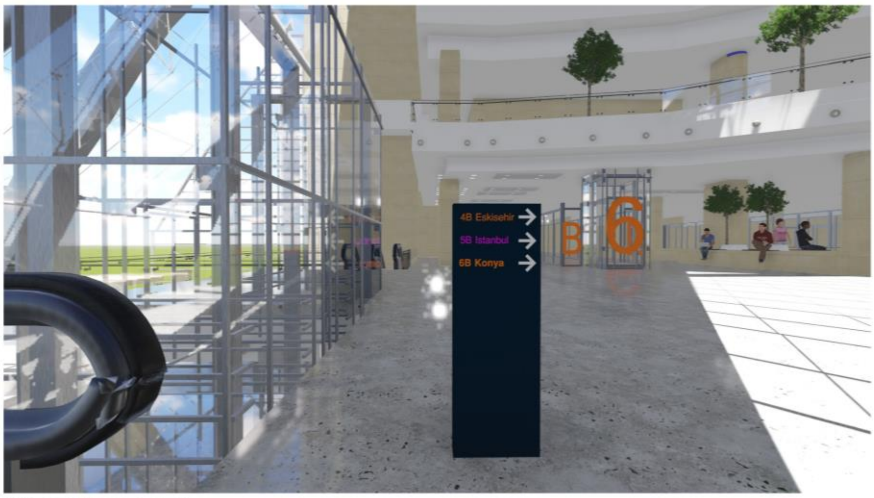
- ( ) Yes
- ( ) No

27

Mark only one oval.

- Yes
- No

28



Mark only one oval.

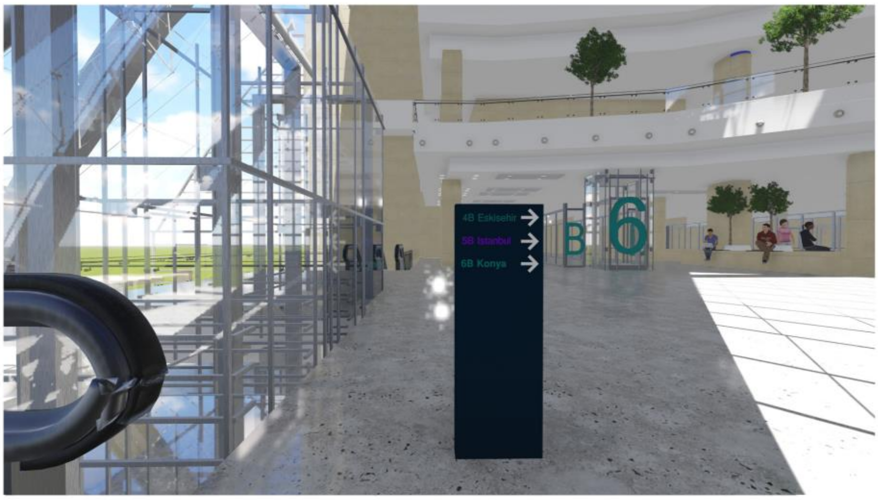
- Yes
- No

29

Mark only one oval.

- Yes
- No

30



Mark only one oval.

- Yes
- No

31

Mark only one oval.

- Yes
- No

33

Mark only one oval.

- Yes
- No

34

Mark only one oval.

- Yes
- No

35

Mark only one oval.

- Yes
- No

Color and Memory

36

Mark only one oval.

- ⬭ Yes
- ⬭ No

Color and Memory

37

Mark only one oval.

- ⬭ Yes
- ⬭ No

38

Mark only one oval.

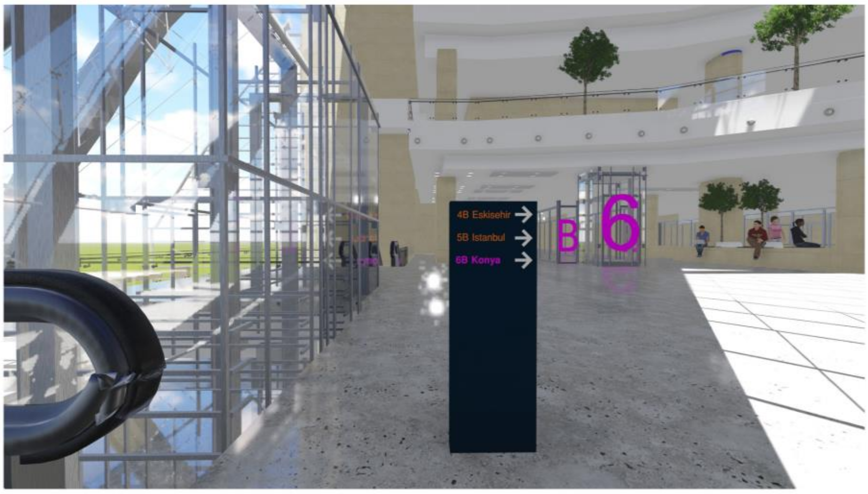
- Yes
- No

39

Mark only one oval.

