THE EFFECTS OF CORRELATED COLOR TEMPERATURE ON WAYFINDING: A STUDY IN A VIRTUAL AIRPORT ENVIRONMENT

A Master's Thesis

by

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Graduate School of Economics and Social Sciences
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in

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ANKARA

August 2013

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

Assist. Prof. Dr. Nilgün Olguntürk
Supervisor

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

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ABSTRACT

THE EFFECTS OF CORRELATED COLOR TEMPERATURE ON WAYFINDING: A STUDY IN A VIRTUAL AIRPORT ENVIRONMENT

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The aim of the study is to understand the effects of correlated color temperature on wayfinding performance in airports and to compare different color temperatures in order to understand their effects on wayfinding performance. The experiment was conducted with three different sample groups in three different lighting settings that are 3000 K, 6500 K and 12000 K. The participants were total ninety graduate students from twenty-one different departments of twenty-six different universities. The study was conducted in a single phase. The volunteered participants experienced the desktop VE one by one. The participants were seated at the computer and were tested by the researcher. They were asked to direct the researcher from the starting point to the final destination which was stated as gate numbered 109. It was found that correlated color temperature has no significant effect on wayfinding performance in terms of the time spent, the total number of error, the total number of decision points and the route choice during finding the route. However, the correlated color temperature has a significant effect on experiencing hesitations. It was found that the total number of hesitations decrease while the correlated color temperature increases from 3000 K to 12000 K.

Keywords: Wayfinding Performance, Color Temperature, Lighting, Virtual Environment, Airport

ÖZET

IŞIĞIN RENK SICAKLIĞININ YÖN BULMAYA ETKİSİ: SANAL HAVAALANI ORTAMINDA BİR ÇALIŞMA

Kumoğlu, Özge
İç Mimarlık ve Çevre Tasarımı Yüksek Lisans Programı
Danışman: Y. Doç. Dr. Nilgün Olguntürk

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Bu çalışmanın amacı, ışığın renk sıcaklığının havaalanlarında kullanıcının yön bulma yetisi üzerindeki etkilerini anlamak ve farklı renk sıcaklıklarındaki aydınlatmaların yön bulma yetisine olan etkilerini anlamak için karşılaştırmaktır. Deney 3000 K, 6500 K ve 12000 K olmak üzere üç farklı aydınlatma için üç farklı katılımcı grubuyla gerçekleştirilmiştir. Katılımcılar yirmi-altı farklı üniversitenin, yirmi-bir farklı bölümünden, toplam doksan yüksek lisans öğrencisinden oluşmaktadır. Çalışma tek aşamada yürütülmüştür. Gönüllü olan katılımcılar birebir masaüstü sanal ortamı deneyimlemişlerdir. Katılımcılar bilgisayar karşısında araştırmacı tarafından birebir test edilmişlerdir. Katılımcılardan araştırmacıyı başlama noktasından hedef noktası olan 109 numaralı kapıya götürmeleri istenmiştir. Işığın renk sıcaklığının yön bulma yetisine etkisi performans sırasında geçen zaman, hata yapma sayısı, karar noktası sayısı ve rota seçimi anlamında farklılık göstermediği bulunmuştur. Ancak, ışığın renk sıcaklığının duraksama / tereddüt etme deneyimine etki ettiği görülmüştür. Işığın renk sıcaklığının artması ile duraksama / tereddüt etme sayısının 3000 K'den 12000 K'e doğru azaldığı bulunmuştur.

Anahtar kelimeler: Yön Bulma Performansı, Renk Sıcaklığı, Aydınlatma, Sanal Ortam, Havaalanı.

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CHAPTER I

INTRODUCTION

Arthur & Passini (1992) briefly defined wayfinding as a process of reaching a destination, in a familiar or unfamiliar environment. Montello & Freundschuh (2005) indicated that navigation is a coordinated and goal directed movement through a space. Navigation consists of two parts, travel and wayfinding. Travel is the actual motion from the current location to the new location. The second constituent of navigation is wayfinding defined as ‘’the strategic and tactical element that guides movement’’ (Sadeghian et al., 2006: 2, cited in Sancaktar & Demirkan, 2006). In other words, wayfinding includes activities such as trip planning and route choice. The difficulty of navigating in unfamiliar environments suggests the need to support navigation with the use of environmental design elements such as layout, landmarks, and signage, in real and virtual spaces.

Spatial orientation is the ability of a person to situate his or her location in a setting which is totally based on forming an adequate cognitive map of the space and the layout (Arthur & Passini, 1992). Research done before explored the spatial characteristics affecting wayfinding behavior and spatial orientation and they mostly focused on; landmarks, color coding, visibility index, signage systems, spatial differences, complexity of plan layout, legibility of plan layout, and etc. (Abu-Ghazzeh, 1996; Abu-Obeid, 1998; Başkaya et al., 2004; Başoğlu, 2007; Bounds, 2010; Dada, 1997; Evans et al., 1980; Garling et al., 1986; Gentry, 2010; Helvacıoğlu & Olguntürk, 2009; Heth et al., 1997; Hidayetoğlu et al., 2012; O'Neill, 1991; Wener & Kaminoff, 1983). Besides, research done before explored also the individual differences affecting wayfinding behavior and spatial orientation mostly in terms of; familiarity, age differences and gender differences (Chebat et al., 2008; Chen et al., 2009; Choi et al., 2006; Coluccia & Louse, 2004; Doğu, 2001; Doğu & Erkip, 2000; Head & Isom, 2010; Kato & Takeuchi, 2003; Lawton, 1994, 1996, 2001; Lawton & Kallai, 2002; Moffat et al., 2001; O'Neill, 1992; Osmann & Wiedenbeurer, 2004; Tlauka et al., 2005). The researched environments were mostly clinics, hospitals, school environments, kindergartens and shopping malls (Abu-Ghazzeh, 1996; Başoğlu, 2002; Başkaya et al., 2004; Bounds, 2010; Carpman, 2000; Doğu, 2001; Doğu & Erkip, 2000; Helvacıoğlu & Olguntürk, 2009; Hidayetoğlu et al., 2012; Lehnung et al., 2003; Piccardi et al., 2011; Weisman, 1987).

According to the definition of Peponis et al. (1990) wayfinding is the ability to reach a destination in a short time without experiencing fear and stress. Traveling condition is one of the most stressful wayfinding processes because time is a crucial issue. Contributing users' ability to make them find their routes faster and catch their flights on time without experiencing stress and annoyance is an important design problem.

Light is one of the important physical factors influencing the perception of a space which may also affect the wayfinding performance of users. Perception is defined as the process of obtaining information through the senses (Arthur & Passini, 1992). There have been studies done on the effects of light on perception (Durak et al., 2007; Flynn et al., 1973; 1979; Fotios & Levermore, 1999; Manav & Yener, 1999). Correlated color temperature (CCT) is the appearance of color of light source which can be measured in degrees of Kelvin (Egan & Olgyay, 2002). It is seen that research that have been done before on CCT mostly focused on; mood, perception, psychological effects, working performance, and individual liking (Boyce & Cuttle, 1990; Davis & Ginthner, 1990; Hoof et al., 2009; Knez, 1995, 2001; Knez & Kers, 2000; Manav & Küçükdoğu, 2006; Manav & Yener, 1999; Odabaşıoğlu, 2009), and the building types explored in terms of color temperature is offices, working areas, residential buildings, nursing homes and clinics.

It is important to understand the effects of CCT of lighting on wayfinding performance of travelers in airports because the effect of CCT on perception is explored, yet it is not known whether CCT has an effect on wayfinding performance or not. There is not any research in literature exploring the relationship between CCT and wayfinding performance.

This study purports to fill in the gap in wayfinding and lighting research, exploring the effect of CCT and this tool could provide an aid in wayfinding whether or not.

1.1.Aim of the Study

The main purpose of this study is to understand the effects of CCT of lighting on wayfinding performance in airports. It is important to understand how CCT of lighting affects travelers' wayfinding performance yet it is not known whether CCT has effect on wayfinding performance or not. There is not any research in literature exploring the relationship between CCT and wayfinding performance.

In addition, different CCT were tested in this study in order to understand their different effects on wayfinding performance on travelers.

1.2.Structure of the Thesis

The thesis consists of seven chapters. The first chapter is the introduction, in which the concept of wayfinding and the factors affecting wayfinding behavior and perception are briefly stated. In addition, the aim of the study and the structure of the thesis are also explained.

The second chapter explores the definition of wayfinding and the criteria used measuring wayfinding performance. Firstly, wayfinding in the built environment is defined through literature on the subject over the years and the significance of wayfinding research is stated. Secondly the criteria used while measuring the wayfinding performance are explained with the literature review. The wayfinding performance criteria are classified in five parts; time spent, error, decision point, hesitation and route choice. Thirdly, wayfinding research in the virtual environments (VEs) is given with some case studies. Besides, advantages and limitations of wayfinding research in VEs are stated. Lastly, individual differences affecting wayfinding behavior are analyzed in terms of familiarity, age differences and gender differences.

In the third chapter, firstly, the basic terms about lighting and CCT that are used in this study are explained. Secondly, CCT research is explored with the previous studies. Lastly, the relationship between CCT and performance is dwelled on.

In the fourth chapter, the basic aspects in airport design are explained. After that, the spatial characteristics affecting wayfinding behavior in airports are explored in terms of plan layout and building configuration, visual accessibility and architectural differentiation.

In the fifth chapter, the experiment is described with the aim, research questions and hypotheses. The methodology of the experiment is defined with the identification of the sample group, description of the image sets of the experiment and explanation of the experiment procedures. The results are statistically analyzed and evaluated. The results are discussed in relation to previous studies related to the subject and research notes are also given to enrich the study.

In the last chapter, major conclusions about the study are stated and suggestions for further research are composed.

CHAPTER II

WAYFINDING

2.1. The Definition of Wayfinding

The term wayfinding was firstly used by Kevin Lynch, (1960) who explored how the characteristics of an urban space affected people and how well people remembered physical features in it. Hence, the researchers have given many definitions of wayfinding and the knowledge about wayfinding has broadened over the years.

Arthur & Passini (1992) briefly defined wayfinding as a process of reaching a destination, in a familiar or unfamiliar environment. Wayfinding is also described as an ability to situate oneself in a location and reach at intended destinations or to navigate in spatial environments, both cognitively and behaviorally (Passini, 1984; Rovine & Weisman, 1989). Wayfinding is the process of making decisions and following a path or route between an origin and a desired destination (Golledge, 1999). Golledge (1999) also emphasized that wayfinding is a persuasive, directed and motivated activity.

In this study, the most explanatory definition of wayfinding is pertained from Arthur & Passini (1992). Arthur & Passini (1992) stated that wayfinding is a spatial problem solving activity that comprises of three specific but interrelated processes. These processes are; "*decision making* and the development of a plan of action; *decision execution* that 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: 25). Arthur & Passini (1992) also gave the definition of cognitive mapping as a part of environmental perception where cognition is basically source of information to make and execute decisions. At this point, understanding the difference between perception and cognition is important. Perception is defined as the process of obtaining information through the senses; cognition is defined as understanding and being able to manipulate information (Arthur & Passini, 1992). Obtaining information is not enough for being able to find one's way, understanding and manipulating the information is also an essential part of the wayfinding process.

As it is understood from the above definitions of wayfinding, the term is closely related with spatial orientation. Spatial orientation is the ability of a person to situate his or her location in a setting which is totally based on forming an adequate cognitive map of the space and the layout (Arthur & Passini, 1992). People tend to feel disoriented if they cannot situate themselves within that representation and they cannot develop a plan to reach their destination. The act of wayfinding can be viewed as a continuous sequence of problem-solving tasks requiring information about the environment (Passini, 1984).

While users may have a route in mind when they begin their journey, wayfinding is an active and dynamic activity and is prone to change form the initial plan users may have in mind. Users will formulate predictions about environmental features that they may encounter and then compare these predictions with the information found in the actual environment; this all happens actively as the user moves through the environment (Passini, 1984).

There are different viewpoints about the significance of the wayfinding research in the literature. Discussing the goal of wayfinding design is important in order to understand its significance. The goal of wayfinding design is to provide the information necessary for users in order to correctly make and execute decisions within the environment (Passini, 1984). Arthur & Passini (1992) stated that wayfinding design aims to plan the appropriate circulation system and shape interior design so that all elements facilitate easy wayfinding among users.

Successful wayfinding design should allow people to;

- situate their location within a setting,
- determine their destination,
- develop a route plan which takes them from their location to their destination,
- execute the plan and arrange any required changes.

Peponis et al. (1990) put a different aspect: wayfinding is the ability to reach a destination in a short time without experiencing fear and stress. Some researches that have been done before justified this definition and agreed on wayfinding activity having both psychological and physiological effects on people (Arthur & Passini, 1992; Başoğlu, 2007; Best, 1970; Helvacıoğlu & Olguntürk, 2009; Knez & Kerz, 2000; Lawton, 1994; Lawton & Kallai, 2002; Yoo, 1994). Lawton (1994) stated that wayfinding can be adversely affected by a phenomenon known as ‘’spatial anxiety’’, in which someone encountering orientation problems may experience increased anxiety. Yoo (1994) pointed out when people get lost and unable to orientate themselves, they experience increased blood pressure, headaches, feelings of desperation and weariness.

In addition to that, traveling condition is one of the most stressful wayfinding processes because time becomes an important issue (Peponis et al., 1990). Arthur & Passini (1992) characterized terminals by a combination of confusion, apprehension, and disorientation. Travelers deprived of clues for orienting themselves together with the anxiety of being wrongly directed may result in people missing their flights or buses.

Moreover, Andre (1991) reported that, over one million people who asked for information from the information booth at Chicago O’Hare Airport in 1989, 74% of them asked for direction. About 90% of the questions directed to airline customer representatives pertained to direction and only 10% of the nineteen people surveyed on the use of ‘’You Are Here’’ maps were able to use it correctly.

Additionally, Calgary International Airport (1993, cited in Dada, 1997: 1) reported "11.8% of its terminal users as having wayfinding problems in 1992, which translates roughly 1500 users per day. Although the airport reported 5% of terminal users as having problems finding their way in 1993, a closer look reveals that over 18% of these surveyed (209 out of 1139) asked for direction from workers and volunteers. About 4% of the surveyed terminal users at New York's LaGuardia Airport reported having wayfinding problems. For an airport that processed 20.7 million passengers in 1994 (Airports International, July/August 1995, cited in Dada, 1997: 1), the daily average number of passengers with wayfinding problems may be over 2000".

On the other hand, Werner & Kaminoff (1983) put on that asking for directions may be an indication of lack of control over the information that is needed to navigate successfully in an environment. In other words, too many questions about directions proves that the environment does not direct people effectively and give spatial information clearly. In the case of hospitals, Carpman et al. (1984) reported that 78% of the staff gave directions at least three times in a week. Arthur & Passini (1992) reported about 800 work hours are wasted every year in giving directions to visitors in a hospital. Therefore, the numerical data indicate that there is a need in wayfinding research for saving time and labor.

The documented cost of being lost is also stated as real: 1) lost staff time; 2) reduced staff concentration caused by the need to provide directions or other interventions; 3) lost business and dissatisfaction due to frustration and ill-will of users; 4) cost associated with missed appointments or delayed meetings; 5) additional security staff and traffic management costs; 6) compensatory environmental communications systems; 7) potential law suits surrounding lack of safety and accessibility; 8) danger to users wandering into limited access areas of buildings; and 9) injury and death during emergency situations (Arthur & Passini, 1992; Carpman & Grant, 1993; 2002; Zimring, 1990).

2.2. Wayfinding Performance Criteria

Wayfinding performance criteria are important issue for obtaining quantitative data from the experiments in order to measure wayfinding performance coherently. Ruddle & Lessels (2006: 637) proposed three levels of VE metric, based on: ‘’1) users’ task performance (time taken, distance travelled, and number of errors made), 2) physical behavior (locomotion, looking around, and time and error classification, 3) decision making (i.e., cognitive) rationale (think aloud, interview, and questionnaire)’’. Ruddle & Lessels (2006) explained Level 1 (users’ task performance metrics) as metrics that measure how well a user performs a task, which for wayfinding involves a user in finding a particular place; Level 2 (physical behavior metrics) as metrics provide information about what a user was doing during a given task, not just how long they took or how accurately performed; Level 3 (rationale metrics) as metrics which can provide an explanation for why users exhibit given behaviors. This study focuses on the effect of CCT on wayfinding performance of travelers. Therefore, according to the definition of Ruddle & Lessels (2006) Level 1 (users’ task performance metrics) includes appropriate wayfinding performance criteria for this study. The classifications of measurements are explained and previous studies in which these measurements are used to evaluate wayfinding performance are given below.

Time Spent: According to the definition of Peponis et al. (1990) wayfinding is the ability to reach a destination in a short time without experiencing fear and stress. The time spent during the wayfinding task is important criteria to measure the wayfinding performance. The criterion classifies performance in terms of the amount or proportion of time users spend while performing the task.

Coluccia & Iosue (2004) stated that previous studies (Devlin & Bernstein, 1995; Lawton et al., 1996; Moffat et al., 1998; Sandstrom et al., 1998; Saucier et al., 2002) indicated that wayfinding time is significantly correlated with errors (wrong turns) and hesitation frequencies. Travelers, who experienced more errors and hesitations, spend more time for finding the destination.

Error: The number of errors that users make during wayfinding is frequently used as a measure of performance. The type of error that is most commonly identified in wayfinding a miss, which occurs when a user travels within sight of a given location without turning to look at it or takes a wrong turn (Ruddle, Payne & Jones, 1998; Ruddle & Peruch, 2004).

Decision Points and Route Choice: Golledge (1999) defined wayfinding as the process of making decisions and following a path or route between an origin and a desired destination. Decision points are closely related to route choice in wayfinding. As Raubal & Egenhofer (1998) explained, decision points are most apparent whenever a person has the opportunity to select among different paths. In other words, if the traveler chooses a long route, the number of decision point's increase and that influences the difficulty of wayfinding task. Arthur & Passini (1992) and Best (1970) stated that the number of decision points directly influences the difficulty of performing a wayfinding task and he found a correlation; the more choice points, the more likely the respondent was to report becoming lost. Because of this reason, Raubal & Egenhofer (1998) distinguished between points where subjects have one obvious choice to continue the wayfinding task and points where subjects have more than one choice to continue the wayfinding task. They called points with ''choice = 1'' as *enforced decision points*, while points with ''choices > 1'' as *decision points*.

Hesitation: Hesitations that users experience during wayfinding task is frequently used as a measure of performance. Hesitations are generally defined by the number of full stops made by the participants (Choi et al., 2006; Devlin & Bernstein, 1995; Helvacıoğlu & Olguntürk, 2011; Lawton et al., 1996; Moffat et al., 1998; Raubal & Egenhofer, 1998; Sandstrom et al., 1998; Saucier et al., 2002; Veldkamp et al., 2008).

Previous studies on wayfinding with the above criteria report the following findings: Chebat et al. (2008) conducted an experimental study using actual shoppers in a shopping mall showed that the relationship between gender and time necessary to find a specified store. The *time spent* during the wayfinding performance was one of the measurements for the evaluation of this study. The results showed that men spend more time than women.

Tang et al. (2009) conducted a VE experiment in which three scenarios (without emergency signs, with an old-version emergency sign, and with a new-version emergency sign) were created, in an emergency escape game to determine if and how various emergency signs aid wayfinding in the event of an emergency. The *time spent* and the *number of errors* was measurements for this study. It is found that the absence of signs results in slower escape than either old signs or new signs and also males were found to exhibit better wayfinding performance than females.

Chen et al. (2009) investigated user wayfinding navigational performance in terms of two navigational support designs (guide sign and you-are-here map (YAH), wayfinding strategies, task difficulty, and gender differences. The *time spent* was one of the measurements for evaluation in this study. It is found that navigation time for guide signs was significantly shorter than for YAH map support and the results also indicated that males navigated significantly faster than females.

Osmann & Wiedenbauer (2004) explored the role of landmarks on navigation by comparing children and adults in a VE experiment. The *number of errors* and *decision points* (walking distance) were measurements for the evaluation of this study. It is found that no difference between older children and adults in terms of the number of errors and decision points. Moreover, females made more errors exploring the maze without landmarks that means females rely more on the existence of landmarks than males.

Tlauka et al. (2005) explored the gender differences in spatial knowledge that has been acquired through simulated exploration of a virtual shopping centre. *The time* *spent* and the *number of errors* was measurements for the evaluation of wayfinding task. It is found that female participants required more time to travel from the start location to the finish location when following a route through the simulated shopping centre and also while following the route, females made more errors.

