Investigating the Impact of Psychological Factors on Thermal Perception and Walking Experience

by

Mohsen Garshasby Moakhar

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved July 2020 by the
Graduate Supervisory Committee:

Renata Hejduk, Chair
Chingwen Cheng
Paul Coseo
Eric Margolis

ARIZONA STATE UNIVERSITY

August 2020

ABSTRACT

This dissertation focuses on thermal comfort and walking as an experiential phenomenon in outdoor urban environments. The goal of the study is to provide a better understanding of the impact of psychological adaptation factors on thermal comfort. The main research questions included the impact of psychological factors on outdoor thermal comfort as well as the impact of long-term thermal perception on momentary thermal sensation. My research follows a concurrent triangulation strategy as a mixed-methoåd approach, which consisted of a simultaneous collection and analysis of qualitative and quantitative data. Research consisted of five rounds of data collection in different locations beginning February 2018 and continuing through December 2019. During the qualitative phase, I gathered data in the form of an open-ended questionnaire but importantly, self-walking interviews where participants narrated their experience of the environment while recording one-minute long videos. The visual and audible information was first processed using thematic analysis and then further analyzed via Latent Dirichlet Allocation (LDA). During the quantitative phase, I gathered information from participants in the form of three-step survey questionnaires, that data was analyzed using T-Test regression analysis in STATA. The quantitative data helped explore and address the initial research questions, while the qualitative data helped in addressing and explaining the trends and the experiential aspects of thermal environment.

Results revealed that spatial familiarity (as a psychological adaptation factor) has a significant relationship for both overall comfort and thermal comfort within outdoor environments. Moreover, long term thermal memory influences momentary thermal sensation. The results of qualitative and quantitative data were combined, compared, and contrasted to generate new insights in the design of outdoor urban environments. The depth and breadth of the qualitative data set consisting of more than a thousand minute-long of narrated video segments along with hundreds of pages of transcribed text, demonstrated the subjective aspects of thermal comfort. This research highlights the importance of context-based and human-centric design in any evidence-based design approach for outdoor environments. The implications of the study can provide new insights not only for architects and urban designers, but also for city planners, stakeholders, public officials, and policymakers.

DEDICATION

I dedicate this dissertation to my parents, brother and sister, who have always offered unwavering support and encouragement throughout my doctoral journey.

ACKNOWLEDGMENTS

I would like to express my most profound appreciation to my committee chair, Dr. Renata Hejduk, for all her advice, generous understanding, and competent direction throughout my academic journey at Arizona State University. I want to thank my committee members, Dr. Eric Margolis, Dr. Chingwen Cheng, and Dr. Paul Coseo for their intellectual suggestions and feedback to better my research. Without the guidance and persistent help from my committee, this dissertation would not have been possible. I will strive to grow as an impactful researcher and educator in the field of environmental design. It is my great professional hope to continue collaborations with you in the future.

I would also like to express my sincere gratitude to Prof. Max Underwood, Dr. Beverly Brandt, and Prof. Kenneth Brooks for their unconditional support and guidance and for all the efforts to mentor me. I am also grateful to all the faculty and staff for creating an environment of support, encouragement, and respect at the Design School, Arizona State University.

Finally, I would like to sincerely thank my wholehearted friends and true champions, Saeed, Melika, and Dalal, who supported me through my toughest time. I thank them both for the good moments of suffering and frustration, and for continuously inspiring me as we learned from each other and assisted one another throughout this journey.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

CHAPTER Page

LIST OF TABLES

Table Page

Table Page

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

Outdoor spaces are critical components of today's urban environment. Therefore, the design of these environments becomes essential since they can promote sustainability (as a mode of transport) and well-being (in the form of walking, exercise, and other physical activities). This study attempted to shed light on the influence of psychological adaptation factors on thermal perception. The study's main research questions consisted of:

1- How does familiarity impact thermal perception, controlling for weather and physical conditions?

2- To what extent does familiarity account for thermal comfort in presence of other thermo-spatial factors?

3- How do the streetscape characteristics influence the momentary and long-term thermal perception of pedestrians?

The study provided background on the human thermal environment, thermal perception, and different physical, environmental, physiological, and psychological factors influential on thermal comfort in the context of outdoor environments. Moreover, the use of concepts such as thermal sensation and perception schemata concerning time scale and spatial scale was discussed. This study focused on exploring the subjective parameters of human thermal experience in urban environments in light of environmental psychology theories. The project paid particular attention to studies that employed mixed methods approaches to understand the subjective human parameters better.

This study utilized a mixed-method design (Tashakkori & Teddlie, 2003), to enhance the examination of the research questions (Creswell & Clark, 2011). A concurrent triangulation strategy was employed, in which both qualitative and quantitative data were collected concurrently, and then the two databases were compared to determine if there is convergence, differences, or some combination (J. W. Creswell, 2002, 2013; J. W. Creswell et al., 2003). This method is generally used to offset the weakness inherent with one method with the strength and depth of the other (or conversely, the strength of one adds to the strength of the other) (Creswell, 2013).