- Yes
- No

40



Mark only one oval.

- ◯ Yes
- ◯ No

41

Mark only one oval.

- ◯ Yes
- ◯ No

42

Mark only one oval.

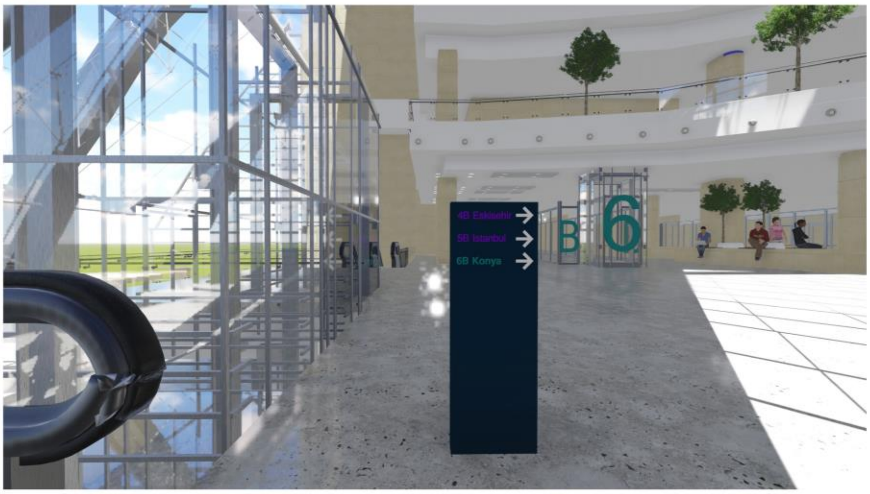
- Yes
- No

43

Mark only one oval.

- Yes
- No

44



Mark only one oval.

- ◯ Yes
- ◯ No

Color and Memory

45

Mark only one oval.

- Yes
- No

Color and Memory

46

Mark only one oval.

- Yes
- No

47

Mark only one oval.

- [ ] Yes
- [ ] No

48

Mark only one oval.

- [ ] Yes
- [ ] No

APPENDIX B

Table B.1. The number of the questions compared for research questions 1 and 2.

Questions	**Colors**	**True Memory (Question Numbers)**	**False Memory (Question Numbers)**
Research Question 1	Orange Magenta Purple Turquoise Black White	1,2, 3,4, 5,6, 7,8, 9,10 11,12	
Research Question 2	Orange Magenta Purple Turquoise Black White	1,2, 3,4, 5,6, 7,8, 9,10, 11,12	13,14, 25,26,37,38 15,16, 27,28,39,40, 17,18, 29,30,41,42 19,20,31,32,43,44 21,22,33,34,45,46 23,24,35,36,47,48

Table B.2. The number of the questions compared for research question 2.1.

	True Memory		False Memory	
	Colors	**Question Numbers**	**Colors**	**Question Numbers**
Research Question 2.1	Warm Cool Neutral	1,2,3,4 5,6,7,8 9,10,11,12	Warm Cool Neutral	13,14,15,16,25,26,27,28,37,38,39,40 17,18,19,20,29,30,31,32,41,42,43,44 21,22,23,24,33,34,35,36,45,46,47,48

Table B.3. The number of the questions compared for research questions 2.2

	True Memory			False Memory		
Research Question 2.2	**Colors**	**Question Numbers for Ground Floor**	**Question Numbers for First Floor**	**Colors**	**Question Numbers for Ground Floor**	**Question Numbers for First Floors**
	Orange Magenta Purple Turquoise Black White	1 3 5 7 9 11	2 4 6 8 10 12	Orange Magenta Purple Turquoise Black White	13, 25,37, 15,27,39 17,29,41 19,31,43 21,33,45	14, 26, 38 16, 28, 40 18, 30, 42 20, 32, 44 22, 34, 46 24, 36, 48

					23,35,47	

Table B.4. The number of the questions compared for research questions 2.3

Research Question 2.3	**Colors**	**Question Numbers for 4B Eskişehir**	**Question Numbers for 5B İstanbul**	**Question Numbers for 6B Konya**
	Orange	13,14	25,26	37,38
	Magenta	15,16	27,28	39,40
	Purple	17,18	29,30	41,42
	Turquoise	19,20	31,32	43,44
	Black	21,22	33,34	45,46
	White	23,24	35,36	47,48