Farran et al. (2012) investigated the influence of color as an environmental cue when learning a route in a VE. The *number of errors* was one of the measurements for the evaluation of route task. It is found that adults with Williams's syndrome made significantly more errors than the typically developing 9-year-olds, but not the 6-year-olds.

Cohen & Schuepfer (1980) investigated the representation of landmarks and routes in children and adults in a VE. The number of errors and the number of decisions were measurements for the evaluation of route task. The results showed that second graders made significantly more incorrect turn choices than sixth graders, who, in turn, made more errors than adults. This means that children relied more on the position and sequence of landmarks than adults did. Besides, there are no gender differences found in this study in terms of making errors.

Raubal & Egenhofer (1998) proposed a computational method measuring such complexity of wayfinding tasks in built environments that consisted of two critical elements: choices and clues. A case study of wayfinding conducted in which the applicability of the method in airports demonstrated. Six situations represented a different level of complexity (two types of choices, and three types of clues). It is found that the space with more than one choice and no clues or poor clues is considered more complex for wayfinding. The participants experienced hesitations in the situations that are considered as more complex. The *number of decision points*, *route choice* and *hesitations* were classifications for this study to measure wayfinding complexity.

Veldkamp et al. (2008) presented an experiment carried out to study the design options of a GPS-based navigation aid for elderly with beginning dementia. It is showed that dementia patients performed better on recognition of landmarks compared with recognition and recall of spatial layout. The *number of errors* and *decision points* and *hesitations* were the measurements for this study.

Moffat et al. (2001) explored age differences in navigational behavior in a VE. The *number of errors*, *time* and *route choice* were the measurements for this study. It is found that compared to younger participants, older volunteers took longer to solve each trial, traversed a longer distance, and made significantly more spatial memory errors.

Choi et al. (2006) investigated sex-specific relationships between route-learning strategies and abilities in a university building. The *number of decision points* (distance of the route), *route choice*, frequencies of *hesitations* and the *number of errors* (wrong turns) were the measurements for the evaluation of route task. Results indicated that males used a significantly shorter route than females did.

Helvacıoğlu & Olguntürk (2011) explored the contribution of color to children's wayfinding ability in school environments and to examine the differences between colors in terms of their remembrance and usability in route learning process. The *time spent* finding the end point and experiencing *hesitations* during the route finding process are measurements for evaluation in this study. It is found that children hesitated less on the route and found their way faster with colored boxes.

2.3. Wayfinding Research in Virtual Environments

Wayfinding research can be investigated either in naturalistic settings or in laboratory experiments. Nowadays, VEs, which allow the simulation of three-dimensional environments on a computer, have been increasingly used. In the real world, it is hard to control all the variables, and in some cases it is almost impossible. In order to examine the effect of a specific condition, one needs to control all the variables in the physical setting which is more possible in simulated settings. There are many research that have conducted in a VE (Albert et al., 1999; Cohen & Schuepfer, 1980; Darken & Silbert, 1996; Farran et al., 2012; Gillner & Mallot, 1998; Hidayetoğlu et al., 2012; Moffat et al., 2001; O'Neill, 1992; Osmann, 2002; Osmann & Wiedenbauer, 2004; Piccardi et al., 2011; Ruddle et al., 1997; 1998; Ruddle & Lessels, 2006; Ruddle & Peruch, 2004; Sadeghian et al., 2006; Sancaktar & Demirkan, 2006; Tang et al., 2009; Tlauka et al., 2005; Willemsen & Gooch, 2002).

Osmann (2002) explained that VEs can be divided in desktop and immersive systems which are both useful options for the simulation of spatial environments. In desktop systems conventional desktop computer displays are utilized, whereas an immersive virtual environment is one, where the user is situated in the VE by the use of special output devices like head-mounted displays.

The research done before showed that the use of VEs in spatial cognition research is more advantageous than real environments, in terms of;

- More controllable environment which can be changed quickly and in an economic manner,
- Participants can operate in a self-determined way,
- Nearly all kind of environments can be simulated and navigation can be measured on-line (Osmann & Wiedenburer, 2004).

Furthermore, participants can acquire knowledge about directions and distances (Albert et al., 1999; Willemsen & Gooch, 2002), develop route and survey knowledge (Gillner & Mallot, 1998; Osmann, 2002), and navigate effectively in a VE (Darken & Silbert, 1996; Ruddle et al., 1999). Besides of the positive aspects there are also some limitations especially in the use of desktop VEs, e.g. lack of proprioceptive sensory information (Witmer et al., 1996). Proprioception means locating one-self in an environment and proprioceptive sensory information is about understanding the accurate distance. Research that have done before agreed on acquiring distance knowledge in VEs different from real environments (Gillner & Mallot, 1998; Heineken & Schulte, 2000; Ruddle et al., 1997; Tlauka et al., 2005; Witmer et al., 1996). The users cannot acquire accurate distance knowledge in VEs; however, evidence indicated that missing proprioceptive feedback might not be crucial regarding spatial learning. Waller et al. (2001) showed that there was no difference between learning the spatial representation of mazes in wire-frame virtual and in real-world conditions. Furthermore, Westerman et al. (2001) showed that the efficiency of navigation was poorer in an immersive VE than in a desktop VE.

In the case of this study, conducting an experiment in a desktop VE is more appropriate since changing the color temperature of lighting elements are conveniently possible in a virtual environment in order to understand the effects of color temperature on wayfinding in airports.

In the case of this study, a wayfinding performance criterion is prepared considering the limitations of desktop VE. For instance, estimating the distance is not a criteria for this study to measure the wayfinding performance because of the limitations of desktop VE (lack of proprioceptive sensory information).

The only limitation in the case of this study might be the participants were not real travelers. In other words, the participants did not experience the real condition of travelling stress, missing flight and etc., during the wayfinding task. The experiment conducted in a laboratory setting in which participants have not the same psychological situations in real travelling conditions, may be a factor influencing the wayfinding performance of the participants.

2.4. Individual Differences Affecting Wayfinding Behavior

Individual factors have important influence on wayfinding performance such as familiarity, gender, age, cultural background, education, profession, and disability. The three factors such as familiarity, age and gender are known mostly among the individual differences stated above. Due to the fact that understanding the certain effects of other individual differences is nearly impossible because there are too many variables that has to be controlled in order to explore the certain effects.

Spatial familiarity is interpreted as simply ‘’how well a place is known’’ (Chalmers & Knight, 1985, cited in Doğu, 2001). Most of the studies have agreed on that familiarity has positive impact on experience of spatial orientation and wayfinding behavior. Golledge (1991) explained that as familiarity within an environment is increased, a more flexible, configurational representation of that space can be developed. Ruddle et al. (1998) found out in his study, the increased familiarity provided more accurate spatial knowledge in a simulated environment. Doğu & Erkip (2000) examined spatial factors affecting wayfinding behavior of individuals in a shopping mall. It is found that familiarity is the most important factor that affects wayfinding behavior in interior spaces. O’Neill (1992) stated that as familiarity increases, performances on wayfinding and spatial orientation tasks improve both in accuracy and latency, and the degree of complexity of the layout of the environment becomes less important. According to O’Neill’s exploration (1992) familiarity is more important factor affecting wayfinding performance rather than spatial factors.

Age has a significant effect on user's ability of wayfinding. The effects of age on difference in wayfinding behavior and mental processes taking place during this activity have been subject to numerous studies over the years (Cornell et al., 1999; Lawton, 1994; Passini et. al, 1995; 1998; 2000; Weisman, 1987). Children beyond kindergarten age are competent wayfinders (Bell et al., 1996). Elderly users are more likely to suffer memory loss and become disoriented, which restrains their wayfinding ability. Studies indicated that wayfinding behavior and accuracy are affected by the outcomes of aging such as lack of concentration and memory disorders as in dementia of Alzheimer type (Passini et al., 1998; 2000).

Researches that have been done before agreed on are a gender difference in wayfinding abilities. Gender differences are said to be significant in some cases of spatial abilities such as spatial perception, mental rotation and spatiotemporal ability (Bryant, 1982; Casey & Brabeck, 1990; Schiff & Oldak, 1990), and the differences of ability may be results of neural and hormonal biologic differences (Kimura & Hampton, 1993). Biological hypotheses are generally based on the assumption that sexual hormones influence the cognitive development. Besides, hormone manipulation affects not only sexual behavior but also some aspects of cognition, particularly spatial memory (Williams et al., 1990, cited in Coluccia & Louse, 2004). Moffat & Hampson (1996) explored in spatial ability tests, women perform well when hormones levels are low (when menstrual cycle starts). Otherwise, male performance in spatial tasks seems to fluctuate in during the day, in accordance with natural variations of testosterone levels: when concentration of male hormones is high, performance increases: when concentration is low, performance decreases. Furthermore, according to the study of Van Goozen et al. (1995) administration of androgen to females significantly reduces verbal ability and enhances spatial performance, whereas deprivation of androgen has the opposite effects on males.

Lawton (1996) reported that gender differences are due to different strategies used to solve orientation problems and explains men use orientation strategy while women use route strategy. Women are more likely than men to report that they rely on landmark-based route information which is named as route strategy, whereas men are more likely to report that they orient to global reference points (global directions: north, west, south or east) which is named as orientation strategy, such as the cardinal directions or the position of the sun in the sky (Lawton, 1994; 1996). In other words, men tend to situate themselves in an environment by the aid of global reference points which is basically orientation strategy, whereas women tend to use route strategy which they especially search for environmental cues such as landmarks, architectural differentiations and distinctions. Environmental cues are factors that increase the awareness about the environment and facilitate wayfinding task. Also Lawton finds out that women made more errors on pointing tasks and were less confident than men. Pointing task is the measurement of control over the information that is needed to navigate successfully in an environment.

Osmann & Wiedenbauer (2004) explored the role of landmarks on wayfinding for adults and children. Landmarks are kind of an environmental cue that attracts participants' attention. The participants learned a route with a slide presentation, and then the participants had to recall the inherent landmarks to find their way in a virtual environment. The results showed that second graders relied more on the presence of landmarks than sixth graders and adults, and recalled fewer landmarks. Besides, females relied more on landmarks than males did.

Differential performance of man and women indicated above justifies that there is different wayfinding strategies used. Lawton (1996) noted that biological factors may be included in the explanation of these differences. Some of psychologists claim that the difference may be due to the traditional role of men as explorers and hunters of game – activities that often took them to distant unfamiliar places and required large-scale environmental knowledge acquisition (Doğu, 2001). Golledge (1999) stated that the traditional gathering activities of women produced very detailed local area knowledge, but little experience with distant places except when tribal seasonal wanderings occurred.

CHAPTER III

THE EFFECTS OF CORRELATED COLOR TEMPERATURE

Light is an energy that provides people to experience the visual world. As Egan & Olgyay (2002) stated, light changes the experience of human and also definition of central concept of architecture. ‘’An awareness of both the properties of light and the experience of the observer is essential to an understanding of the luminous world’’ (Egan & Olgyay, 2002). Moreover, light has a considerable effect on how people perceive the physical qualities of a space and also it connotes meaning and emotion to that space (Knez, 2001). Egan & Olgyay explained (2002) the visual experience as a combination of seeing and interpreting which is closed to perception of the environment in with many different cues. Lighting of a space does not only affect its' users physiologically, but also affects them psychologically. The effect of lighting on people’s behavior is an important issue in providing better interior spaces. Therefore, light should be considered as en essential design element along with form, color, and texture and like the others, also is a significant contributor to spatial compositions.

Lighting can play important role on the human mood, health, performance and social behaviors in a space.

3.1. Lighting and Correlated Color Temperature

It is necessary to understand the basic terminology about lighting in order to discuss the effects of CCT deeply. Illuminance and luminance are the two main terms of lighting. Additionally, this study basically focuses on CCT and other related terms.

IESNA Lighting Handbook (2000) gives the definition of illuminance as "the density of the luminous flux, the perceived power of light, incident at a point on a surface". It means illuminance is the measure of intensity of the light incident on a surface. Illuminance can be measured in lux (lx) and also foot-candle (fc), with an illuminance meter. Luminance is defined as "the intensity of visible brightness of a source or surface in the direction of the observer, divided by the area of the source or surface seen" (IESNA, 2000). Luminance can be measured in candela per square meter (cd/m2), with a luminance meter.

Color temperature of any light source whose chromaticity coordinates fall directly on the Planckian locus, as it is seen in the CIE Chromaticity chart (see Fig. 1), has a color temperature equal to the blackbody temperature of the Planckian radiator with those coordinates. Color temperature is usually expressed in Kelvin (K). The concept of color temperature is especially useful for incandescent lamps, which vary closely approximate a blackbody spectrum throughout the visible region. For these lamps, the color temperature also defines the spectrum in this region.

For white lights that don't have chromaticity coordinates that fall exactly on the Planckian locus but do lie near it, the CCT is used. The CCT of a light source, also expressed in Kelvins, is defined as the temperature of the blackbody source that is closest to the chromaticity of the source in the CIE 1960 UCS (*u*, *v*) system. CCT is an essential metric in the general lighting industry to specify the perceived color of fluorescent lights and other nonincandescent white-light sources such as LEDs and high intensity discharge HID lamps. The color produced by these lamps when they are energized, is classified as 'white' ranging from a very cool white to a very warm white (Flynn et al., 1988). The Kelvin value indicates the degree of whiteness. The higher the temperature, the whiter the light. It goes from deep red at low temperatures through orange, yellowish white, white, and finally bluish white at very high temperatures (Wikipedia, June, 10, 2013). Chromacity or CCT simply refers to the color appearance of a light source, ''warm'' for low CCT values and ''cool'' for high CCT values (IESNA, 2000).

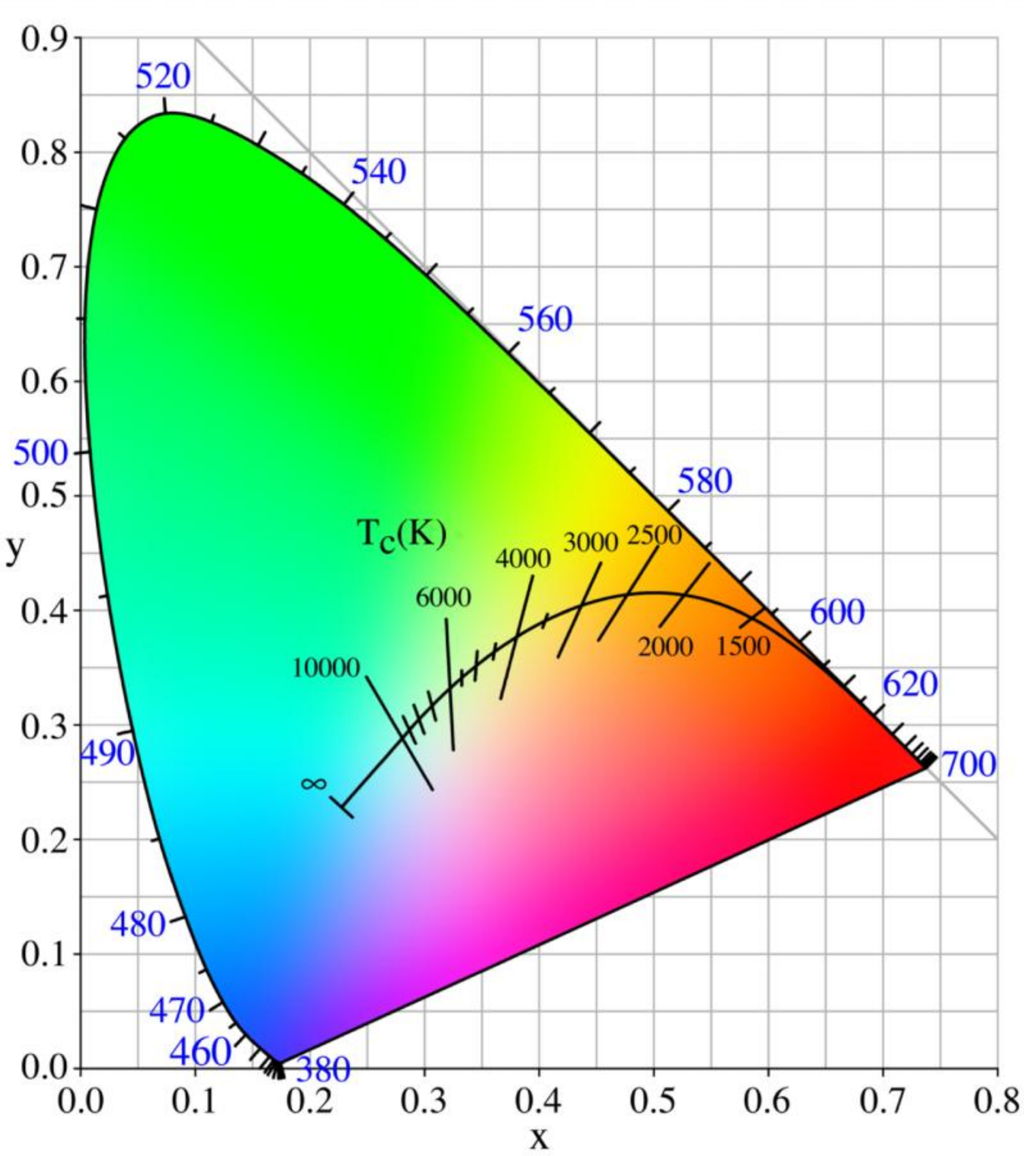

Figure 1: A view showing Black body locus on CIE chromaticity diagram (Source: http://upload.wikimedia.org/wikipedia/commons/b/ba/PlanckianLocus.png)

Color rendering is the general expression for the effect of a light source on the color appearance of objects (IESNA, 2000). The color rendering index (CRI) is the ''measure of how well light sources render color'' (Egan & Olgyay, 2002: 79). A CRI of 100 is considered as best (Flynn et al., 1988). Light sources may appear the same when they are lit, but unless their spectral composition is the same, objects colors seen under those lights will appear different. The CRI is an indication of how similar the color of an object is rendered by a light source relative to a specific Kelvin temperature on the black body line. The higher the CRI, the better (''more natural") colors will appear (Jones, 1989). In other words, two lamps having identical CRIs can have widely varying color rendering abilities. To compare lamps, they must have nearly the same chromaticity or color temperature. For instance, fluorescent lamps at a CRI of 67 can be compared to fluorescent lamps at a CRI of 90, but cannot be compared to other lamps.

In the literature, there is significant information about the relationship between color temperature and the illuminance level and named as ''the Kruithof Effect".
The Kruithof effect is the white area that defines the preferred combinations of the color temperature of a light source and the illuminance as seen in Figure 2. Color temperature/illuminance combinations in the lower shaded area in Figure 2 are claimed to produce cold, drab environments, while those in the upper shaded area are believed to produce overly colorful and unnatural environments (IESNA, 2000: (3) 40-41).