In February 2018, the IRB approval was obtained for this study (IRB STUDY00007788). Research consisted of five rounds of data collection from students in "Introduction to Environmental Design" and "Architecture Appreciation" lecture courses respectively at Arizona State University (ASU) and Mississippi State University (MSU) as an extra credit assignment beginning in February 2018 and ending on December 2019. Below is the breakdown of the five rounds of data collection:

1- Spring 2018 (Online), ASU, Worldwide
2- Summer 2018 (Online), ASU, Worldwide
3- Fall 2018 (Session A, Online), ASU, Worldwide
4- Fall 2018 (Session C, In-Person), ASU, Tempe Campus
5- Fall 2019, (Session C, In-Person), MSU, Starkville Campus

During the qualitative phase, data were collected in the form of an open-ended questionnaire but importantly, self-walking interviews where participants narrated their experience of the environment while recording one-minute long videos. The visual and audible information was first processed using thematic analysis and then further analyzed via Latent Dirichlet Allocation (LDA). During the quantitative phase, information was collected from participants in the form of three-step survey questionnaires on Qualtrics, that data was analyzed using T-Test regression analysis in STATA. The quantitative data helped explore and address the initial research questions. In contrast, the qualitative data helped in addressing and explaining the trends and the experiential aspects of comfort and perception in the built environment.

CHAPTER 2 REVIEW OF LITERATURE

Overview

Outdoor spaces are critical components of today's urban environment. Therefore, the design of these environments becomes essential since they can promote sustainability (as a mode of transport) and well-being (in the form of walking, exercise, and other physical activities). It is now evident that the numerical efforts to increase or decrease the air temperature as a thermal comfort index may not result in more thermally comfortable outdoor spaces when pedestrians continue to report discomfort in outdoor environments. Therefore, understanding thermal comfort and perception from the pedestrian's perspective is key to designing thermally comfortable environments.

The following review provides background of the theoretical and research methods applied to the human thermal environment, thermal perception, and different physical, environmental, physiological, and psychological factors influencing thermal comfort in outdoor environments. Concepts such as thermal sensation and perception schemata concerning time scale and spatial scale are discussed. The review focuses on elaborating the subjective parameters of human thermal experience in urban environments, in light of theories from environmental psychology. The review pays particular attention to studies that employed mixed-methods approaches to understand subjective human parameters better.

Thermal Comfort

Studies on the human thermal environment that focused on thermal experience began in 1920 (Houghten & Yaglou, 1923), leading to the development of several thermal indices, mostly based on air temperature and relative humidity. Not until the

1970s, did Fanger (1970) introduce the classical concept for describing thermal perception; he named it "thermal comfort." Fanger described thermal comfort as the human satisfaction with its thermal environment, and used this explanation to define a concept, Predictive Mean Vote (PMV) that measures thermal comfort for indoor environments as a physiological index. Fanger's model was used to predict the mean thermal sensation of a group of people, and their respective percentage of dissatisfaction, e.g., Predicted Mean Vote-Predicted Percentage Dissatisfied (PMV-PPD). Although this model was based on the evaluation of thermal comfort in indoor environments, it was the first attempt to create measurable indices: metabolism, clothing, air temperature, mean radiant temperature, air velocity, and air humidity. It is important to note that this model did not take the psychological factors within the users into consideration.

Other physiological indices have been developed and tested later, including physiological equivalent temperature (PET) (Matzarakis et al., 1999; Mayer & Höppe, 1987). Höppe (2002) developed a model for describing thermal comfort and named it the universal thermal climate index (UTCI). Höppe's model did not apply the classical steady-state model for outdoor environments but acknowledged dynamic and continuously changing conditions of such spaces indicating the necessity for other methods to measure subjective parameters for thermal comfort.

The second approach developed in the 1990s is called the adaptive model. As a progression from Fanger's model, the adaptive model is based on three inter-related factors: physiological, behavioral, and psychological aspects (de Dear & Brager, 1998; Nicol & Humphreys, 2002). Even though this model considers psychological factors, it was based on chamber climate studies and did not comprehensively address outdoor environmental conditions. Therefore, the model does not adequately measure thermal comfort indices for outdoor environments.

Research on thermal comfort has exponentially increased over the past few decades. In a comprehensive effort, Rupp et al. (2015) reviewed 466 papers on thermal comfort from 2005 to 2015. The findings of this review highlighted the significance of adaptive thermal comfort models complementary to classical Fanger's model. The authors noted that a limited amount of research had been conducted on outdoor environments. Rupp et al. (2015) affirmed that multidisciplinary association with psychologists, physiologists, sociologists, and philosophers could be of great value for the development of an integral research approach. Systemic/holistic and mixed methods may help develop a better comprehension of sensation, perception and thermal comfort along physiological psychological and social dimensions. Rupp et al. justified the need to enhance the understanding of human perception of thermal environments.