Table B.5. The number of the questions compared for research questions 2.4

	Number of Questions	
Single Colors	Orange 1,2	Magenta 3,4
	Purple 5,6	Turquoise 7,8
	Black 9,10	White 1 1,12
Single and Paired Colors	Orange 1,2	Orange + Magenta 13,14,25,26,37,38
	Orange 1,2	Magenta + Orange 15,16,27,28,39,40
	Magenta 3,4	Orange + Magenta 13,14,25,26,37,38
	Magenta 3,4	Magenta + Orange 15,16,27,28,39,40
	Purple 5,6	Purple+ Turquoise 17,18,29,30,41,42
	Purple 5,6	Turquoise+ Purple 19,20,31,32,43,44
	Turquoise 7,8	Purple + Turquoise 17,18,29,30,41,42

	Turquoise 7,8	Turquoise+ Purple 19,20,31,32,43,44
	Black 9,10	Black+ White 21,22,33,34,45,46
	Black 9,10	White+ Black 23,24,35,36,47,48
	White 11,12	Black + White 21,22,33,34,45,46
	White 11,12	White + Black 23,24,35,36,47,48
Paired Colors	Magenta + Orange vs 13,14,25,26,37,38	Orange + Magenta 15,16,27,28,39,40
	Purple + Turquoise 17,18,29,30,41,42	Turquoise + Purple vs 19,20,31,32,43,44
	Black + White 21,22,33,34,45,46	White + Black 23,24,35,36,47,48

Appendix C

Data Analysis

Table C.1. Chi-Square Test for Independence for familiarity

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	27,600(a)	19	,091
Likelihood Ratio	38,034	19	,006
Linear- by-Linear Association	21,743	1	,000
N of Valid Cases	48		

a. 40 cells (100%) have expected count less than 5. The minimum expected count is ,50.

Table C.2. Chi-Square Test for Independence for gender

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	18,800(a)	18	,456
Likelihood Ratio	23,907	18	,158
Linear- by-Linear Association	11,378	1	,001
N of Valid Cases	48		

a. 38 cells (100%) have expected count less than 5. The minimum expected count is ,50.

Table C.3. Chi-Square Test for Independence for age

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	38,967(a)	30	,126
Likelihood Ratio	50,069	30	,012
Linear- by-Linear Association	9,980	1	,002
N of Valid Cases	72		

a. 48 cells (100%) have expected count less than 5. The minimum expected count is ,67.

Table C.4. Chi-Square Test for Independence for relationship between different colors on remembering the sign color

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	9,484(a)	5	,091
Likelihood Ratio	9,584	5	,088
N of Valid Cases	1080		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 59,83.

Table C.5. Chi-Square Test for Independence for relationship between misleading information and remembering the sign color

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	5,572(a)	5	,350
Likelihood Ratio	5,525	5	,355
Linear- by-Linear Association	3,057	1	0,80
N of Valid Cases	3,057	1	,080

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 11,88.

Table C.6. Chi-Square Test for Independence for relationship between misinformation and color scheme on remembering the sign color

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	4,092(a)	2	,129
Likelihood Ratio	4,053	2	,132
Linear- by-Linear Association	2,251	1	0,134
N of Valid Cases	3061		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 225,42.

Table C.7. Chi-Square Test for Independence for relationship between misleading information and location of the signage for true memory colors.

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,723(a)	5	,982
Likelihood Ratio	,724	5	,982
Linear- by-Linear Association	154	1	0,695
N of Valid Cases	721		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 54,16.

Table C.8. Chi-Square Test for Independence for relationship between misleading information and location of the signage for false memory colors.

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	1,168(a)	5	,948
Likelihood Ratio	1,168	5	,948
Linear- by-Linear Association	,579	1	,447
N of Valid Cases	2340		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 175,59.

Table C.9. Chi-Square Test for Independence for relationship between misleading information and location of the signage for 4B Eskişehir

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,663(a)	5	,985
Likelihood Ratio	,664	5	,985
Linear- by-Linear Association	,122	1	,727
N of Valid Cases	727		

b. 0 cells (,0%) have expected count less than 5. The minimum expected count is 52,14.

Table C.10. Chi-Square Test for for relationship between misleading information and location of the signage for 5B İstanbul

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,505(a)	5	,992
Likelihood Ratio	,505	5	,992
Linear- by-Linear Association	,239	1	,625
N of Valid Cases	798		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 60,24.

Table C.11. Chi-Square Test for relationship between misleading information and location of the signage for 6B Konya

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,722(a)	5	,982
Likelihood Ratio	,722	5	,982
Linear- by-Linear Association	,229	1	,632
N of Valid Cases	815		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 58,28.

Table C.12. Chi-Square Test for Independence for relationship between misleading information and order of the color on remembering the sign color

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	1,638(a)	10	,998
Likelihood Ratio	1,643	10	,998
Linear- by-Linear Association	,021	1	,886
N of Valid Cases	2340		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 109,67.

Table C.13. Chi-Square Test for Independence for relationship between misleading information and single colors (Magenta and Orange)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	0,29 (a)	1	,864
Likelihood Ratio	,029	1	,865
Linear- by-Linear Association	,029	1	,864
N of Valid Cases	247		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 57,33.