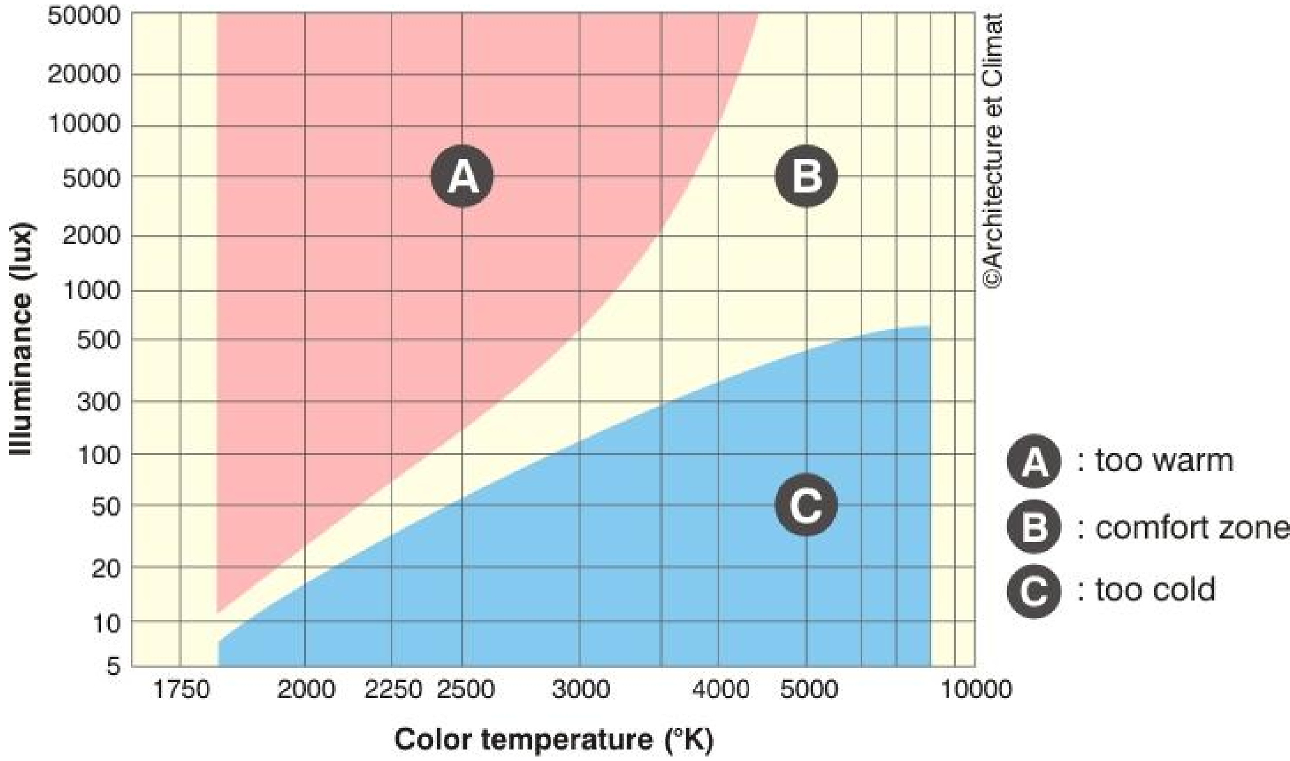

Figure 2: A diagram showing the Kruithof Effect

(Source: https://www.educate-sustainability.eu/kb/content/lamps)

Color of light can be changed according to its wavelength. It is possible to obtain different colors from different light sources. Hence, various sources of lighting for different colors are analyzed briefly.

Incandescent lamps: The advantages of incandescent lamps include a low initial cost, high color rendering ability and general ease of operation (IES, 1987). Incandescent technology allows lamps to operate over a wide range of voltages and amperages. This allows for both easy dimming and low-voltage circuits (Egan & Olgyay, 2002). There are hundreds of variations of wattages, sizes, shapes, and colors of incandescent lamps. CCT of incandescent lamps varies between 2400 K and 2900 K (Philips Online Catalogue, June 24, 2013).

Tungsten-Halogen lamps: Tungsten halogen lamps are basically incandescent lamps that operate at higher pressure and temperature than standard incandescent lamps, producing a whiter light and longer lamp life (IES). The high operating temperature of tungsten-halogen lamps produces a pleasing light which has excellent color and brilliance. Tungsten-halogen lamps also have a longer lamp life and are more compact than ordinary incandescent lamps (Egan, 2002). CCT of tungsten halogen lamps vary between 2800K and 3200K (Philips Online Catalogue, June 24, 2013).

Fluorescent lamps: Fluorescent lamps produce light by passing an electric arc through a mixture of an inert gas (argon or argon/krypton) and mercury (a tiny amount) (IES). The color of light produced by fluorescent lamps is largely determined by the phosphors which coat the inside of the bulb. CCTs from 2700 K to 12000 K are available (Phillips Online Catalogue). A major advantage of fluorescent lamps is their efficacy typically between 40 and 80 lm/W. Due to relatively low initial cost and a relatively long lamp life (10000 to 20000 hours), fluorescents are useful for general ambient lighting (Egan & Olgyay, 2002: 171).

High intensity discharge lamps (HID): HID lamps produce light in a different way than the previous lamp types examined. HID light is produced directly from the arc itself. Due to the high pressure under which these types operate, the arc becomes extremely intense. Once turned off, it must cool down to reduce the arc tube pressure before the arc can restrike. This arc is relatively short (compared to a fluorescent lamp) and therefore it is considered a point source.

HID lamps are the most powerful lighting sources commonly used in architecture. They include mercury, metal halide, high pressure sodium and low pressure sodium. They operate on the same general principle but producing dramatically different results.

These lamps vary in wattage from 39 - 1500 watts. They have lamp life ratings from 6000 - 24000 hours, with some special types exceeding 24000 hours.
The color of light produced varies greatly, depending on the type. CRI ranges from 20 - 95 with CCTs from 2000 K to 6700 K (Phillips Online Catalogue).

Mercury and low pressure sodium have limited use due to their older technology. They are mostly used as outdoor lamp as a ‘’barn light’’, one that can be see when traveling country roads at night. CCTs vary between 1700 K and 6800 K (Philips Online Catalogue, June 24, 2013).

HID source have traditionally been used outside due to their lamp size, poor color, high brightness, and ability to operate over a wide range of temperatures. However, recent technological advances have vastly improved the color, stabilization of the color, and lumen maintenance and have produced smaller sources. These lamps are now good alternatives for many incandescent architectural applications (IESNA, 2000).

The developed technology provided metal halide and high pressure sodium lamps with improved color rendering with CRI rating from 65-95 and a choice of CCT is available which are between 2100 K and 4300 K (Philips Online Catalogue).

Common indoor applications are; retails, industrial facilities, airport terminals, and atriums. Additionally common outdoor applications are classified as street lighting, building facades, airport exterior gate areas, stadiums, bridges and tunnels (IES, 1987).

Light emitting diodes (LEDs): LEDs, or light-emitting diodes, are electronic light sources. A LED is a semiconductor device that emits visible light of a certain color. LED lighting is fundamentally different from conventional light sources such as incandescent, fluorescent, and gas-discharge lamps. A LED uses no mercury, no lead, no gas or filament, it has no fragile glass bulb, and it has no failure-prone moving parts. LED is a type of solid-state diode that emits light when voltage is applied. LEDs become illuminated by the movement of electrons through a semiconductor material. All colors can be obtained by using LED. LEDs usage becomes widespread for general lighting in addition to their applications in traffic signals, signage lighting and automatives. CCT range varies between 2700 K and 4000 K (Philips Online Catalogue, June 24, 2013).

3.2. Correlated Color Temperature Research

Lighting, as a controlled application of light, can change the human perception in different ways. For instance, the color properties of lamps, as a function of their spectral distribution, have considerable impacts on the perception of an interior space illuminated with that light (Fotios & Levermore, 1999). By changing the quality and quantity of light, attraction or attention to a space, impressions of spaciousness, cheerfulness and playfulness can be reinforced, and also, sensations of spatial intimacy or warmth can be stimulated. As an example, impression of relaxation of a space can be reinforced by nonuniform lighting, peripheral (wall) lighting and warm tones of white light (IES, 1987).

Odabaşıoğlu (2009) explored the effects of colored lighting on the perception of interior spaces. Three different lighting settings that are red, green and white were compared. It is found that red and green lighting affect the perception of an interior space. They were found associated to be used mostly in bars and also shops, cafes, cinemas. On the other hand, white lighting was associated to be used in offices, houses and schools.

Experiments examining the psychological effects of varying CCT and illuminance have suggested that using lamps with high CCT values at low illuminances make a space appear cold and dim. Conversely, using lamps with low CCT values at high illuminances will make a space appear artificial and overly colorful (Kruithof effect) (IESNA, 2000).

On the other hand, according to the researches done by Boyce & Cuttle (1990) and Davis & Ginthner (1990), where color adaptation occurs with no opportunity to compare the lamps with different CCTs, the CCT of the light source is relatively unimportant in perception. Where comparisons can be made or the color adaptation does not occur, CCT is more likely to be important (IESNA, 2000).

On the other hand, Aksagür (1977, cited in Manav & Küçükdoğu, 2006) stated that a space is found to be more spacious under 5000 K CCT fluorescent lamps than it was under 2700 K CCT halogen lamps. This study indicated that the change in CCT changes the impression of spaciousness of a space.

Kanaya et al. (1979, cited in Manav & Küçükdoğu, 2006) stated in the findings of the study while measuring the relation between space perception and CCT, that perception of brightness in a space is reinforced with the CRI but not with the CCT. Bornstein (1975) indicated that light from sources that are in equal wattage having wavelengths between 550 and 600nm are perceived as the brightest for which corresponds to yellow-green color. The perception of the brightness decreased dramatically towards violet and red colors.

Considering the quality and quantity of lighting, Manav & Küçükdoğu (2006) found out that both changes in illuminance level and CCT affect space evaluation. 56 participants evaluate two experiment settings as appropriate for office environments that are 4000 K CCT – 750lx and mixed CCT – 2000lx. The change in illuminance level also affects the psychological comfort. Biner & Butler (1989) indicated also that lighting levels may affect arousal which is a measure of how an environment stimulates perception of people. CCT affects the emotional responses of people, as well as space evaluation. Knez (1995) stated that females react more positively to warm white lighting than males. This indicates that the CCT of light has also different emotional effects on gender.

Lighting is one of the factors that affect the comfort in a space. Fleischer et.al. (2001) stated that according to the results of the study done with the workers of an office; warm light sources and low illuminance levels make people feel comfortable. Among the scenarios created with 4000 K CCT, the scenario with 500lx illuminance is preferred among 56 office workers but the space is found to be uncomfortable (Manav & Küçükdoğu, 2006).

Luminance, light distribution, and light spectrum also influence the perception of room brightness to a significant extent (IESNA, 2000). According to Tiller & Veitch (1995), the apparent brightness of a room depends not only on the amount of light falling on the horizontal surfaces in the space but also depends on the light source color and lamp color rendering. Manav & Yener (1999) compared two different lighting settings in office environment that are; fluorescent lamp at 5000 K and incandescent lamp at 2700 K. It is found out that the space is defined as "spacious" and visual clarity increased in setting illuminated with fluorescent lamp at 5000 K, besides when the setting is illuminated with incandescent lamp at 2700 K, the space is defined as "comfortable", "pleasing" and "relaxing".

Lighting also affects spatial orientation and wayfinding. For instance, when navigating around a barrier, people tend to follow the direction of higher illuminance (Taylor & Socov, 1974, cited in IESNA, 2000). These results support the idea that the configuration and quality of lighting might be used to direct circulation, and as an aid to wayfinding.

Color preferences are explored in the previous studies but there are only a few studies on individual preferences based on CCT. As Manav (2007) claimed, the changes in CCT and illumination level affect the visual appeal of a space. She has found that for the impressions of comfort, spaciousness, and brightness in a space, an illumination level of 2000 lx is preferred to 500 lx. For impressions of comfort and spaciousness, a 4000 K color temperature is preferred to 2700 K.

Knez & Kers (2000) found out the effects of office lighting on mood and cognitive performance and a gender effect in work-related judgment. Two laboratory exposure experiments are designed that compared 3000 K and 4000 K. No effect of the lighting on cognitive performance was obtained. The room lighting was perceived differently by genders.

Hoof, Schoutens & Aarts (2009) worked on high CCT lighting (17000 K versus 2700 K) for institutionalized older people with dementia. It finds out there is no significant difference in terms of improvements in behavior.

Manav & Küçükdoğu (2006) worked on the impact of illuminance and CCT on performance at offices (4000 K-2700 K-mixed CCT). It finds out number of errors increased under mixed CCT.

There are differences in preferences of CCT when undertaking different tasks and activities. As Odabaşıoğlu (2009) explored people prefer colored lightings in bars, cafes, cinemas, and restaurants whereas they prefer white lighting in offices, residences and schools. In addition to that, these preferences may be depended on cultural background, mood, age, gender and life experiences.

Further studies are necessary in order to have deep information about individual differences in preferences of CCT.

3.3. Correlated Color Temperature and Performance

As it is stated above, illuminance level, CCT, color rendering index, and brightness of a light source has considerable effects on the perception of a space, emotional responses and preferences of people (see sec. 3.2.).

Previous studies on wayfinding explored the effects of illuminance level and lighting intensity (Hidayetoğlu et al., 2012; Taylor & Socov, 1974, as cited in IESNA, 2000). On the other hand, wayfinding performance is measured by looseness (deviation from direct route) (Best, 1970), number of wrong turns (Collette et al., 1972; O'Neill, 1991; Werner & Kaminoff, 1983) backtracking, hesitation, time to complete the wayfinding task and rate of travel (O'Neill, 1991). However, there are no researches exploring the effects of CCTs on wayfinding. In addition to that studies on CCT and lighting quality are evaluated on different type of performance tasks such as questioning and 2D matching paper based judgment and memory tests.

For instance, Manav & Küçükdoğu (2006) evaluated the performance of 56 office workers through asking questions; the speed of answering questions and making errors are accepted as factors affecting performance. They investigated the effects of color temperature and illuminance level on performance by comparing four different illuminance levels (500-750-1000-2000 lx) and three different CCTs (4000 K-2700 K-mixed CCT). The experiment finds out that illuminance level is not a factor affecting performance on its own, yet CCT has significant effect on performance. It is observed that in a setting under mixed CCT at 500lx, the mean average of making errors is maximum.

Hidayetoğlu et al. (2012) found out the effects of different colors and CCT s on spatial perception and wayfinding in an university building. A video prepared virtually and watched to participants. It is found that attractiveness and memorability of warm colors with high CCTs were higher compare to other colors and color temperatures. The participant did not let to wander in the space, therefore the task type is cognitive, yet the participant is passive.

Knez (1995) evaluated 96 participants with several cognitive tasks namely, memory, problem solving and judgment such as; text reading measures a long term recall and recognition, free recall test, embedded figure test and performance appraisal test. Knez (1995) investigated the effect of indoor lighting on cognitive performance via mood by comparing two illuminance levels (dim; 300lx vs. bright; 1500lx), two CCTs ('warm' white; 3000 K vs. 'cool' white; 4000 K) at high CRI (95). The experiment showed that CCT which induced the least negative mood enhanced the performance long-term memory and problem solving tasks, in both genders.

When evaluating a performance, comparing the same type of tasks is important in order to provide more coherent results. Passini & Arthur (1992) described wayfinding as a problem solving cognitive performance comprising the following processes; decision making, decision executing and information processing (see sec. 2.1.). There are some similar cognition tasks in the literature as it is stated above, yet the participants are not in a three dimensional activity and active. The difference of this case of study is the evaluation of wayfinding performance is more participant integrated in an active participation, three dimensional, cognitive type of task.

Therefore, in this case of study, there will be some similarities and also differences in terms of obtained results because of the different types of evaluation tests.

CHAPTER IV

AIRPORT DESIGN

4.1. Basic Aspects in Airport Design

Airport is described as a mega structure wherein urban traffic is smoothly converted into airborne traffic and that, along this route, converts the traveler into a passenger with automated behavior (Bosma, 1996, cited in Tekdağ et al., 2005). For this reason, the functional structure of the airport becomes ‘circulation’. Airports are labyrinth-like structures in which people are likely to lose themselves or at least get confused to slow down their flow. For this reason, space definition, wayfinding and signage and information systems are the features of the terminal design that should be carefully considered. In addition, Bosma (1996) also stated that an airport is as successful as the ease, speed and efficiency with which travelers switch from one means of transportation to another.

As a result, passenger circulation is the primary problem of the airport design. Edwards (1998: 112) pointed out that ‘’airport design is expected to eliminate ambiguity and confusion, addressing instead questions of clarity of use, functional legibility and route identification.

There are three main types of airports:

- International airports that serve 20 million passengers per year.
- National airports that serve 2-20 million passengers per year.
- Regional airports that serve up to 2 million passengers per year (Edwards, 1998).

The stated numbers only describes some idea on the size of the design problem as the increasing number of travelers means increasing complexity, particularly, in the passenger building. While wayfinding is more easily accomplished in regional airports, it becomes more challenging as the level of traveler and flight traffic increases at national and international airports, particularly those with high percentages of connecting travelers and significant volumes of domestic and international travelers (Gentry, 2010). The main factors influencing the design of airport is explained in terms of security, density of traffic, traveler walking distances, commerce, and design standards (Tekdağ et al., 2005).

Security: Security in airports can be classified as passive security and active security. Passive security is provided by the whole design of the airport regardless to the control of airport operator. In common, there is no human action in passive security; however, it still has an effect on passenger circulation by dividing or connecting spaces, defining routes, etc. Active security is frequently controlled gates and areas, by the help of either airport or aircraft operators.

Density of traffic: The density of flows the peak hours determines the size of circulation spaces and types of circulation systems. Large flows of passengers require efficiency in the space sizes, different types of circulation design such as moving pavements, and ramps rather than lifts.

Traveler walking distances: In an airport, travelers have to walk great distances, burdened with bags, trying to find their way in a confusing environment and stressed by the pressure of meeting a departure time (De Neufville et al., 2002). So that, the walking distances should be designed as far as short.

Commerce: The attractiveness of the commercial areas in the airports requires special focus. Besides, goods delivery routes for the commercial units are another pressure on the design as these routes are expected to not intersect with the traveler routes.

Design standards: The organizations that will be mentioned below, determines the design standards for planning the airport system. The standards include almost any design criteria involving the sizes and features of the airports and also circulation system within them.

FAA- Federal Aviation Administration is responsible for the standards that are used in the USA.

TSA- Transportation Security Administration is the association that controls the security issues in the airports of the USA.

ICAO- International Civil Aviation Organization provides uniformity in the airports at the international level.

IATA- International Air Transport Association is the global trade organization of the air transport industry. It focuses on the commercial aspects of the airports.

As Jim (1998) stated an airport is an interface between ground transportation and air transportation that comprises three sections; the airspace, the airfield, and the traveler terminal. Each section has its own circulation characteristics based on its scale, type and density. There are many circulation flows in an airport yet this study is mainly about the design of the airport terminal as traveler oriented. As Blow (1998) stated separation of arriving and departing travelers and also international and domestic travelers provide feasibility, interchangeability, clarity of passenger movement, centralized control of passengers, and it eases density of traffic flow.

Blow (1998) stated the major traveler circulation system defined to provide more effectively and securely are in sequence:

-Kerbside,

-Security check point,

-Public concourse landside,

-Check in,

-Pre-departure security check,

-Outbound immigration check for international departing passengers,

-Public concourse in the airside,

-Final security check and secondary check in before the bridges, reaching the plane,

-Security check for arriving passengers,

-Health check for some international arriving passengers if needed,

-Inbound immigration check for international arrivals,

-Baggage reclaim,

-Inbound customs check for international arrivals,

-Public concourse,

-Kerbside.

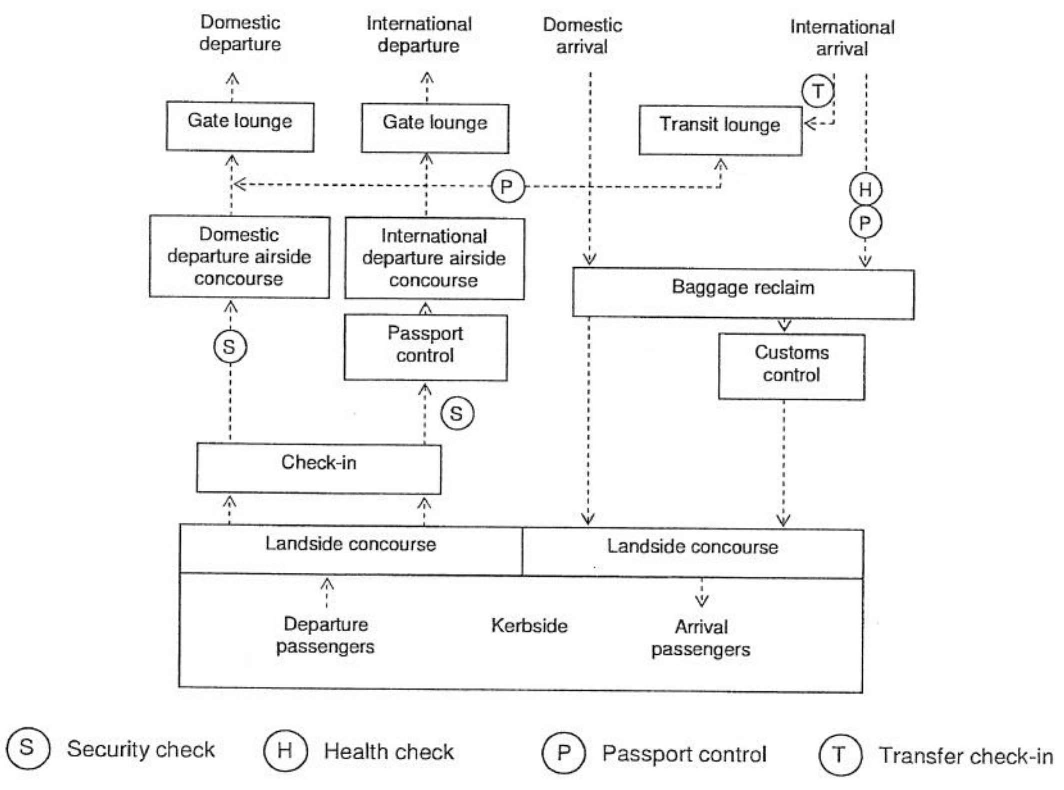

Figure 3: Main route areas on passenger circulation in airport terminal building

(Source: Adapted from Edwards, 1996: 88, cited in Tekdağ et. al., 2005: 35)

4.2. Spatial Characteristics Affecting Wayfinding Behavior in Airports

Passini (1984) put forward that a well designed environment will be simple to navigate without an extensive use of signs. A successfully designed wayfinding system enhances wayfinding ability by encouraging the formation of a cognitive map of the environment. There is a strong relationship between the facilitation of wayfinding and physical setting and its exhibited information. "All of the information we receive from the environment during the wayfinding activity is called environmental information." (Doğu, 2001: 4). Wayfinding is expected to be easy in an environment which is rich in useful information, yet if the environment has too much useless information (visual pollution), it is inevitable that users become more confused (O'Neill, 1991). The environmental information should be attractive, simple and continuous in order to increase the level of perception for building better cognitive maps by the travelers.

Travelers need some environmental clues in order to provide their spatial orientation and wayfinding in the airport terminal building. As O'Neill (1991) stated the environmental information can be provided to travelers by architectural and graphical expressions which may be attractive, simple and continuous in order to increase the level of perception. By using the environmental information travelers can decide their route planning without get lost.

According to Weisman, 1985, cited in Dada, 1997: 16, building design can ease wayfinding by having the following features:

- a clear expression about its circulation system,
- distinct elements such as information desk, landscaping, artwork, as landmarks,
- spaces grouped into destination zones,
- architectural differentiation,
- perceptual access,
- plan configuration.

In order to provide more manageable wayfinding systems, airport designers should consider some spatial characteristics to achieve successful wayfinding design that is easy accessible route for the travelers in the airport building. These spatial characteristics can be analyzed in terms of plan layout and building configuration, visual accessibility and architectural differentiation.

Plan Layout and Building Configuration: All researchers agreed that the legibility or complexity of plan layout may affect the wayfinding performance and cognitive mapping (Abu-Obeid, 1998; Appleyard, 1970; Garling et al., 1981; Garling & Golledge, 1989; Lynch, 1960; O'Neill, 1991, 1991; Passini, 1980; Weisman, 1981). Besides that there is an agreement that travelers comprehend the physical environment easily if the plan layout is legible and simple. The logical placement of functions, the use of clear sight lines from one decision point to the next and visual openness to comprehend what lies ahead are measures that greatly enhance wayfinding in airport terminals (Gentry, 2010).

Weisman (1981) found that students reported being lost less frequently in university buildings whose floor plans they judged ''simpler'' and more ''eligible''. Evans (1982) pointed out that the illegibility of a setting may induce stress by producing confusion and a feeling of incompetence. Wener & Kaminoff (1983) investigated that legibility in a correctional center significantly reduced user confusion, anger, perceived crowding, and overall emotional discomfort. Moreover, a number of studies suggest that the complexity of a floor plan configuration is the primary influence on wayfinding performance (O'Neill, 1991; Peponis et al., 1990). O'Neill (1991) found that even with incremental increases in floor plan complexity, people have significantly greater problems with understanding spatial layout, and reduced wayfinding performance. He suggested that the complexity of a floor plan form affects the wayfinding performance negatively. Weisman (1981) stated that the overall plan configuration of a building, particularly the ease and accuracy with which one can build a mental image of it has some considerable impact on the wayfinding behavior. People use schemes of typical building layouts to find their way in new settings. General knowledge of buildings, in the form of schemes, helps people to orient themselves in unfamiliar environments (Gross & Zimring, 1992). It is common among travelers to get lost in spaces that are too much alike and hard to differentiate.

Overall configuration is influential in wayfinding and understanding of configuration is often the final development stage of learning of settings (Peponis et al., 1990). Arthur & Passini (1992) distinguished between two aspects in wayfinding communication; perception of a path, its use, and accessibility and understanding the configuration of the circulation system. The articulation of paths facilitates an understanding of the circulation system and gives users an indication of the direction of movement and the importance of the destination and whether or not there is access to it (Arthur & Passini, 1992).

The architectural expression of the circulation system makes a building easier to understand. Well articulated buildings tell us everything about their internal central organization. A person perceiving a well-articulated building is in possession of valuable wayfinding information. The perceived spatial organization serves as a framework for constructing a cognitive map and, for integrating information that will be obtained once inside (Arthur & Passini, 1992).

Başkaya et al. (2004) explored spatial orientation and wayfinding behavior of newcomers in an unfamiliar environment comprising two polyclinics, one setting with symmetrical layout and another setting with an asymmetrical layout. In asymmetrical setting, the participants drew complete sketch maps. In symmetrical setting, some participants drew incomplete sketch maps

Visual Accessibility: Visual accessibility is an important factor affecting wayfinding positively in the built environment since it provides travelers with information about the circulation system, the horizontal (i.e. corridors) and vertical paths (i.e. stairs, elevators, escalators), spaces adjacent to these paths, etc. Arthur & Passini (1992) suggested that buildings organized around an open core have the advantage of providing users with a visual access to the form of the circulation system. As buildings become larger, visual accessibility becomes more important to provide successful wayfinding design.

Seidel's (1982) study at the Dallas / Fort Worth Airport confirmed that the spatial structure of the physical environment has a strong influence on people's wayfinding behavior. For travelers arriving at the gate with direct visual access to the baggage claim, wayfinding was easier.

Landscape elements help to maintain and enhance access and mobility of the users of an airport. Both plants and water elements can used to be direct passengers or to prevent from an inaccessible area while emphasizing the architectural form of the airport terminal. These elements sometimes serve as a barrier without preventing the visual access which enhances the security and also they serve as an environmental information about the direction of the passenger circulation.

Architectural Differentiation: According to Abu-Obeid's (1998) study, having a good floor plan is not enough to help people form clear environmental representations if it is not accompanied by pictorial differentiation. Abu-Obeid (1998) also explained pictorial differentiation as variety of pictorial elements in a building environment such as buildings contours, shapes, surface qualities, spatial qualities, entrances and etc. According to Appleyard (1969), when buildings have clear contours and distinctive surfaces that differentiate them from their surroundings, they are usually more distinct. Stairs, lifts, corridors, doorways, and floor finishings are all landmarks used to determine the way to a given destination (Sims, 1991).

In order to prevent the adverse effects of repetition in architecture on wayfinding, a certain degree of environmental complexity is required. That environmental complexity can be provided by the architectural differentiation. The architectural differentiation means exhibiting essential environmental information to users in terms of spatial clues in order to prevent getting confused between spaces and eventually be lost. As buildings become larger in scale and their complexity increase, it becomes difficult to perceive the setting as a whole. In order to form a mental map of the setting, spatial clues must be identified clearly. Fewings (2001: 180) emphasized that "Inside buildings, people use several clues or visual and spatial variables in order to find their way around.". The hierarchy of routes through the terminal and size of spaces should inform the passengers whether the corridor is a major or minor one. The spacious internal volumes, such as the landside terminal will indicate this is a major gathering space for all passengers throughout the terminal. Volumes with a single story height would clearly indicate that this corridor would be for emergency use or guide the user to more private spaces, such as washrooms (Gentry, 2010).

When the same organizational principle without any differentiation among different parts of environment (architectural repetition) becomes prominent, recalling increasingly becomes difficult and architectural differentiation becomes a major factor that influences wayfinding (Darken, 1996). Travelers can only map these spatial entities if they are distinct, that means, if they have an identity that distinguishes them from surrounding spaces (Arthur & Passini, 1992). In addition to that, Arthur & Passini (1992) stated that using color, material and texture differences in spatial features such as structures above or below paths articulate the building organization. Color helps with the differentiation between elements in a setting and / or between settings themselves (Lang, 1987).

Different colors and material types can be used to prevent the adverse affects of architectural repetition. They can also attract travelers' attention and can be memorized to find their way in the airport building due to "architectural differentiation”. Color and material changes can be used in spatial changes such as; fire exit. Critical points in the flow, such as main entrances, check in and customs control can be marked by changes in design in terms of material, color and texture. These architectural differentiation points support and enhance the perception of wayfinding because of the reason that spatial clues are identified clearly, travelers form a mental map of a setting easily. Fewings (2001: 182) stated that "Color pathways or other forms of color co-ordination can also be used in order to direct the flow of people.".

Color-coding is another systematic usage of architectural differentiation by grouping the similar activities in a place. Madrid Barajas Airport is a successful example of color-coded building which provides easiness of travelers’ wayfinding. The airport terminal has divided in four colored part such as red, yellow, blue and green. The color coding used in Madrid Barajas Airport provides architectural differentiation and increase the environmental perception. "In the centre of the building, the exposed steelwork is colored sunflower yellow, with the colors changing gradually along the length of the 1.2km pier from red on the southern side to blue on the northern side, adding brightness and warmth to the building and helping traveler orientation" (http://www.richardrogers.co.uk/, May 20, 2013).

Figure 4: The North Pier demonstrates the use of graduated colors on structural elements of Madrid Barajas Airport (Source: http://www.richardrogers.co.uk/render.aspx?siteID=1&navIDs=1,4,24,296,1035)

Figure 5: A view from Madrid Barajas Airport

(Source: http://www.flickr.com/photos/dalbera/4685193920/)

Figure 6: A view from Madrid Barajas Airport

(Source: http://www.uni-za.com/8-of-the-most-beautiful-airports/)

Figure 7: Signage system is also color-coded in Madrid Barajas Airport

(Source: http://www.panoramio.com/photo/921834)

Architectural differentiation can also be achieved with lighting. Light may help passengers to identify their location and find their way to their destinations. Lighting is an important element which affects the public spaces in terms of understanding the environmental information. Lighting has great impact on perception, comfort, general ambiance, mood and safety (see chapter 3.2.). Travelers want to feel themselves in a safe area while passing from one area to another. Lighting is a useful tool to create an atmosphere that encourages or discourages people from directing into a certain area. "A glimpse of light can signify an entry or an exit, or a change in the level of privacy or security" (Pon, 2008). Lack of light will induce hesitation, and complete darkness causes fear. Successful lighting design may reduce the stress of wayfinding. The power and effect of lighting have importance on traveler circulation in the airport terminal. The architectural lighting system helps people to gain environmental knowledge to understand spatial architectural form and layout.

Different color temperature of lighting arrangements can also used to be to differentiate the spaces. It is important for travelers to understand where to go in a terminal building; at this point the color differences in terms of materials and lightings or the colorful signs should be useful to direct passengers. The application of controllable color temperature may be used to improve users' environmental perception and ease reaching environmental cues. The studies done before explored the aids of color usage on wayfinding (Başoğlu, 2007; Bounds, 2010; Evans et. al., 1980; Farran et al., 2012; Helvacıoğlu & Olguntürk, 2009; Hidayetoğlu et al., 2010; Osmann & Wiedenbauer, 2004), yet there are not any researches about the effects of color temperature of lighting on wayfinding.

The illuminance level recommended for circulation areas in airports is identified as 200lx, however there are no recommendations identified for color temperature of lighting in airports (IESNA). In addition to that Edwards (1996) put forward that it is important to maintain similar pattern of lighting by day and by night so that passenger perceptions of route and volume do not vary. Spontaneous changes of light can affect the perception of the space and hence it makes difficult to form the mental map of the space.

The researches justified that architectural differentiation in terms of color, landmarks, illuminance level and color temperature of lighting elements have positive effects on environmental perception and wayfinding. That can also be used as environmental clues that ease users' wayfinding tasks.

CHAPTER V

THE EXPERIMENT

5.1. Aim of the Study

The aim of the study is to understand the effects of CCT of lighting on wayfinding performances in airports. Understanding how CCT of lighting affects travelers' wayfinding performances. In addition, this study compares the differences between different CCTs of lighting and purports to finds out which CCT of lighting aids to travelers in terms of wayfinding in airport buildings.

5.1.1. Research Questions

The effect of CCT on wayfinding performance:

1. Is there a significant effect of CCT of lighting on wayfinding performance of travelers' in terms of the time spent for finding the final destination:

a) In the whole group.

b) In the males group.

c) In the females group.

2. Is there a significant effect of CCT of lighting on wayfinding performance of travelers' in terms of the number of errors in finding the final destination:

a) In the whole group.

b) In the males group.

c) In the females group.

3. Is there a significant effect of CCT of lighting on wayfinding performance of travelers' in terms of the number of decision points in finding the final destination:

a) In the whole group.

b) In the males group.

c) In the females group.

4. Is there a significant effect of CCT of lighting on wayfinding performance of travelers' in terms of the number of hesitation points in finding the final destination:

a) In the whole group.

b) In the males group.

c) In the females group.

5. Is there a significant effect of CCT of lighting on wayfinding performance of travelers' in terms of the route choice in finding the final destination:

a) In the whole group.

b) In the males group.

c) In the females group

Gender difference:

1. Are there any gender differences for different CCTs on wayfinding performances of travelers' in terms of the time spent in finding the final destination:

a) In the whole group.

b) In Set 1 (3000 K).

c) In Set 2 (6500 K).

d) In Set 3 (12000 K).

2. Are there any gender differences for different CCTs on wayfinding performances of travelers' in terms of the number of errors in finding the final destination:

a) In the whole group.

b) In Set 1 (3000 K).

c) In Set 2 (6500 K).

d) In Set 3 (12000 K).

3. Are there any gender differences for different CCTs on wayfinding performances of travelers' in terms of the number of decision points in finding the final destination:

a) In the whole group.

b) In Set 1 (3000 K).

c) In Set 2 (6500 K).

d) In Set 3 (12000 K).

4. Are there any gender differences for different CCTs on wayfinding performances of travelers' in terms of the number of hesitation points in finding the final destination:

a) In the whole group.

b) In Set 1 (3000 K).

c) In Set 2 (6500 K).

d) In Set 3 (12000 K).

5. Are there any gender differences for different CCTs on wayfinding performances of travelers' in terms of the route choice in finding the final destination:

a) In the whole group.

b) In Set 1 (3000 K).

c) In Set 2 (6500 K).

d) In Set 3 (12000 K).

5.1.2. Hypotheses

1. There is a significant effect of CCT of lighting on wayfinding performance of travelers' in airports.

2. Different CCTs of lighting determine different wayfinding performances of travelers' in airports.

3. There is a gender difference in wayfinding performance of travelers' in airports.

5.2. Method of the Study

5.2.1. Sample Group

The sample group consisted of graduate or undergraduate university students from any department and any university in order to provide a variety. 90 students were chosen randomly. There were 45 females and 45 males whose age range was from 19 to 45. The experiment was conducted with three different sample groups for the three different experiment sets.

Table 1: Participant Numbers on the Basis of Experiment Sets and Gender

		GENDER		Total
		Female	Male	
EXPERIMENT SETS	SET 1	15	15	30
	SET2	15	15	30
	SET3	15	15	30
Total		45	45	90

5.2.2. Procedure

5.2.2.1. Selecting the Route

Before the experiment, 15 volunteered visitors and four airport staff were chosen randomly, for an unstructured interview in Esenboğa airport. The aim was to understand whether the travelers find their way easily or not and how they can find it. Besides, the density of circulation area, visitors profile, the design of color scheme, spatial organization, lighting quality were all observed in order to prepare a generic airport in VE and select a route for the experiment. Providing an appropriate route representing a real traveling experience was important. According to the knowledge gained from airport staff, people mostly asked questions as soon as they entered the airport about how to go to their assigned gates. Therefore, using the route starting from entrance to a specified gate as a typical route was decided on.

5.2.2.2. Modeling

For this research, VE was preferred since controlling the color temperature of lighting in an airport is only possible in a VE. 3DS Max was used for modeling and Mental Ray renderer provided opportunities to fix CCTs and illuminance levels of lighting. There were also other renderers available, yet the only renderer that could fix the CCT and illuminance level of lighting scientifically was Mental Ray. 35

cameras were located in every six meters, which means 35 images prepared for each experiment setting which were shown to the participants.

5.2.2.3. Sets of the Experiment

There were three different experiment settings. The difference between these settings was in the CCT of lighting only. The color scheme, illuminance level and space organization are kept the same for all the experiment settings. At the first setting, the CCT of lighting was set to 3000 K (yellowish white). At the second setting, the CCT of lighting was set to 6500 K (daylight/neutral white). At the third setting, the CCT of lighting was set to 12000 K (bluish white). For the perceptual effect of CCT Egan & Olgyay (2002: 76, see Fig. 9.) was referred to. It is important to have different lighting sets in order to understand the effects of CCT on wayfinding performance.

Figure 8: Partial plan of the airport building with selected route

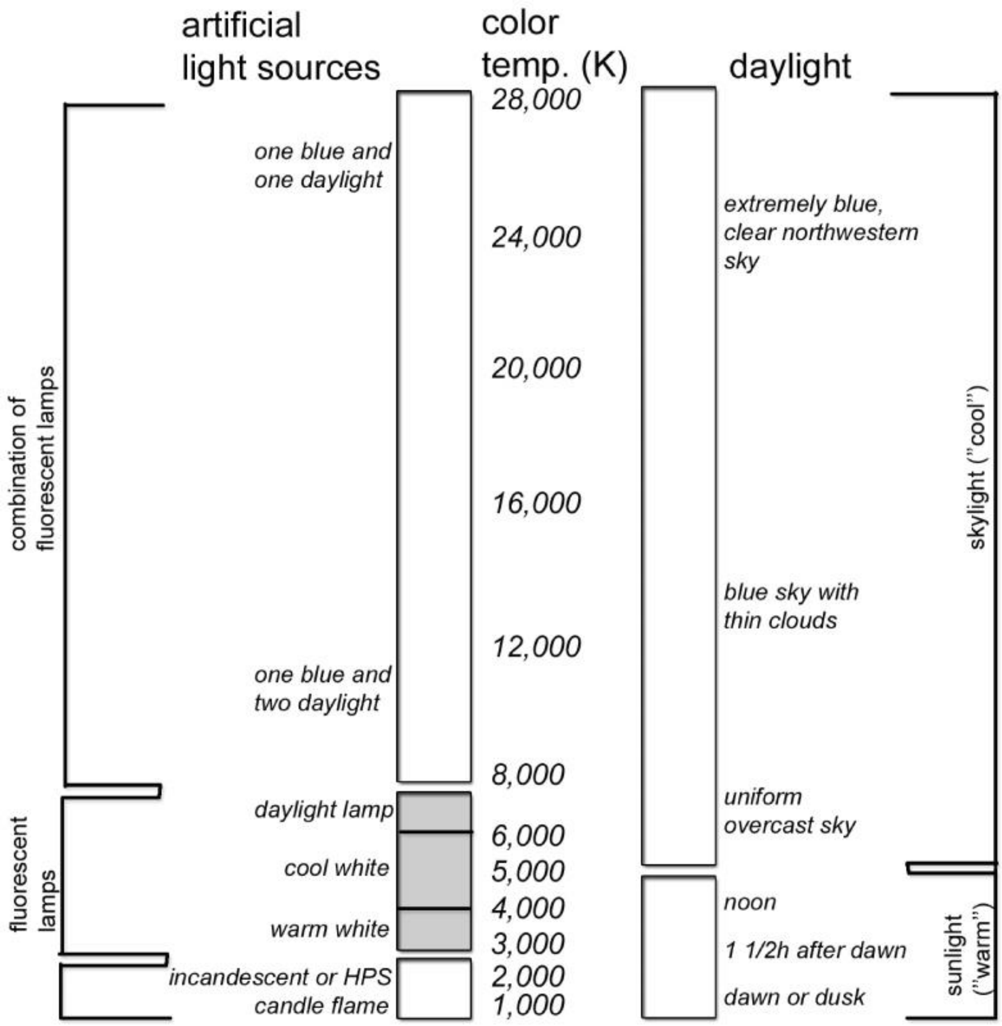

Figure 9: A chart shows color temperatures of artificial light sources and daylight

(Source: Egan & Olgyay, 2002: 76)

Figure 10: A VE view illuminated with 3000 K CCT at 200lx

Figure 11: A VE view illuminated with 6500 K CCT at 200lx

Figure 12: A VE view illuminated with 12000 K CCT at 200lx

5.2.2.4. The Experiment

The study was conducted in a single phase. The participants, who are all volunteers, experienced the desktop VE one by one. The participants were seated at the computer and were tested by the researcher. First the explanation was read to each participant: ‘’ Here is an airport. We will start our tour from the entrance and the gate numbered 109 is the destination. Please direct me after each photograph with one of the expressions of go right / left / forward / back.’’ During the experiment, the participant was listening to the background noise of airport on earphones. The VE movements, errors, hesitations, route choices of each participant were noted by the researcher.