Table C.14. Chi-Square Test for Independence for relationship between misleading information and single colors (Turquoise and Purple)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,616 (a)	1	,433
Likelihood Ratio	,616	1	,433
Linear- by-Linear Association	,613	1	,434
N of Valid Cases	232		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 56,01.

Table C.15. Chi-Square Test for Independence for relationship between misleading information and single colors (White and Black)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,014 (a)	1	,907
Likelihood Ratio	,014	1	,907
Linear- by-Linear Association	,014	1	,907
N of Valid Cases	242		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 54,55.

Table C.16. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Magenta and Magenta Orange)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,057 (a)	1	,811
Likelihood Ratio	,057	1	,811
Linear- by-Linear Association	,057	1	,811
N of Valid Cases	482		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 63,16.

Table C.17. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Magenta and Orange Magenta)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,017 (a)	1	,895
Likelihood Ratio	,017	1	,895
Linear- by-Linear Association	,017	1	,895
N of Valid Cases	486		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 62,64.

Table C.18. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Orange and Magenta Orange)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,001 (a)	1	,979
Likelihood Ratio	,001	1	,979
Linear- by-Linear Association	,001	1	,979
N of Valid Cases	471		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 58,12.

Table C.19. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Orange and Orange Magenta)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,006 (a)	1	,938
Likelihood Ratio	,006	1	,938
Linear- by-Linear Association	,006	1	,938
N of Valid Cases	475		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 57,63.

Table C.20. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Turquoise and Turquoise Purple)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,404 (a)	1	,525
Likelihood Ratio	,404	1	,525
Linear- by-Linear Association	,403	1	,526
N of Valid Cases	532		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 59,02.

Table C.21. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Turquoise and Purple Turquoise)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,318 (a)	1	,573
Likelihood Ratio	,318	1	,573
Linear- by-Linear Association	,317	1	,573
N of Valid Cases	521		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 58,70.

Table C.22. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Purple and Turquoise Purple)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,121 (a)	1	,728
Likelihood Ratio	,121	1	,727
Linear- by-Linear Association	,121	1	,728
N of Valid Cases	526		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 55,64.

Table C.23. Chi-Square Test for Independence for for relationship between misleading information and single and paired colors

(Purple and Purple Turquoise)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,173 (a)	1	,678
Likelihood Ratio	,173	1	,678
Linear- by-Linear Association	,172	1	,678
N of Valid Cases	515		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 55,95.

Table C.24. Chi-Square Test for Independence for relationship between misleading information and single and paired colors

(White and White Black)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,372 (a)	1	,542
Likelihood Ratio	,372	1	,542
Linear- by-Linear Association	,372	1	,542
N of Valid Cases	547		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 63,95.

Table C.25. Chi-Square Test for Independence for relationship between misleading information and single and paired colors

(White and Black White)

	Value	**df**	**Asymptotic Significant (2- sided)**
Pearson Chi-Square	,063(a)	1	,802
Likelihood Ratio	,063	1	,802
Linear- by-Linear Association	,063	1	,802
N of Valid Cases	532		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 65,75.

Table C.26. Chi-Square Test for Independence for relationship between misleading information and single and paired colors

(Black and White Black)

	Value	**df**	**Asymptotic Significant (2- sided)**
Pearson Chi-Square	,182(a)	1	,669
Likelihood Ratio	,182	1	,669
Linear- by-Linear Association	,182	1	,670
N of Valid Cases	525		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 53,01.

Table C.27. Chi-Square Test for Independence for relationship between misleading information and single and paired colors (Black and Black White)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,009(a)	1	,926
Likelihood Ratio	,009	1	,926
Linear- by-Linear Association	,009	1	,626
N of Valid Cases	510		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 54,47.

Table C.28. Chi-Square Test for Independence for relationship between misleading information and paired colors (Magenta Orange and Orange Magenta)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,022 (a)	1	,883
Likelihood Ratio	,022	1	,883
Linear- by-Linear Association	,022	1	,883
N of Valid Cases	710		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 173,02.

Table C.29. Chi-Square Test for Independence for relationship between misleading information and paired colors (Turquoise Purple and Purple Turquoise)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,011 (a)	1	,917
Likelihood Ratio	,011	1	,917
Linear- by-Linear Association	,011	1	,917
N of Valid Cases	815		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 200,26.

Table C.30. Chi-Square Test for Independence for relationship between misleading information and paired colors (White Black and Black White)

	Value	df	Asymptotic Significant (2- sided)
Pearson Chi-Square	,261(a)	1	,609
Likelihood Ratio	,261	1	,609
Linear- by-Linear Association	,261	1	,609
N of Valid Cases	815		

a. 0 cells (,0%) have expected count less than 5. The minimum expected count is 194,36.