5.3. Findings

Statistical Package for the Social Sciences (SPSS) 19.0 was used to analyze the data. In the analysis of the data, the one-way analysis of variance F-test (ANOVA), the correlated and uncorrelated T-tests, independent-samples T-test and Descriptive Cross-tabulations were used.

Findings from the statistical analysis are given in respect of the stated research questions (see sec. 5.1.1.).

5.3.1. The effect of CCT on wayfinding performance

The effects of CCT on wayfinding performance were evaluated and analyzed for five headings that are:

- The time spent for finding the final destination.
- The number of errors in finding the final destination.
- The number of decision points in finding the final destination.
- The number of hesitation points in finding the final destination.
- The route choice.

5.3.1.1. The time spent for finding the final destination

The time is kept by the researcher for every single participant during the performance for finding the final destination. The time spent is one of the important factors that measures wayfinding performance.

The time spent for finding the final destination of three sample groups (three experiment sets that are Set 1 (3000 K CCT), Set 2 (6500 K CCT) and Set 3 (12000 K CCT) were assessed by comparing the duration of the wayfinding task. Because the differences between more than two sample groups were compared, one-way ANOVA test was used.

Whole Group: The one-way ANOVA indicated that the main effect of CCT on the time spent for wayfinding task was found not to be significant ($F_{2,87}=1.847$, $p=0.164$) (see Appendix C, Table C.1). 50 seconds was the minimum time and 329 seconds was the maximum time recorded. The statistical analysis verified that there is no significant effect of CCT on the time spent in finding the final destination in the whole group.

Males Group: The one-way ANOVA indicated that the main effect of CCT on the time of wayfinding task was found not to be significant ($F_{2,87}=2.005$, $p=0.147$) (see Appendix C, Table C.2). 50 seconds was the minimum time and 329 seconds was the maximum time recorded among the males group. The statistical analysis verified that there is no significant effect of CCT on the time spent in finding the final destination among the males group.

Females Group: The one-way ANOVA indicated that the main effect of CCT on the time of wayfinding task was found not to be significant ($F_{2,87}=0.641$, $p=0.532$) (see Appendix C, Table C.3). 61 seconds was the minimum time and 243 seconds was the maximum time recorded among the females group. The statistical analysis verified that there is no significant effect of CCT on the time spent in finding the final destination among the females group.

5.3.1.2. The number of errors in finding the final destination

The numbers of wrong turns were evaluated as "error" in this study. When the participant turned to a wrong direction, the case was evaluated as "making an error" and each error point was noted on the experiment sheet by the researcher.

Whole Group: Firstly, the total number of errors in finding the final destination was assessed on the one-way ANOVA test. The total number of errors in the whole group means 30 participants' total number of errors for each setting in finding the final destination. The one-way ANOVA indicated that the main effect of color temperature on the total number of errors is not statistically significant ($F_{2,87}$=0.047, p=0.954) (see Appendix C, Table C.4.).

The participants' errors are classified as one error or more than one error and no errors. In the experiment sets, it is observed that 48% (43 participants) made at least one error and 52% (47 participants) did not make any errors in finding the final destination. The observed numbers for minimum and maximum errors were found to be zero and four, respectively. The numbers for the three different settings can be seen in Table 2. As it is clearly seen in Table 2, there is not a significant difference of error making or not-making in three different settings. Chi-Square Test indicated that there is no association between making error and CCT ($\chi2$= 0.089, df = 2, p = 0.956) (see Appendix C, Table C.5).

Table 2: Cross-tabulation for number of errors in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the whole group

	colortemperature			Total
	3000K	6500K	12000K	
No errors	16	15	16	47
Errors	14	15	14	43
Total	30	30	30	90

Males Group: The total number of errors in the males group means 15 participants' total number of wrong turns for each setting until finding the final destination. The minimum number of error was zero and the maximum number of errors was three among the males group observed. The one-way ANOVA indicated that the main effect of CCT on the number of error was found not to be significant ($F_{2,87}$=0.518, p =0.600) (see Appendix C, Table C.6.). Besides that, the participants' errors are classified as one error or more than one error and no errors. In the experiment sets, 49% (22 participants) made at least one error and 51% (23 participants) did not made any errors during finding the final destination. And the scatter for the three different settings can be seen in Table 3. As it is observed in Table 3, there is not a significant difference of making errors in three different settings. Chi-Square Test indicated that there is no association between making error and CCT ($\chi2$ = 2.312, df = 2, p= 0.315) (see Appendix C, Table C.7).

Table 3: Cross-tabulation for the number of errors in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the males group

	colortemperature			Total
	3000K	6500K	12000K	
No error	7	6	10	23
Error	8	9	5	22
Total	15	15	15	45

Females Group: The total number of errors in the females group means 15 participants' total number of wrong turns for each setting until finding the final destination. The minimum number of error was zero and the maximum number of error was two among females group observed. The one-way ANOVA indicated that the main effect of CCT on the number of error was found not to be significant ($F_{2,87}$=0.375, p=0.690) (see Appendix C, Table C.8.). In addition to that, 47% (21 participants out of 45) made at least one error and 53% (24 participants out of 45) did not make any errors during finding the final destination. And the scatter for the three different settings can be seen in Table 8. As it is observed in Table 4, there is not a significant difference of making errors in three different settings. Chi-Square Test indicated that there is no association between making error and CCT ($\chi2$ =1.607, df = 2, p = 0.448) (see Appendix C, Table C.9).

Table 4: Cross-tabulation for the number of errors in finding the final destination with 3 settings (3000 K - 6500 K - 12000 K) in the females group

	colortemperature			Total
	3000K	6500K	12000K	
Error	6	6	9	21
No error	9	9	6	24
Total	15	15	15	45

5.3.1.3. The number of decision points in finding the final destination

There were 35 perspective views in each experiment setting with six meter intervals. The participant directs the researcher after each photograph with one of the expressions of go right / left / forward / back. Each expression signifies a decision point. The number of decision points is one of the important factors in evaluating the wayfinding performance that also measures the walking distance in finding the final destination. The minimum number of observed decision points was five (walking distance: 30 meters) and the maximum number of observed decision points was 23 (walking distance: 138 meters) among the participants.

Whole Group: The total number of decision points in finding the final destination was assessed on the one-way ANOVA test. The total number of decision points in the whole group means the total of 30 participants' number of decision points for each setting in finding the final destination. The one-way ANOVA indicated that the main effect of CCT on the total number of decision points in finding the final destination is not statistically significant ($F_{2,87}=0.372$, $p=0.690$) (see Appendix C, Table C.10.).

Males Group: The total number of decision points in the males group means the total of 15 participants' number of decision points for each setting in finding the final destination. The one-way ANOVA indicated that the main effect of CCT on the total number of decision points in finding the final destination among males group was not significant ($F_{2,87}=1.059$, $p=0.356$) (see Appendix C, Table C.11.). In addition to that, the minimum number of decision points was five (walking distance: 30 meters) and the maximum number of decision points was observed 23 (walking distance: 138 meters) among the males group.

Females Group: The total number of decision points in the females group means the total of 15 participants' number of decision points for each setting in finding the final destination. The one-way ANOVA indicated that the main effect of CCT on the total number of decision points in finding the final destination among females group was not to be significant ($F_{2,87}$=0.066, p =0.936) (see Appendix C, Table C.12.). Besides that the observed minimum number of decision points was five (walking distance: 30 meters) and the maximum number of error was 21 (walking distance: 126 meters) among the females group.

5.3.1.4. The number of hesitation points in finding the final destination

Beusmans et al. (1995) recorded reaction times for the direction responses in three seconds as maximum. Hence, for this study, the participants who waited for more than three seconds at a decision point were accepted as experienced hesitation.

Whole Group: Firstly, the total number of hesitation points in finding the final destination of three sample groups (three experiment sets that are Set 1, Set 2 and Set 3) were assessed by comparing the total number of hesitations during the wayfinding task. The total number of hesitation points means 30 participants' total number of hesitation points for each setting until finding the final destination. The total number of hesitation points in finding the final destination was assessed on the one-way

ANOVA test. The one-way ANOVA indicated that there is a significant difference between sample groups in terms of the total number of hesitation points in finding the final destination ($F_{2,87}$=8.196, p =0.001) (see Appendix C, Table C.13.).

After discovering a statistical difference, it should be determined which one of the sample group differs from the others. For this reason, Post Hoc Comparison Test was used. Scheffe is the most conservative type of Post Hoc Comparison Test (Argyrous, 2005, as cited in Helvacıoğlu, 2007). It examines sub-groups formed by various combinations of the sample groups, rather than just pair wise comparisons. Because of all these advantages, Scheffe type of Post Hoc Comparison Test was used. The test pointed out that, Set 1 (illuminated with 3000 K CCT) showed a significant difference when compared with the Set 2 (illuminated with 6500 K CCT) and Set 3 (illuminated with 12000 K CCT). However, there is no significant difference between Set 2 (illuminated with 6500 K CCT) and Set 3 (illuminated with 12000 K CT) (see Appendix C, Table C.14. for Scheffe Post Hoc Comparison Test). As seen in Table 5, the total number of hesitation points are the least in Set 3 (illuminated with 12000 K CCT) and the total number of hesitation points increased towards Set 1 (illuminated with 3000 K CCT). All these statistical analysis verified that there is a significant contribution of lighting to people's wayfinding performance as they hesitate less while finding their way in environments illuminated with 6500 K or 12000 K CCT.

Experienced hesitations of participants were evaluated also as one or more than one experienced hesitation and no experienced hesitation. In the experiment sets, 14% (13 participants) experienced at least one hesitation and 86% (77 participants) did not experience any hesitations in the time of finding the final destination, and the scatter for the three different settings can be seen in Table 5. The observed counts in Table 5 show significant difference of experienced hesitations in three different settings. Chi-Square Test indicated that there is association between experienced hesitations and CCT ($\chi 2 = 9.351$, df = 2, p = 0.009) (see Appendix C, Table C.15).

Table 5: Cross-tabulation for hesitations in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the whole group

	colortemperature			Total
	3000K	6500K	12000K	
Hesitate	29	27	21	77
Not hesitate	1	3	9	13
Total	30	30	30	90

Males Group: The total number of hesitation points in the males group means 15 participants' total number of hesitation points for each setting until finding the final destination. The total number of hesitation points during finding the final destination was assessed on the one-way ANOVA test. The one-way ANOVA indicated that there is a significant difference between sample males groups in terms of the total number of hesitation points during finding the final destination ($F_{2,87} = 5.530$, p = 0.007) (see Appendix C, Table C.16.).

The Scheffe type of Post Hoc Comparison Test pointed out that, Set 1 (illuminated with 3000 K CCT) showed a significant difference when compared with the Set 2 (illuminated with 6500 K CCT) and Set 3 (illuminated with 12000 K CCT). However, there is not a significant difference between Set 2 (illuminated with 6500

K CCT) and Set 3 (illuminated with 12000 K CCT) (see Appendix C, Table C.17. for Scheffe Post Hoc Comparison Test).

It is obviously seen that the total number of hesitation points are the least at Set 3 (illuminated with 12000 K CCT) and the total number of hesitation points increased at Set 1 (illuminated with 3000 K CCT). All these statistical analysis verified that there is a significant contribution of lighting at 6500K CCT and 12000 K CCT to males' group wayfinding performance as they hesitate less while finding their way in. This result is in accordance with the whole sample group result, yet p values are different as it can be seen in detail (see Appendix C Tables C.14 and C.17).

Secondly, the participants were classified as one or more than one experienced hesitation and no experienced hesitations. In the experiment sets, 78% (35 participants out of 45) experience at least one hesitation and 22% (10 participants out of 45) did not experience any hesitations in the time of finding the final destination. And the numbers for the three different settings can be seen in Table 6. As it is observed in Table 6 there is a significant difference of experienced hesitations in three different settings. Chi-Square Test indicated that there is association between experienced hesitations and CCT ($\chi2 = 13.371$, df=2, $p = 0.001$) (see Appendix C, Table C.18).

Table 6: Cross-tabulation for the number of hesitation points in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the males group

	colortemperature			Total
	3000K	6500K	12000K	
Hesitate	15	13	7	35
Not hesitate	0	2	8	10
Total	15	15	15	45

Females Group: The total number of hesitation points in the females group means 15 participants' total number of hesitation points for each setting until finding the final destination. The total number of hesitation points during finding the final destination was assessed on the one-way ANOVA test. The one-way ANOVA indicated that there is not a significant difference between sample females groups in terms of the number of hesitation points during finding the final destination ($F_{2,87} = 2.592$, $p = 0.087$) (see Appendix C, Table C.19.). In addition to that, 7% (three participants out of 45) experienced at least one hesitation and 93% (42 participants out of 45) did not experience any hesitations during finding the final destination. The scatter for the three different settings can be seen in Table7. As it is observed in Table 7, there is no significant difference of experienced hesitations in three different settings. Chi-Square Test indicated that there is no association between experienced hesitations and CCT ($\chi2 = 0.000$, df = 2, p= 1.000) (see Appendix C, Table C.20).

Table 7: Cross-tabulation for the number of hesitation points in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the females group

	colortemperature			Total
	3000K	6500K	12000K	
Hesitate	14	14	14	42
Not hesitate	1	1	1	3
Total	15	15	15	45

5.3.1.5. The route choice

There were two routes reaching the same final destination but one route is shorter than the other route. The route choices of the participants were evaluated as short or long. Some participants preferred to turn right at the entrance of the building while ignoring the signage and went through the long route; however there were the signage of "domestic flights", going forward at the entrance as the short route (see Figure 8).

Whole Participant Group: The long or short route choice in finding the final destination was assessed on the one-way ANOVA test. The short route choice was 54% (49 participants) and the long route choice was 46% (41 participants) in total (see Table 8). The one-way ANOVA indicated that the main effect of CCT on the route choice in finding the final destination was not significant ($F_{2,87}$=0.570, p =0.567) (see Appendix C, Table C.21.).

In addition, the scatter for the three different settings can be seen in Table 8. As it is observed in Table 8, there is no significant difference of route choice in three different settings. Chi-Square Test indicated that there is no association between selecting route and CCT ($\chi2 = 1.165$, df = 2, p = 0.559) (see Appendix C, Table C.22).

Table 8: Cross-tabulation for the route choice in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the whole group

		colortemperature			Total
		3000K	6500K	12000K	
routechoice	long	12	16	13	41
	short	18	14	17	49
Total		30	30	30	90

Males Group: The short route choice was 53% (24 participants out of 45) and the long route choice was 47% (21 participants out of 45) (see Table 9). The one-way ANOVA indicated that the main effect of CCT on the route choice in finding the final destination was not significant ($F_{2,87} = 1.909$, p = 0.161) (see Appendix C, Table C.23.). Chi-Square Test indicated that there is no association between selecting route and CCT ($\chi2 = 3.750$, df=2, p= 0.153) (see Appendix C, Table C.24).

Table 9: Cross-tabulation for the route choice in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the males group

		colortemperature			Total
		3000K	6500K	12000K	
routechoice	long	8	9	4	21
	short	7	6	11	24
Total		15	15	15	45

Females Group: The short route choice was observed 53% (24 participants out of 45) and the long route choice was observed 47% (21 participants out of 45) (see Table 10). The one-way ANOVA indicated that the main effect of CCT on the route choice during finding the final destination was not significant ($F_{2,87} = 1.727$, $p = 0.190$) (see Appendix C, Table C.25.). Chi-Square Test indicated that there is no association between selecting route and CCT ($\chi 2 = 3.420$, df = 2, $p = 0.181$) (see Appendix C, Table C.26).

Table 10: Cross-tabulation for the route choice in finding the final destination with three settings (3000 K - 6500 K - 12000 K) in the females group

		colortemperature			Total
		3000K	6500K	12000K	
routechoice	long	4	7	9	20
	short	11	8	6	25
Total		15	15	15	45

5.3.2. Gender Difference

The effects of CCT on wayfinding performance in males and females group were evaluated and analyzed under five headings that are:

- The time spent for finding the final destination.
- The number of errors in finding the final destination.
- The number of decision points in finding the final destination.
- The number of hesitation points in finding the final destination.
- The route choice.

The statistical analysis is conducted on 45 male and 45 female participants. Each experiment setting was applied on 15 participants.

5.3.2.1. The time spent in finding the final destination

The time spent in finding the final destination of three samples in two different gender groups (three experiment sets that are Set 1, Set 2 and Set 3) were assessed by comparing the duration of wayfinding task. Because of looking at the differences between more than two sample groups, one-way ANOVA test was used. Moreover, Independent Samples T-test is used to explore if there is a gender difference on wayfinding performance or not, in the whole participant group.

Whole Group: According to Independent Samples T-test, there is no significant effect of gender on time spent during wayfinding performance between the three settings ($t = -0.086$, $df = 88$, $p = 0.932$) (see Appendix C, Table C.27).

Set 1: According to Independent Samples T-test, there is no significant effect of gender on the time spent during wayfinding performance in setting 1 (3000 K CCT) ($t = -0.734$, $df = 28$, $p = 0.469$) (see Appendix C, Table C.28).

Set 2: According to Independent Samples T-test, there is no significant effect of gender on time spent during wayfinding performance in setting 2 (6500 K CCT) ($t = -0.518$, $df = 28$, $p = 0.608$) (see Appendix C, Table C.29).

Set 3: According to Independent Samples T-test, there is no significant effect of gender on the time spent during wayfinding performance in setting 3 (12000 K CCT) ($t = -1.326$, $df = 28$, $p = 0.196$) (see Appendix C, Table C.30).

5.3.2.2. The number of errors in finding the final destination

Whole Participant Group: According to Independent Samples T-test, there is no significant effect of gender on the total number of errors during wayfinding performance between the three settings ($t = -0.756$, $df = 88$, $p = 0.452$) (see Appendix C, Table C.31).

In addition, 47 % females (21 female participants) made at least one error whereas 49% males (22 male participants) made also at least one error and 53% females (24 female participants) did not make any errors during finding the final destination whereas 51% males (23 male participants) did not make any errors as it is seen in Table 11. There is no significant difference of making errors according to gender. Chi-Square Test indicated that there is no association between making errors and gender ($\chi 2 = 0.045$, $df = 1$, $p = 0.833$) (see Appendix C, Table C.32).

Table 11: Cross-tabulation for the number of errors and gender relationship in finding the final destination in the whole group

	gender		Total
	males	females	
No errors	23	24	47
Errors	22	21	43
Total	45	45	90

Set 1: According to Independent Samples T-test, there is no significant effect of gender on the total number of errors during wayfinding performance in setting 1 (3000 K CCT) ($t = -0.957$, $df = 28$, $p = 0.347$) (see Appendix C, Table C.33). Chi-Square Test indicated that there is no association between making errors and gender ($\chi 2 = 0.536$, $df = 1$, $p = 0.464$) (see Appendix C, Table C.34).

Table 12: Cross-tabulation for the number of errors in finding the final destination in Set 1

		errors		Total
		no errors	errors	
gender	males	7	8	15
	females	9	6	15
Total		16	14	30

Set 2: According to Independent Samples T-test, there is no significant effect of gender on the total number of errors made during wayfinding performance in setting 2 (6500 K CCT) ($t = -0.962$, $df = 28$, $p = 0.344$) (see Appendix C, Table C.35). Chi-Square Test indicated that there is no association between making errors and gender ($\chi 2 = 1.200$, $df = 1$, $p = 0.273$) (see Appendix C, Table C.36).

Table 13: Cross-tabulation for the number of errors in finding the final destination in Set 2

		gender		Total
		males	females	
	no error	6	9	15
	error	9	6	15
Total		15	15	30

Set 3: According to Independent Samples T-test, there is no significant effect of gender on the number of errors made during wayfinding performance in setting 3 (12000 K CT) ($t = -0.671$, $df = 28$, $p = 0.508$) (see Appendix C, Table C.37). Chi-Square Test indicated that there is no association between making errors and gender ($\chi 2 = 2.143$, $df = 1$, $p = 0.143$) (see Appendix C, Table C.38).

Table 14: Cross-tabulation for the number of errors in finding the final destination

	gender		Total
	males	females	
error	5	9	14
no error	10	6	16
Total	15	15	30

5.3.2.3. The number of decision points in finding the final destination

Whole Group: According to Independent Samples T-test, there is no significant effect of gender on the total number of decision points during wayfinding performance between the three settings ($t = -1.151$, $df = 88$, $p = 0.253$) (see Appendix C, Table C.39).

Set 1: According to Independent Samples T-test, there is not a significant effect of gender on the total number of decision points during wayfinding performance in setting 1 (3000 K CCT) ($t = -1.207$, $df = 28$, $p = 0.238$) (see Appendix C, Table C.40).

Set 2: According to Independent Samples T-test, there is no significant effect of gender on the number of decision points during wayfinding performance in setting 2 (6500 K CCT) ($t = -0.981$, $df = 28$, $p = 0.335$) (see Appendix C, Table C.41).

Set 3: According to Independent Samples T-test, there is no significant effect of gender on the number of decision points during wayfinding performance in setting 3 (12000 K CCT) ($t = -0.464$, $df = 28$, $p = 0.646$) (see Appendix C, Table C.42).

5.3.2.4. The number of hesitation points in finding the final destination

Whole Participant Group: According to Independent Samples T-test, there is significant effect of gender on the total number of hesitation points in wayfinding performance between the three settings ($t = -0.550$, $df = 88$, $p = 0.583$) (see Appendix C, Table C.43). 93% females (42 female participants) experience at least one hesitation whereas 22% males (10 male participants) experience at least one hesitation and 7% females (three female participants) did not experience any hesitations during finding the final destination whereas 78% males (35 male participants) did not experience any hesitations as it is observed in the cross-tabulation (Table 15). Chi-Square Test indicated that there is association between experienced hesitations and gender ($\chi 2 = 4.406$, $df = 1$, $p = 0.036$) (see Appendix C, Table C.44).

Table 15: Cross-tabulation for the number of hesitations and gender relationship in finding the final destination in the whole group

	gender		Total
	males	females	
Not hesitate	10	3	13
Hesitate	35	42	77
Total	45	45	90

Set 1: According to Independent Samples T-test, there is no significant effect of gender on the number of hesitation points in wayfinding performance in setting 1 (3000 K CCT) ($t = -0.616$, $df = 28$, $p = 0.543$) (see Appendix C, Table C.45).Chi-Square Test indicated that there is no association between experiencing hesitations and gender ($\chi2 = 1.034$, $df = 1$, $p = 0.309$) (see Appendix C, Table C.46).

Table 16: Cross-tabulation for the number of hesitations in finding the final destination in Set 1

		hesitations		Total
		not hesitate	hesitate	
gender	males	0	15	15
	females	1	14	15
Total		1	29	30

Set 2: According to Independent Samples T-test, there is no significant effect of gender on the number of hesitation points during wayfinding performance in setting 2 (6500 K CCT) ($t = -0.774$, $df = 28$, $p = 0.445$) (see Appendix C, Table C.47). Chi-Square Test indicated that there is no association between experiencing hesitations and gender ($\chi2 = 0.370$, $df = 1$, $p = 0.543$) (see Appendix C, Table C.48).

Table 17: Cross-tabulation for the number of hesitations in finding the final destination in Set 2

	gender		Total
	males	females	
not hesitate	2	1	3
hesitate	13	14	27
Total	15	15	30

Set 3: According to Independent Samples T-test, there is no significant effect of gender on the total number of hesitation points during wayfinding performance in setting 3 (12000 K CCT) ($t = -1.031$, $df = 28$, $p = 0.311$) (see Appendix C, Table C.49). In addition to that, participants were evaluated as experienced one or more than one hesitation and no hesitations (see Table 18). Chi-Square Test indicated that there is association between experienced one or more hesitation and no hesitations and gender ($\chi2 = 7.778$, $df=1$, $p=0.005$) (see Appendix C, Table C.50).

Table 18: Cross-tabulation for the number of hesitations in finding the final destination in Set 3

	gender		Total
	males	females	
Hesitate	7	14	21
Not hesitate	8	1	9
Total	15	15	30

5.3.2.5. The route choice

Whole Participant Group: According to Independent Samples T-test, there is no significant effect of gender on the route choice during wayfinding performance between the three settings ($t = -0.209$, $df = 88$, $p = 0.835$) (see Appendix C, Table C.51). Participants were evaluated as selecting the short or long route (see Table 19). Chi-Square Test indicated that there is no association between selecting route and gender ($\chi 2 = 0.045$, $df = 1$, $p = 0.832$) (see Appendix C, Table C.52).

Table 19: Cross-tabulation for the route choice and gender relationship in finding the final destination in the whole group

		routechoice		Total
		short	long	
gender	female	24	21	45
	male	25	20	45
Total		49	41	90

Set 1: According to Independent Samples T-test, there is no significant effect of gender on the route choice during wayfinding performance in setting 1 (3000 K CCT) ($t = -1.497$, $df = 28$, $p = 0.146$) (see Appendix C, Table C.53). Participants were evaluated as selecting the short or long route (see Table 20). Chi-Square Test indicated that there is no association between selecting route and gender ($\chi 2 = 2.222$, $df = 1$, $p = 0.136$) (see Appendix C, Table C.54).

Table 20: Cross-tabulation for the route choice and gender relationship in finding the final destination in Set 1

		routechoice		Total
		short	long	
gender	males	7	8	15
	females	11	4	15
Total		18	12	30

Set 2: According to Independent Samples T-test, there is no significant effect of gender on the route choice during wayfinding performance in setting 2 (6500 K CT) (t = -0.714, df = 28, p = 0.481) (see Appendix C, Table C.55). Participants were evaluated as selecting the short or long route (see Table 21). Chi-Square Test indicated that there is no association between selecting route and gender ($\chi 2 = 0.536$, df = 1, p = 0.464) (see Appendix C, Table C.56).

Table 21: Cross-tabulation for the route choice and gender relationship in finding the final destination in Set 2

		gender		Total
		males	females	
routechoice	short	6	8	14
	long	9	7	16
Total		15	15	30

Set 3: According to Independent Samples T-test, there is not significant effect of gender on the route choice during wayfinding performance in setting 3 (12000 K CCT) (t = -1.890, df = 28, p = 0.069) (see Appendix C, Table C.57). It is seen that,

73% males (11 male participants out of 15) and 40% females (six female participants out of 15) chose the short route (see Table 22). Hence, males tend to choose the shorter route in 12000 K CCT. Chi-Square Test indicated that there is no association between selecting route and gender ($\chi 2$ =3.394, df=1, p=0.065) (see Appendix C, Table C.58).

Table 22: Cross-tabulation for the route choice and gender relationship in finding the final destination in Set 3

		gender		Total
		males	females	
routechoice	long	4	9	13
	short	11	6	17
Total		15	15	30

5.3.3. Other Findings

Correlations between time spent in finding the final destination and route choice in the whole group: According to the result of Pearson Correlation test, there is a significant medium level positive correlation between the time spent in finding the final destination and route choice (corr=0.662, at 0.01 level-two tailed) (see Appendix C, Table C.59). Thus, the participants were spending more time when they chose long route while they were finding their way.

Correlations between time spent in finding the final destination and the number of hesitations in the whole group: According to the result of Pearson Correlation test, there is a significant medium level positive correlation between the time spent in finding the final destination and the number of hesitations (corr=0.689, at 0.01 level-two tailed) (see Appendix C, Table C.60). Thus, the participants were spending more time when they experienced more hesitations while they were finding their way.

Correlations between time spent in finding the final destination and number of errors in the whole group: According to the result of Pearson Correlation test, a significant medium level correlation was found. The time spent in finding the final destination and number of errors are in positive correlation (corr=0.695, at 0.01 level two-tailed) (see Appendix C, Table C.61). The more the participants make errors, the more time they needed to find the final destination.

Correlations between number of decision points and errors in the whole group: According to the result of Pearson Correlation test, there is a significant medium level positive correlation between the number of decision points and errors (corr=0.696, at 0.01 level-two tailed) (see Appendix C, Table C.62). Thus, the participants were making more errors when they stopped more often (as decision points) while they were finding their way.

Correlations between number of hesitation points and decision points in the whole group: According to the result of Pearson Correlation test, a significant medium level correlation was found. Number of hesitation and decision points are in positive correlation (corr=0.580, at 0.01 level two-tailed) (see Appendix C, Table C.63). The more the participants hesitate, the more decision stops (at decision points) they needed.

5.4. Discussion

In this thesis, the effect of CCT on wayfinding in airports in a virtual environment was studied. It was hypothesized that there are differences between different CCTs on the performances of wayfinding. The participants' performances were compared under three different color temperatures; 3000 K, 6500 K and 12000 K, considering the following topics; a) the time spent in finding the final destination, b) the number of errors in finding the final destination, c) the number of decision points in finding the final destination, d) the number of hesitation points in finding the final destination, e) the route choice.

The results showed some similarities and differences with the wayfinding performance findings in the literature. In this study it was found that there is no effect of any CCT in terms of the time spent, number of errors, number of decision points, route choice and there is no significant effect of gender on wayfinding performance in the whole participants group.

Chebat et al. (2008) conducted an experimental study using actual shoppers in a shopping mall showed the relationship between gender and time necessary to find a specified store. The *time spent* during the wayfinding performance was one of the measurements for the evaluation of this study. The results showed that men spend more time than women.

Osmann & Wiedenbauer (2004) explored the role of landmarks on navigation by comparing children and adults in a virtual environment experiment. The *number of* *errors* and *decision points* (walking distance) were measurements for the evaluation of this study. No difference is found between older children and adults in terms of the number of errors and decision points. Females, however, made more errors exploring the maze without landmarks that means females rely more on the existence of landmarks than males.

Tlauka et al. (2005) explored the gender differences in spatial knowledge that has been acquired through simulated exploration of a virtual shopping centre. *The time spent* and the *numbers of errors* were measurements for the evaluation of wayfinding task. It is found that female participants required more time to travel from the start location to the finish location when following a route through the simulated shopping centre and also while following the route, females made more errors.

Cohen & Schuepfer (1980) investigated the representation of landmarks and routes in children and adults in a VE. *The number of errors and the number of decisions* were measurements for the evaluation of route task. The results showed that second graders made significantly more incorrect turn choices than sixth graders, who, in turn, made more errors than adults. This means that children relied more on the position and sequence of landmarks than adults did. Besides, there is no gender differences found in this study in terms of making errors.

Moffat et al. (2001) explored age differences in navigational behavior in a VE. The *number of errors*, *time* and *route choice* were the measurements for this study. It is found that compared to younger participants, older volunteers took longer to solve each trial, traversed a longer distance, and made significantly more spatial memory errors.

Choi et al. (2006) investigated sex-specific relationships between route-learning strategies and abilities in a university building. The *number of decision points* (distance of the route), *route choice*, frequencies of *hesitations* and the *number of errors* (wrong turns) were the measurements for the evaluation of route task. Results indicated that males used a significantly shorter route than females did.

Helvacıoğlu & Olguntürk (2011) explored the contribution of color to children's wayfinding ability in school environments. They examined the differences between colors in terms of their remembrance and usability in route learning process. The *time spent* finding the end point and experiencing *hesitations* during the route finding process are measurements for evaluation in this study. It is found that children hesitated less on the route and found their way faster with colored boxes.

According to the previous studies stated above, there are several different results in wayfinding performance in terms of: time spent, number of errors, number of decision points, number of hesitations and route choices. However, the variables of all these studies were different from this study. There are not any studies measuring the effects of CCT of lighting on wayfinding performance of travelers'. There are some studies on the effects of CCT of lighting, yet they concentrated on different performance tasks stated below.

Manav & Küçükdoğu (2006) evaluated the performance of 56 office workers through asking questions; the speed of answering questions and making errors are accepted as factors affecting workers' performance. They investigated effects of CCT and illuminance level on performance by comparing four different illuminance levels (500-750-1000-2000 lx) and three different CCTs (4000 K – 2700 K - mixed CCT). The experiment found out that illuminance level is not a factor affecting performance on its own, yet CCT has significant effect on performance in terms of making errors and the speed of answering questions. It is observed that in a setting under mixed CCT at 500lx, the mean average of making errors is maximum. No gender differences were not found in Manav & Küçükdoğu's (2006) study.

Knez (1995) evaluated 96 participants with several cognitive tasks namely memory, problem solving and judgment such as, text reading measuring a long term recall and recognition, free recall test, embedded figure test and performance appraisal test. Knez investigated the effect of indoor lighting on cognitive performance via mood by comparing two illuminance levels (dim 300lx vs bright 1500lx), two CCTs ('warm' white 3000K vs. 'cool' white 4000K) at high CRI (95). The experiment showed that CCT which induced the least negative mood enhanced the performance long-term memory and problem solving tasks, in both genders.

According to the previous studies concentrated on CCT of lighting which are stated above, CCT has an effect on two-dimensional paper based cognitive tasks, yet there is not any study measuring the effect of CCT on wayfinding performance. Passini & Arthur (1992) described wayfinding as a problem solving cognitive performance comprising the following processes, decision making, decision executing and information processing (see sec. 2.1.). There were some similar cognition tasks in the literature as it is stated above, yet the participants were not in a three dimensional activity and they were not active. The difference of this case of study is the evaluation of wayfinding performance where there is more active participation, three dimensional, cognitive type of task. Therefore, the different types of performance tasks (two dimensional cognitive tasks vs. three dimensional cognitive tasks) may be the reason for taking different results, moreover making comparisons between different types of tasks is not true.

It is found that CCT has a significant effect on the number of hesitation points in whole participants group ($p=0.001$; see Appendix C, Table C.13.). 3000 K CCT (set 1) showed a significant difference when compared with 6500 K CCT (set 2) and 12000K CCT (set 3) ($p=0.001$, $p=0.017$; see Appendix C, Table C.14.). However, there is not a significant difference between 6500K CCT (set 2) and 12000K CCT (set 3) ($p=0.625$; see Appendix C, Table C.14.). It is pointed out that CCT has a significant effect on users' experienced hesitation while finding their route. Participants who were taking the experiment under 6500 K CCT (set 2) and 12000 K CCT (set 3) behaved significantly more self-confident in finding their final destination with less number of hesitation points. Males group is affected from CCT in terms of more experienced hesitation than females group.

Coluccia & Iosue (2004) stated that previous studies (Devlin & Bernstein, 1995; Lawton et al., 1996; Moffat et al., 1998; Sandstrom et al., 1998; Saucier et al., 2002) indicated that wayfinding time is significantly correlated with errors (wrong turns) and hesitation frequencies. Travelers, who experienced more errors and hesitations, spend more time for finding the destination. In this study, correlations were found between the time spent & the number of errors, the time spent & the number of hesitations, the time spent & route choice, the number of decision points & the number of errors, and the number of hesitation point & the number of decision points.

In the whole of the group, in all three settings, both males and females chose either the long or the short route with no preference of one over the other. In 3000 K CCT and 6500 K CCT, again there seems to be no significant preference of one route over the other. In 12000 K CCT, females picked up the long route, while males seem to choose the short route. In terms of performance, 12000 K CCT helped male participants to choose the short route. The only gender difference is found in setting 3 (12000 K CCT); gender has a significant effect on the route choice ($p=0.069$; see Appendix C, Table C.56.). It is seen that females group prefer the long route whereas males prefer the short route.

Traveling condition is one of the most stressful wayfinding processes, as users may feel stressed and it may cause psychological and physiological reactions when they feel disoriented. The effect of CCT on time and the number of errors during wayfinding performance is not found significant, yet CCT has a significant effect on experienced hesitations which is another important factor for traveling condition.

CHAPTER VII

CONCLUSION

The contribution of CCT to users' wayfinding performance in airports, and the difference between CCTs in terms of the time spent, number of error making, number of decision points, number of hesitation points and route choice in wayfinding process were explored in a VE.

In the literature, there is not enough experimental data about the effect of CCT on wayfinding process. As it is stated in IESNA, lighting may have an effect on wayfinding behavior, yet the findings till today are very limited. Further studies using a wider range of lighting conditions and additional independent variables are required before firm conclusions about the effects of illuminance on orientation, wayfinding, activation, and attention can be drawn (IESNA). In the literature it is seen that wayfinding studies mostly concentrated on color, landmarks, familiarity, signage systems, spatial differences, plan layout and behaviors of users but not that much on effects of lighting. When it is concentrated on the CCT studies in the literature, it is seen that most of the studies focused on perception, individual liking, working performance, psychological and physiological effects. There is not any research concentrated on the relationship between CCT and wayfinding performance. Because of that, the general composition of this thesis and statistical results of the research are important to fill the gap in the literature about the effects of CCT on wayfinding performances.

It was found that there is no significant relationship between CCT and time spent, number of errors, number of decisions and route choice during the wayfinding performance. However, the results showed that there is a significant effect of CCT on number of hesitations. It is seen that number of hesitation points increased at 3000 K CCT whereas they decreased at 6500 K CCT and 12000 K CCT. Thus, it can be referred that 6500 K CCT or 12000 K CCT is better for traveling in terms of experiencing hesitations.

Airports are one of the most important public places in these days of the global world. Therefore, it is important to analyze the type of environment provided for travelers since growing number of people prefer traveling by planes. In those environments, namely the airports, passenger circulation and wayfinding are issues which come into prominent attention.

Up till now, color of the space and CCT of lighting are generally explored as separated issues, yet it is important to examine the effects of them together to understand the built environment deeply and in a more realistic manner. For future studies, it is important to point out that, examining the color scheme of the space and color temperature of lighting together in the concept of wayfinding performance would add to our knowledge on human behavior and our environments.

Lastly, in this study there are also some limitations because the experiment was conducted in VE, not in real world. In this study, conducting an experiment in a VE is more appropriate since changing the CCT of lighting elements are conveniently possible in a VE in order to understand the effects of CCT on wayfinding in airports. The research done before showed that the use of VEs in spatial cognition research is more advantageous than real environments (Wiedenburer & Osmann, 2004; see chapter 2.3). The limitation of the study is, the participants may behave differently in the real world experiment. In further studies, the effects of CCT on wayfinding could be studied in a real world experiment.

The findings of the experiment may provide some clues not only for interior architects but also for environmental psychologists who may be interested in different factors affecting user behavior.

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APPENDICES

APPENDIX A - EXPERIMENT NOTES OF THE RESEARCHER

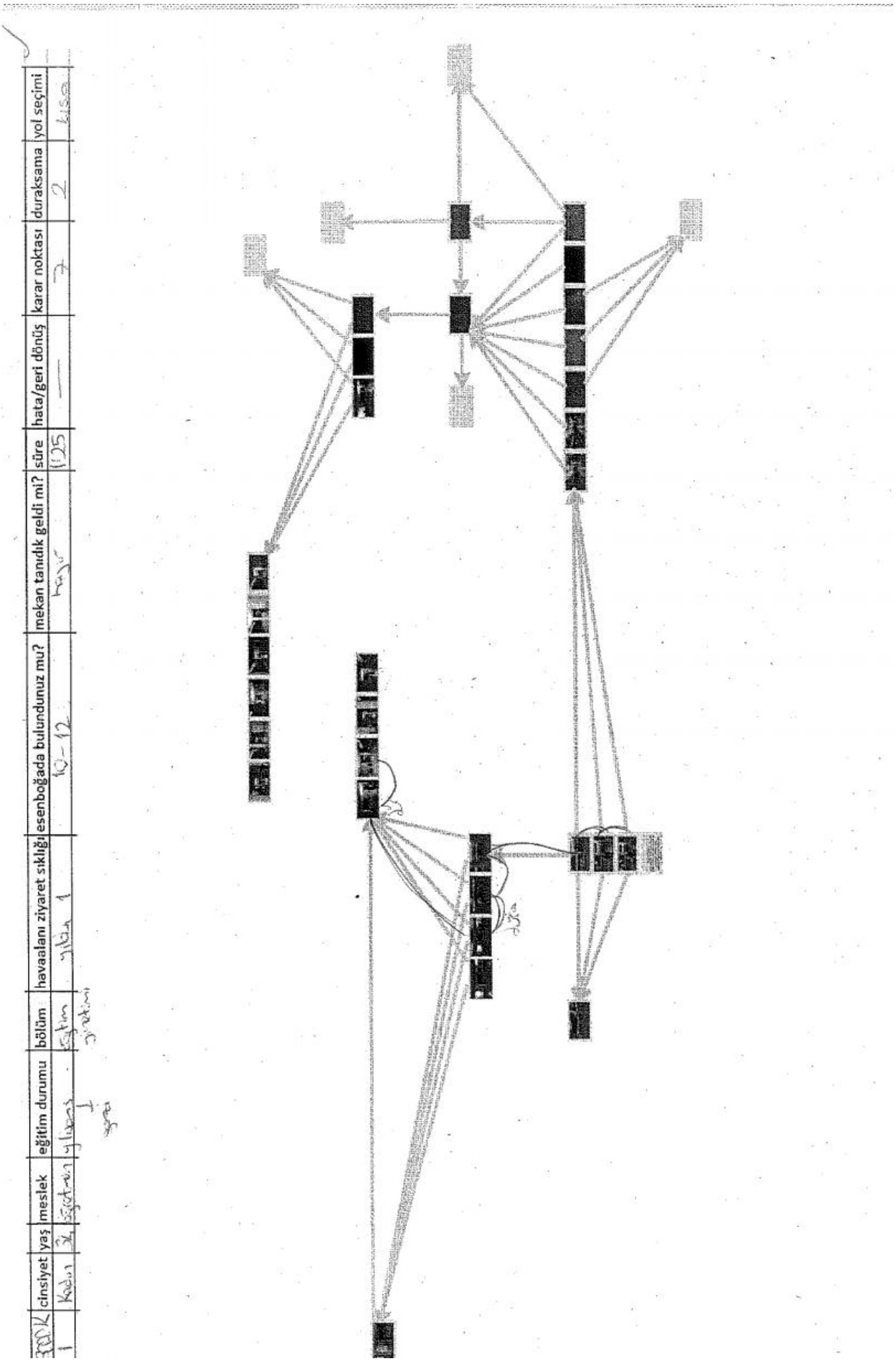


Figure 13a: Experiment Note of the Researcher (3000 K CT)

500 K	cinsiyet	yaş	meslek	eğitim durumu	bölüm	havaalanı ziyaret sıklığı	esenboğada bulundunuz mu?	mekan tanıdık geldi mi?	süre	hata/geri dönüş	karar noktası	duraksama	yol seçimi
4	Kadın	23	veteriner	Y.lisans	vete.	yılda 2-3	8-5	—	1:24	1	9	1	kısa

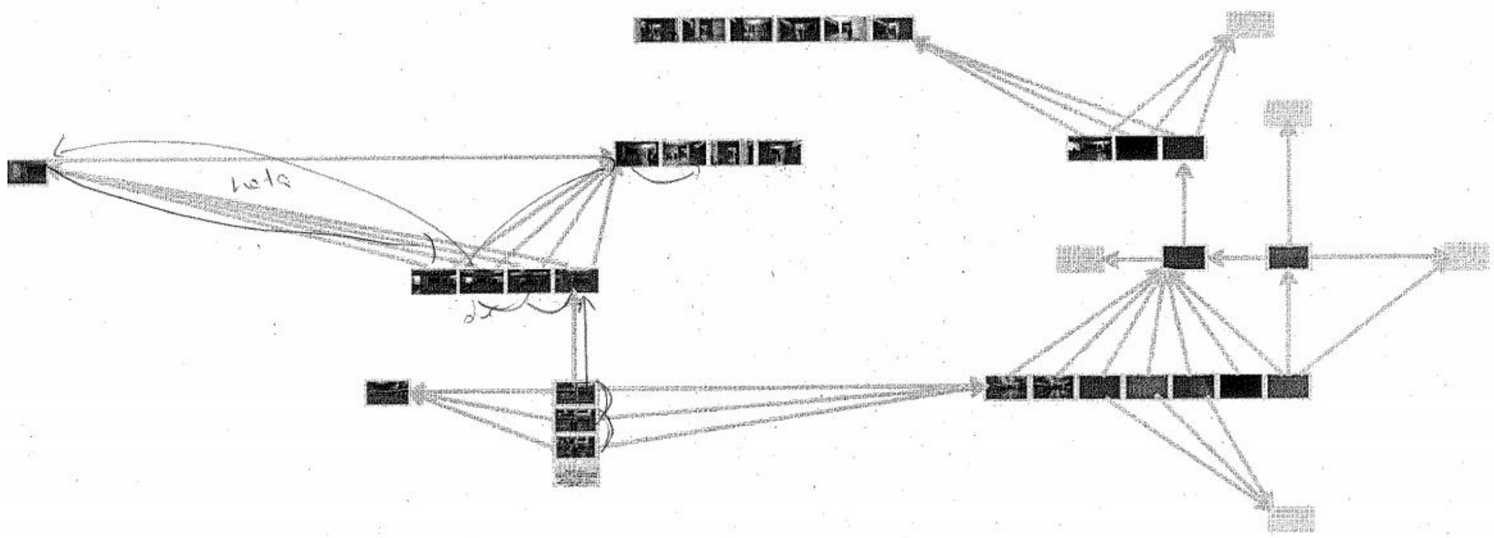
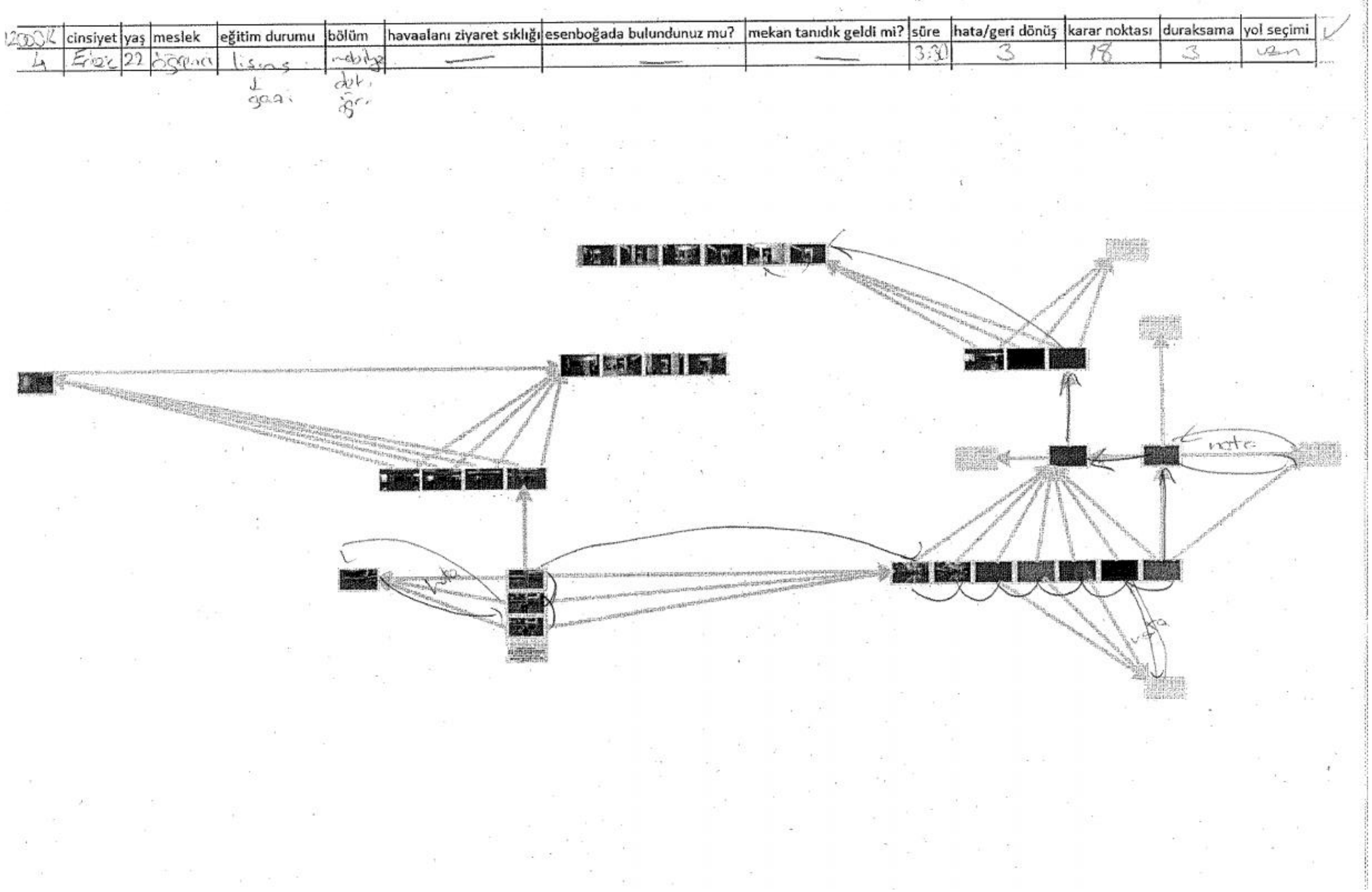


Figure 13b: Experiment Note of the Researcher (6500 K CT)



12000 K	cinsiyet	yaş	meslek	eğitim durumu	bölüm	havaalanı ziyaret sıklığı	esenboğada bulundunuz mu?	mekan tanıdık geldi mi?	süre	hata/geri dönüş	karar noktası	duraksama	yol seçimi
4	Erkek	22	öğrenci	lisans	[illegible]	—	—	—	3:30	3	18	3	[illegible]

Figure 13c: Experiment Note of the Researcher (12000 K CT)

APPENDIX B - RESEARCH NOTES

3,000 K	cinsiyet	yaş	meslek	eğitim durumu	bolum	havaalanı ziyaret sıklığı	esenboğada bulundunuz mu?	mekan tanıdık geldi mi?	sure	hata/geri donuş	karar noktası	duraksama	yol seçimi
1	K	24	öğrenci	lisans/odtü	matematik				3:05	0	13	1	uzun
2	K	22	öğrenci	lisans/gazi	psikolojik rehberlik	-	-	-	2:57	1	10	2	kısa
3	K	22	öğrenci	lisans/anadolu	kamu yönetimi	-	-	-	2:16	0	7	2	kısa
4	K	23	öğrenci	lisans/gazi	giyim endüstrisi öğrt.	2 yılda 1	evet	evet	1:31	0	8	0	kısa
5	K	27	öğrenci	lisans/namık kemal	işletme	yılda 1	evet	-	2:30	0	8	2	kısa
6	K	27	öğrenci	lisans/hacettepe	rekreasyon	-	-	-	1:35	0	6	2	kısa
7	K	23	öğretmen	lisans/gazi	biyoloji				3:50	2	21	4	uzun
8	K	25	öğretmen	lisans/ankara	konservatuar	2yılda 1	-	-	1:30	0	6	2	kısa
9	K	23	öğrenci	lisans/cumhuriyet	iktisat	-	-	-	1:30	1	9	3	kısa
10	K	23	öğrenci	lisans/gazi	kamu yönetimi	-	-	-	2:59	1	15	4	uzun
11	K	28	öğretmen	lisans/muğla	edebiyat	-	-	-	2:48	1	9	3	kısa
12	K	25	öğrenci	y.lisans/gazi	felsefe	yılda 1	4-5kere	evet	2:20	2	10	3	uzun
13	K	31	öğretmen	y.lisans/kırıkkale	sınıf öğretmenliği	yılda 1	10kere		1:09	0	5	1	kısa
14	K	34	öğretmen	y.lisans/gazi	eğitim yönetimi	yılda 1	10-12kere	-	1:25	0	7	2	kısa
15	K	23	tercüman	lisans/hacettepe	mütercim tercümanlık	yılda 1	-	-	1:45	0	6	1	kısa
								kadın ortalaması	2:12	0,533333333	9,333333333	2,133333333	kısa
1	E	27	öğretmen	y.lisans/hacettepe	matematik	yılda 1-2	evet	-	2:29	0	11	1	uzun
2	E	28	öğrenci	lisans/anadolu	işletme	2 ayda 1	evet	-	3:40	2	18	4	uzun
3	E	25	otomotiv	lisans öğrenci	işletme	-	-	-	2:23	0	18	1	uzun
4	E	25	öğrenci	lisans/cumhuriyet	işletme	yılda 3-4	1kere	-	3:47	1	9	3	uzun
5	E	24	öğrenci	lisans/gazi	beden eğitimi	2 ayda 1	1kere	-	5:29	4	23	4	uzun
6	E	22	öğrenci	lisans/hacettepe	işletme	-	-	-	3:40	2	14	4	uzun
7	E	24	öğrenci	lisans/çanakkale 18mar	maliye	-	-	-	1:32	1	9	1	kısa
8	E	23	öğrenci	lisans/ankara	veterinerlik	yılda1	3kere		1:09	0	7	1	kısa
9	E	29	öğrenci	doktora/gazi	işletme	ayda1	20kere	evet	1:16	0	8	2	kısa
10	E	28	öğrenci	y.lisans/gazi	metal öğretmenliği	neredeyse hiç	1kere	-	1:20	0	7	2	kısa
11	E	23	öğrenci	lisans/zonguldak	işletme	yılda2	-	-	1:40	1	9	1	kısa
12	E	22	öğrenci	lisans/gazi	makine	-	-	-	1:56	0	8	4	kısa
13	E	31	bankacı	lisans/uludağ	iktisat	yılda1	3kere	-	1:12	0	7	3	kısa
14	E	23	öğrenci	lisans/hacettepe	edebiyat	3-4yılda1	1kere		3:00	1	11	3	uzun
15	E	22	öğrenci	önlisans/gazi	bilgisayar programlama	-	-	-	2:50	1	11	2	uzun
								erkek ortalaması	2:29	0,866666667	11,33333333	2,4	uzun
								toplam ortalama	02:19	0,695	10,095	2,265	kısa

Figure 14a: Research Notes (3000 K CT)

6,500 K	cinsiyet	yaş	meslek	eğitim durumu	bölüm	hevaelanı ziyaret sıklığı	esenboğada bulundunuz mu	mekan tanıdık geldi mi	süre	hata/geri dönüş	karar noktası	duraksema	yol seçimi
1	K	23	öğrenci	lisans/ankara	gıda müh.	yılda 1	-	-	1:32	0	8	1	kısa
2	K	24	öğrenci	lisans/katü	istatistik	yılda 2-3	5-6kere	-	1:32	0	8	2	kısa
3	K	24	öğretmen	lisans/kırıkkale	edebiyat	-	-	-	4:03	2	19	3	uzun
4	K	31	doktor	lisans/gazi	diyetisyen	2ayda 1	3kere	-	1:40	0	11	1	uzun
5	K	19	öğrenci	lisans/bilkent	endustri müh.	-	-	-	2:00	0	9	1	uzun
6	K	21	öğrenci	önlisans/anadolu	işletme	-	2kere	-	2:59	1	11	3	uzun
7	K	23	öğrenci	lisans/gazi	iktisat	yılda 1	2kere	-	1:20	0	7	2	kısa
8	K	28	öğrenci	lisans/hacettepe	aile ve tüketici bi	yılda 1	1kere	-	2:42	2	12	3	uzun
9	K	24	öğrenci	lisans/atılım	işletme	-	2kere	-	1:15	0	7	1	kısa
10	K	26	öğrenci	lisans/osmangazi	iktisat	-	2kere	-	2:44	1	12	2	uzun
11	K	23	öğrenci	y.lisans/nevşehir	biyoloji	-	2kere	-	0:54	0	4	0	kısa
12	K	23	veteriner	y.lisans/ankara	veterinerlik	yılda 2-3	8-9kere	-	1:24	1	9	1	kısa
13	K	25	öğrenci	y.lisans/hacettepe	biyomühendislik	yılda1	3kere	-	1:50	1	8	1	kısa
14	K	28	araştırma gör	y.lisans/hacettepe	sağlık bilimleri	yılda1	3-4kere	-	1:01	0	7	1	kısa
15	K	22	öğrenci	lisans/gazi	ekonometri	-	-	-	1:46	0	11	2	uzun
								kadın ortalaması	1:54	0,533333333	9,533333333	1,6	kısa
1	E	23	öğrenci	lisans/balıkesir	işletme	yılda 1	-	-	2:30	1	12	2	uzun
2	E	23	öğrenci	lisans/abant izzet	kamu yönetimi	-	-	-	2:57	2	17	3	uzun
3	E	25	öğrenci	lisans/gazi	iktisat	yılda 2	3kere	-	2:58	2	14	3	uzun
4	E	31	öğretmen	y.lisans	matematik	yılda 5	10kere	-	2:00	0	8	0	kısa
5	E	23	öğrenci	lisans/bilkent	elektronik müh.	2ayda 1	evet	-	2:00	0	13	1	uzun
6	E	26	öğretmen	lisans/yurtdışı	tarih	yılda 12	8 /10kere	evet	1:48	1	10	1	kısa
7	E	23	öğrenci	lisans/uludağ	maliye	yılda 2	1kere	-	3:47	1	18	3	uzun
8	E	23	öğrenci	lisans/gazi	iktisat	yılda 2	3 /4kere		1:05	0	7	0	kısa
9	E	25	öğrenci	lisans/odtü	iktisat	-	-	-	1:49	1	11	1	kısa
10	E	23	öğrenci	lisans/gazi	kamu yönetimi	yılda 1	3kere	-	2:10	1	10	1	uzun
11	E	22	serbest mesl	ön lisans/akdeniz	elektronik	-	-	-	1:28	0	8	1	uzun
12	E	22	öğrenci	meslek yuksek oku	elektronik	-	-	-	1:57	1	12	1	uzun
13	E	20	öğrenci	önlisans/ankara	bilgisayar progran	-	-	-	1:19	0	8	1	kısa
14	E	24	öğretmen	y.lisans/gazi	türk dili ve edebiy	yılda 1	1kere	-	2:00	2	9	1	kısa
15	E	23	öğrenci	lisans/hacettepe	aile ve tüketici bi	-	-	-	1:10	0	5	1	uzun
								erkek ortalaması	2:03	0,8	10,8	1,33333333	uzun
								toplam ortalama	01:58	0,665	10,165	1,465	uzun

Figure 14b: Research Notes (6500 K CT)

12,000 K cinsiyet	yaş	meslek	eğitim durumu	bölüm	havaalanı ziyaret sıklığı	esenboğada bulundunuz mu?	mekan tanıdık geldi mi?	süre	hata/geri dönüş	karar noktası	duraksama	yol seçimi
1 K	24	öğrenci	lisans/gazi	uluslar arası ili	yılda 1	1kere	-	1:47	0	11	0	uzun
2 K	26	öğrenci	lisans/anadolu	kamu yönetim	2yılda 1	3kere	-	2:24	0	9	2	uzun
3 K	25	öğrenci	lisans/anadolu	ckul öncesi öğ	2yılda 1	3kere	evet	2:43	2	16	2	uzun
4 K	23	öğrenci	lisans/karamano	kamu yönetim	yılda 1	3kere	-	3:25	1	14	2	uzun
5 K	43	avukat	y.lisans/ankara	hukuk	yılda 10	2kere	-	2:20	1	11	2	kısa
6 K	25	öğrenci	lisans/çankaya	siyaset bil.-ulu	yılda 3-4	6/7kere	evet	1:24	0	7	1	kısa
7 K	23	avukat	lisans/ufuk	hukuk	yılda 1	-	-	1:48	0	7	2	kısa
8 K	23	öğretmen	lisans/katü	özel eğitim	yılda 1	3kere	-	2:20	1	10	1	uzun
9 K	26	öğretmen	lisans/gazi	guzellik öğretı	-	-	-	2:55	0	11	1	uzun
10 K	19	öğrenci	lisans/anadolu	işletme	-	-	-	2:45	1	8	2	uzun
11 K	25	öğrenci	lisans/kırıkkale	tarih	yılda1	1kere	-	1:39	1	6	1	kısa
12 K	25	öğrenci	lisans/kırıkkale	tarih	-	-	-	1:50	1	10	1	uzun
13 K	32	öğrenci	y.lisans/kırıkkale	eğitim fakülte	-	-	-	1:22	1	7	1	kısa
14 K	22	öğrenci	lisans/hacettepe	psikolojik danı	yılda1-2	-	-	1:45	2	9	2	kısa
15 K	22	öğrenci	lisans/hacettepe	psikolojik danı	yılda2	10kere	evet	1:46	0	11	1	uzun
							kadın ortalaması	2:08	0,733333333	9,8	1,4	uzun
1 E	25	öğretmen	lisans/gazi	sınıf öğrt.	yılda 6	4kere	evet	2:37	2	13	3	kısa
2 E	25	öğretmen	lisans/kırklareli	yapı öğrt.	yılda 1	3-4kere	-	2:34	1	12	1	uzun
3 E	28	öğrenci	lisans/anadolu	maliye	yılda 1	5-6kere	-	3:20	0	11	2	uzun
4 E	28	öğrenci	lisans/çankaya	işletme	yılda 3-4	12kere	evet	2:08	1	8	0	kısa
5 E	22	öğrenci	lisans/çanakkale	maliye	yılda 2	6kere	evet	2:42	1	14	4	uzun
6 E	22	öğrenci	lisns/gazi	sosyal biligiler				1:20	0	8	0	kısa
7 E	22	öğrenci	lisans/gazi	mobilya dekor	-	-	-	3:30	3	18	3	uzun
8 E	23	öğrenci	lisans/gazi	makine	-	-	-	0:57	0	7	0	kısa
9 E	23	öğrenci	lisans/gazi	makine	-	-	-	1:05	0	7	1	kısa
10 E	25	öğrenci	lisans/kırıkkale	elektrik	2yılda1	3kere	-	1:16	0	7	1	kısa
11 E	23	öğrenci	lisans/gazi	konaklama işl	yılda1	2kere	-	0:50	0	7	0	kısa
12 E	23	öğrenci	lisans/gazi	biligisayar öğr	3yılda1	-	-	0:50	0	7	0	kısa
13 E	29	akademisy	y.lisans/başkent	turizm ve rehb	6ayda1	15-20kere	-	1:05	0	6	0	kısa
14 E	36	öğretmen	lisans/ankara	matematik	6ayda1	10kere	-	1:06	0	7	0	kısa
15 E	20	öğrenci	önlisans/ankara	bilgisayar prog	-	-	-	1:08	0	7	0	kısa
							erkek ortalaması	1:45	0,533333333	9,266666667	1	kısa
							toplam ortalama	01:56	0,63	9,53	1,2	kısa

Figure 14c: Research Notes (12000 K CT)

APPENDIX C – STATISTICS

Table C.1. ANOVA for the time spent for finding the final destination in the whole group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10409.267	2	5204.633	1.847	.164
Within Groups	245136.333	87	2817.659		
Total	255545.600	89			

Table C.2. ANOVA for the time spent during finding the final destination in the males group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	14447.778	2	7223.889	2.005	.147
Within Groups	151331.200	42	3603.124		
Total	165778.978	44			

Table C.3. ANOVA for the time spent during finding the final destination in the females group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2657.644	2	1328.822	.641	.532
Within Groups	87087.467	42	2073.511		
Total	89745.111	44			

Table C.4. ANOVA for the number of errors in finding the final destination in the whole group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.067	2	.033	.047	.954
Within Groups	61.933	87	.712		
Total	62.000	89			

Table C.5. Chi Square Test for made errors and no errors in relation with the CCT in the whole group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,089[a]	2	,956
Likelihood Ratio	,089	2	,956
Linear-by-Linear Association	,001	1	,970
N of Valid Cases	90		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 14,33.

Table C.6. ANOVA for the number of errors in finding the final destination in the males group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.933	2	.467	.518	.600
Within Groups	37.867	42	.902		
Total	38.800	44			

Table C.7. Chi Square Test for made errors and no errors in relation with the CCT in the males group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2,312[a]	2	,315
Likelihood Ratio	2,348	2	,309
Linear-by-Linear Association	1,458	1	,227
N of Valid Cases	45		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 7,33.

Table C.8. ANOVA for the number of errors in finding the final destination in the females group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.400	2	.200	.375	.690
Within Groups	22.400	42	.533		
Total	22.800	44			

Table C.9. Chi Square Test for made errors and no errors in relation with the CCT in the females group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1,607[a]	2	,448
Likelihood Ratio	1,612	2	,447
Linear-by-Linear Association	1,338	1	,247
N of Valid Cases	45		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 7,00.

Table C.10. ANOVA for the number of decision points in finding the final destination in the whole group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	10.689	2	5.344	.372	.690
Within Groups	1248.300	87	14.348		
Total	1258.989	89			

Table C.11. ANOVA for the number of decision points in finding the final destination in the males group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	34.533	2	17.267	1.059	.356
Within Groups	684.667	42	16.302		
Total	719.200	44			

Table C.12. ANOVA for the number of decision points in finding the final destination in the females group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.644	2	.822	.066	.936
Within Groups	519.467	42	12.368		
Total	521.111	44			

Table C.13. ANOVA for the number of hesitation points in finding the final destination in the whole group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	18.489	2	9.244	8.196	.001
Within Groups	98.133	87	1.128		
Total	116.622	89			

Table C.14. Post Hoc Comparison Test for the number of hesitation points in finding the final destination with three sample groups (3000 K-6500 K-12000 K)

(I) colortemperature	(J) colortemperature	Mean Difference (I-J)	Std. Error	Sig.	99.9% Confidence Interval	
					Lower Bound	Upper Bound
3000	6500	.800	.274	.017	-.26	1.86
	12000	1.067*	.274	.001	.01	2.13
6500	3000	-.800	.274	.017	-1.86	.26
	12000	.267	.274	.625	-.79	1.33
12000	3000	-1.067*	.274	.001	-2.13	-.01
	6500	-.267	.274	.625	-1.33	.79

*. The mean difference is significant at the .001 level.

Table C.15. Chi Square Test for experienced hesitations and no hesitations in relation with the CCT in the whole group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	9,351[a]	2	,009
Likelihood Ratio	9,406	2	,009
Linear-by-Linear Association	9,031	1	,003
N of Valid Cases	90		

a. 3 cells (50,0%) have expected count less than 5. The minimum expected count is 4,33.

Table C.16. ANOVA for the number of hesitation points in finding the final destination in the males group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.044	2	8.022	5.530	.007
Within Groups	60.933	42	1.451		
Total	76.978	44			

Table C.17. Post Hoc Comparison Test for the number of hesitation points in finding the final destination with three sample groups (3000 K-6500 K-12000 K) among the males

(I) CCT	(J) CCT	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
3000	6500	1,067	,440	,064	-,05	2,18
	12000	1,400*	,440	,011	,28	2,52
6500	3000	-1,067	,440	,064	-2,18	,05
	12000	,333	,440	,752	-,78	1,45
12000	3000	-1,400*	,440	,011	-2,52	-,28
	6500	-,333	,440	,752	-1,45	,78

*. The mean difference is significant at the 0.05 level.

Table C.18. Chi Square Test for experienced hesitations and no hesitations in relation with the CCT in the males group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13,371[a]	2	,001
Likelihood Ratio	15,166	2	,001
Linear-by-Linear Association	12,769	1	,000
N of Valid Cases	45		

a. 3 cells (50,0%) have expected count less than 5. The minimum expected count is 3,33.

Table C.19. ANOVA for the number of hesitation points in finding the final destination in the females group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.311	2	2.156	2.592	.087
Within Groups	34.933	42	.832		
Total	39.244	44			

Table C.20. Chi Square Test for experienced hesitations and no hesitations in relation with the CCT in the females group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,000[a]	2	1,000
Likelihood Ratio	,000	2	1,000
Linear-by-Linear Association	,000	1	1,000
N of Valid Cases	45		

a. 3 cells (50,0%) have expected count less than 5. The minimum expected count is 1,00.

Table C.21. ANOVA for the route choice in the whole group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.289	2	.144	.570	.567
Within Groups	22.033	87	.253		
Total	22.322	89			

Table C.22. Chi Square Test for the route choice in relation with the CCT in the whole group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1,165[a]	2	,559
Likelihood Ratio	1,164	2	,559
Linear-by-Linear Association	,015	1	,902
N of Valid Cases	90		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 13,67.

Table C.23. ANOVA for the route choice in the males group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.933	2	.467	1.909	.161
Within Groups	10.267	42	.244		
Total	11.200	44			

Table C.24. Chi Square Test for the route choice in relation with the CCT in the males group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3,750[a]	2	,153
Likelihood Ratio	3,868	2	,145
Linear-by-Linear Association	2,545	1	,111
N of Valid Cases	45		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 7,00.

Table C.25. ANOVA for the route choice in the females group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.844	2	.422	1.727	.190
Within Groups	10.267	42	.244		
Total	11.111	44			

Table C.26. Chi Square Test for the route choice in relation with the CCT in the females group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3,420[a]	2	,181
Likelihood Ratio	3,511	2	,173
Linear-by-Linear Association	3,151	1	,076
N of Valid Cases	45		

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 6,67.

Table C.27. Independent-Samples T-test for gender difference in whole participant group; the time spent in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
time	Equal variances assumed	2.904	.092	-.086	88	.932	-.978	11.360	-23.554	21.590
	Equal variances not assumed			-.086	80.842	.932	-.978	11.360	-23.582	21.626

Table C.28. Independent-Samples T-test for gender difference in set 1 (3000 K); the time spent in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
time	Equal variances assumed	2.406	.132	-.734	28	.469	-16.867	22.989	-63.957	30.224
	Equal variances not assumed			-.734	23.691	.470	-16.867	22.989	-64.346	30.613

Table C.29. Independent-Samples T-test for gender difference in set 2 (6500 K); the time spent in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
time	Equal variances assumed	.386	.540	-.518	28	.603	-9.067	17.494	-44.901	26.768
	Equal variances not assumed			-.518	27.891	.603	-9.067	17.494	-44.937	26.804

Table C.30. Independent-Samples T-test for gender difference in set 3 (12000 K); the time spent in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
time	Equal variances assumed	6.963	.013	1.326	28	.196	23.000	17.344	-12.527	58.527
	Equal variances not assumed			1.326	23.811	.197	23.000	17.344	-12.810	58.810

Table C.31. Independent-Samples T-test for gender difference in whole participant group; the number of errors in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
errors	Equal variances assumed	1.331	.252	-.756	88	.452	-.133	.176	-.484	.217
	Equal variances not assumed			-.756	82.438	.452	-.133	.176	-.484	.218

Table C.32. Chi Square Test for made errors and no errors in relation with gender in whole participant group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,045[a]	1	,833		
Continuity Correction[b]	,000	1	1,000		
Likelihood Ratio	,045	1	,833		
Fisher's Exact Test				1,000	,500
Linear-by-Linear Association	,044	1	,834		
N of Valid Cases	90				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 21,50.

b. Computed only for a 2x2 table

Table C.33. Independent-Samples T-test for gender difference in set 1 (3000 K); the number of errors in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
errors	Equal variances assumed	.630	.434	-.957	28	.347	-.333	.348	-1.047	.380
	Equal variances not assumed			-.957	24.259	.348	-.333	.348	-1.052	.385

Table C.34. Chi Square Test for made errors and no errors in relation with gender in Set 1 (3000 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,536[a]	1	,464		
Continuity Correction[b]	,134	1	,714		
Likelihood Ratio	,537	1	,464		
Fisher's Exact Test				,715	,358
Linear-by-Linear Association	,518	1	,472		
N of Valid Cases	30				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 7,00.

b. Computed only for a 2x2 table

Table C.35. Independent-Samples T-test for gender difference in set 2 (6500 K); the number of errors in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
errors	Equal variances assumed	.000	1.000	.962	28	.344	267	277	.834	[illegible]
	Equal variances not assumed			-.962	27.952	.344	-.267	277	-.834	[illegible]

Table C.36. Chi Square Test for made errors and no errors in relation with gender in Set 2 (6500 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1,200[a]	1	,273		
Continuity Correction[b]	,533	1	,465		
Likelihood Ratio	1,208	1	,272		
Fisher's Exact Test				,466	,233
Linear-by-Linear Association	1,160	1	,281		
N of Valid Cases	30				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 7,50.

b. Computed only for a 2x2 table

Table C.37. Independent-Samples T-test for gender difference in set 3 (12000 K); the number of errors in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
errors	Equal variances assumed	.549	.465	.671	28	.508	.200	.298	-.411	.811
	Equal variances not assumed			.671	26.263	.508	.200	.298	-.413	.813

Table C.38. Chi Square Test for made errors and no errors in relation with gender in Set 3 (12000 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2,143[a]	1	,143		
Continuity Correction[b]	1,205	1	,272		
Likelihood Ratio	2,170	1	,141		
Fisher's Exact Test				,272	,136
Linear-by-Linear Association	2,071	1	,150		
N of Valid Cases	30				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 7,00.

b. Computed only for a 2x2 table

Table C.39. Independent-Samples T-test for gender difference in whole participant group; the number of decision points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
decisionpoints	Equal variances assumed	1.742	.190	-1.151	88	.253	-.911	.791	-2.484	.662
	Equal variances not assumed			-1.151	85.811	.253	-.911	.791	-2.485	.662

Table C.40. Independent-Samples T-test for gender difference in set 1 (3000 K); the number of decision points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
decisionpoints	Equal variances assumed	.443	.511	-1.207	28	.238	-2.000	1.657	-5.394	1.394
	Equal variances not assumed			-1.207	27.497	.238	-2.000	1.657	-5.397	1.397

Table C.41. Independent-Samples T-test for gender difference in set 2 (6500 K); the number of decision points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
decisionpoints	Equal variances assumed	.189	.667	-.981	28	.335	-1.267	1.291	-3.912	1.379
	Equal variances not assumed			-.981	27.921	.335	-1.267	1.291	-3.912	1.379

Table C.42. Independent-Samples T-test for gender difference in set 3 (12000 K); the number of decision points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
decisionpoints	Equal variances assumed	1.575	.220	.464	28	.646	.533	1.149	-1.821	2.887
	Equal variances not assumed			.464	26.389	.646	.533	1.149	-1.827	2.894

Table C.43. Independent-Samples T-test for gender difference in the whole group; the number of hesitation points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
hesitations	Equal variances assumed	8.686	.004	.550	88	.583	.133	.242	-.348	.615
	Equal variances not assumed			.550	79.609	.584	.133	.242	-.349	.616

Table C.44. Chi Square Test for experienced hesitations and no hesitations in relation with gender in the whole group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4,406[a]	1	,036		
Continuity Correction[b]	3,237	1	,072		
Likelihood Ratio	4,614	1	,032		
Fisher's Exact Test				,069	,034
Linear-by-Linear Association	4,357	1	,037		
N of Valid Cases	90				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 6,50.

b. Computed only for a 2x2 table

Table C.45. Independent-Samples T-test for gender difference in set 1 (3000 K); the number of hesitation points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
hesitations	Equal variances assumed	1.215	.230	-.616	28	.543	-.267	.433	-1.153	.620
	Equal variances not assumed			-.616	27.732	.543	-.267	.433	-1.154	.620

Table C.46. Chi Square Test for experienced hesitations and no hesitations in relation with gender in Set 1 (3000 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1,034[a]	1	,309		
Continuity Correction[b]	,000	1	1,000		
Likelihood Ratio	1,421	1	,233		
Fisher's Exact Test				1,000	,500
Linear-by-Linear Association	1,000	1	,317		
N of Valid Cases	30				

a. 2 cells (50,0%) have expected count less than 5. The minimum expected count is ,50.

b. Computed only for a 2x2 table

Table C.47. Independent-Samples T-test for gender difference in set 2 (6500 K); the number of hesitation points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Hesitations	Equal variances assumed	.009	.925	.774	28	.445	.267	.345	-.439	.972
	Equal variances not assumed			.774	27.365	.446	.267	.346	-.439	.973

Table C.48. Chi Square Test for experienced hesitations and no hesitations in relation with gender in Set 2 (6500 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,370[a]	1	,543		
Continuity Correction[b]	,000	1	1,000		
Likelihood Ratio	,377	1	,539		
Fisher's Exact Test				1,000	,500
Linear-by-Linear Association	,358	1	,550		
N of Valid Cases	30				

a. 2 cells (50,0%) have expected count less than 5. The minimum expected count is 1,50.

b. Computed only for a 2x2 table

Table C.49. Independent-Samples T-test for gender difference in set 3 (12000 K); the number of hesitation points in finding the final destination

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Hesitations	Equal variances assumed	5.405	.027	1.031	28	.311	.400	.388	-.395	1.195
	Equal variances not assumed			1.031	19.763	.315	.400	.388	-.410	1.210

Table C.50. Chi Square Test for experienced hesitations and no hesitations in relation with gender in Set 3 (12000 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	7,778[a]	1	,005		
Continuity Correction[b]	5,714	1	,017		
Likelihood Ratio	8,576	1	,003		
Fisher's Exact Test				,014	,007
Linear-by-Linear Association	7,519	1	,006		
N of Valid Cases	30				

a. 2 cells (50,0%) have expected count less than 5. The minimum expected count is 4,50.

b. Computed only for a 2x2 table

Table C.51. Independent-Samples T-test for gender difference in the whole group; the route choice

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
routechoice	Equal variances assumed	.105	.665	-.209	88	.835	-.022	.106	-.233	.189
	Equal variances not assumed			-.209	87.999	.835	-.022	.106	-.233	.189

Table C.52. Chi Square Test for the route choice in relation with the CCT in the whole group

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,045[a]	1	,832		
Continuity Correction[b]	,000	1	1,000		
Likelihood Ratio	,045	1	,832		
Fisher's Exact Test				1,000	,500
Linear-by-Linear Association	,044	1	,833		
N of Valid Cases	90				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 20,50.

b. Computed only for a 2x2 table

Table C.53. Independent-Samples T-test for gender difference in set 1 (3000 K); the route choice

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
routechoice	Equal variances assumed	3.646	.067	-1.497	28	.145	-.267	.178	-.632	.098
	Equal variances not assumed			-1.497	27.603	.146	-.267	.178	-.632	.099

Table C.54. Chi Square Test for the route choice in relation with the CCT in Set 1 (3000 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2,222[a]	1	,136		
Continuity Correction[b]	1,250	1	,264		
Likelihood Ratio	2,256	1	,133		
Fisher's Exact Test				,264	,132
Linear-by-Linear Association	2,148	1	,143		
N of Valid Cases	30				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 6,00.

b. Computed only for a 2x2 table

Table C.55. Independent-Samples T-test for gender difference in set 2 (6500 K); the route choice

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
routechoice	Equal variances assumed	.413	.526	-.714	28	.481	-.133	.187	-.516	.249
	Equal variances not assumed			-.714	27.991	.481	-.133	.187	-.516	.249

Table C.56. Chi Square Test for the route choice in relation with the CCT in Set 2 (6500 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	,536[a]	1	,464		
Continuity Correction[b]	,134	1	,714		
Likelihood Ratio	,537	1	,464		
Fisher's Exact Test				,715	,358
Linear-by-Linear Association	,518	1	,472		
N of Valid Cases	30				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 7,00.

b. Computed only for a 2x2 table

Table C.57. Independent-Samples T-test for gender difference in set 3 (12000 K); the route choice

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
routechoice	Equal variances assumed	2.120	.157	1.390	28	.069	.333	.176	-.028	.695
	Equal variances not assumed			1.390	27.711	.069	.333	.176	-.028	.695

Table C.58. Chi Square Test for route choice in relation with the CCT in Set 3 (12000 K)

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	3,394[a]	1	,065		
Continuity Correction[b]	2,172	1	,141		
Likelihood Ratio	3,466	1	,063		
Fisher's Exact Test				,139	,070
Linear-by-Linear Association	3,281	1	,070		
N of Valid Cases	30				

a. 0 cells (0,0%) have expected count less than 5. The minimum expected count is 6,50.

b. Computed only for a 2x2 table

Table C.59. Pearson Correlation Test for the time spent in finding the final destination and route choice

		TIME	ROUTE
TIME	Pearson Correlation	1	,662**
	Sig. (2-tailed)		,000
	N	90	90
ROUTE	Pearson Correlation	,662**	1
	Sig. (2-tailed)	,000	
	N	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Table C.60. Pearson Correlation Test for the time spent and the number of hesitations

		TIME	HESITATION
TIME	Pearson Correlation	1	,689**
	Sig. (2-tailed)		,000
	N	90	90
HESITATION	Pearson Correlation	,689**	1
	Sig. (2-tailed)	,000	
	N	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Table C.61. Pearson Correlation Test for the time spent and the number of errors

		TIME	ERROR
TIME	Pearson Correlation	1	,695**
	Sig. (2-tailed)		,000
	N	90	90
ERROR	Pearson Correlation	,695**	1
	Sig. (2-tailed)	,000	
	N	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Table C.62. Pearson Correlation Test for the number of decision points and the number of errors

		decisionpoints	errors
decisionpoints	Pearson Correlation	1	.696**
	Sig. (2-tailed)		.000
	N	90	90
errors	Pearson Correlation	.696**	1
	Sig. (2-tailed)	.000	
	N	90	90

**. Correlation is significant at the 0.01 level (2-tailed).

Table C.63. Pearson Correlation Test for the number of hesitation points and the number of decision points

		decisionpoints	hesitations
decisionpoints	Pearson Correlation	1	.580**
	Sig. (2-tailed)		.000
	N	90	90
hesitations	Pearson Correlation	.580**	1
	Sig. (2-tailed)	.000	
	N	90	90

**. Correlation is significant at the 0.01 level (2-tailed).