Thermal Comfort Models

I note that there are far fewer studies on outdoor thermal comfort than on indoor thermal comfort. Most research consists of limited attempts in the form of case studies and pilots, and existing models are insufficient to address the dynamic complexities of outdoor environments. Chen and Ng (2012); for instance, argued that the use of PMV-PPD for outdoor environments would result in considerable discrepancies between the Actual Sensation Vote (ASV), collected through questionnaires, and the PMV. They argued that since people in outdoor environments are directly exposed to local microclimate conditions -- solar radiation, shading, changes in wind direction and speed -- the PMV-PPD is not sufficient. An alternative model is the Physiological Equivalent

Temperature (PET), which has shown consistent results with ASV. However, even PET did not take into account the dynamic adaptive aspects of human beings, and therefore additional research is necessary.

More recent studies attempted to revise the existing models and make them more suitable and comprehensive for outdoor scenarios, climates, and contexts. A case study in Canada, for example, developed a model (COMFA) based on physical field tests: walking, running, and physical activities (Kenny et al., 2009). However, these models are still incapable of addressing all aspects of the adaptive capacity of individuals and subjective components of the thermal environment.

Thermal Comfort and Psychological Adaptation Factors in Indoor Environments

In a study by Brager & de Dear (1998), they experimented with thermal comfort in naturally ventilated buildings. They found that patterns of thermal responses in these types of buildings are significantly different from other types. The authors explained that occupants tolerated a more extensive range of temperature than in buildings with centralized HVAC systems. Brager & de Dear also claimed that physical and behavioral factors including clothing insulation and indoor airspeed, only accounted for half of the variation. and argued that psychological adaptation factors in the form of altered expectation, could entail changing subjective comfort setpoints. This accounts for the remaining changes in observed comfort temperature. Given the empirical nature of Brager & de Dear's research it is expected that similar results could be observed in outdoor settings as well.

Another term that Brager and de Dear (1998) used is "adaptive opportunity". Adaptive opportunity was defined as how and to what extent individuals tolerate or adapt to a broader range of temperature in any given environment. Their study found that occupants of naturally ventilated buildings had an enormous scope of adaptive opportunities. Therefore, subjects were comfortable in a broader range of temperatures that similarly reflected the thermal environment patterns in their climate. The authors claimed that adaptive capacity provides an opportunity to optimize both energy use and thermal comfort if the designer acknowledged the adaptive mechanism and considers it when designing and operating buildings.

Thermal Comfort and Psychological Adaptation Factors in Outdoor Environments

There have been several studies on outdoor thermal comfort (Nikolopoulou, 2011; Thorsson et al., 2004) also focused on adaptive opportunities. Their research showed that people take conscious or unconscious action to improve their comfort level by adjusting their clothing insulation and metabolic rate when their thermal environment changed.

A study by Oliveira and Andrade (2007) suggested that people are generally aware of their lack of control over outdoor thermal conditions. Thus, they have a greater range of expectations for the variations of temperature outdoors compared to the indoor environment. The results from that study indicated a relationship between outdoor thermal comfort, atmospheric climatic parameters, and individuals' characteristics.

Studies on outdoor thermal comfort are not only limited to generic environments. In a context-specific study, Ahmed (2003) discussed the significance of outdoor thermal comfort in tropical urban environments. The author claimed that the rationale for developing a thermally comfortable outdoor environment is beyond the requirements of urban design and should include guidelines for building design as they both have a significant impact on total energy demands.

A recent comprehensive study by (Liu et al., 2012) measured the weight of three categories of factors influencing thermal comfort; the authors used the analytic hierarchy process (AHP). The adaptive thermal comfort theory is well-accepted for non-airconditioned spaces. According to Liu et al.'s theory, thermal comfort is achieved as a result of the combined effects of ambient physical environmental stimuli and non-physical variables such as personal lifestyle, cultural issues, and socio-economic factors. The authors argued that thermal comfort should not be defined by a specific temperature or the combination of physical environmental variables, but by a dynamic range including local outdoor climate and non-physical social and psychological factors in an open environment. Lui et al. (2012) claimed that thermal comfort achieved by individuals in an actual dynamic environment is the outcome of active adaptation.

Expectation as a Psychological Adaptation Factor

One of the most cited works in the area of psychological adaptation factors is McIntyre (1980) who stated that an individual's reaction to temperatures outside of their comfort zone would depend on expectations, personality, and what they are doing during that time. In line with this argument, G. Brager et al. (2004) conducted an experiment in the San Francisco Bay Area and found that individuals with high levels of control showed a higher comfort temperature in warm conditions compared with those having a low degree of control.

The foundation of adaptive thermal comfort theory was well described by G. S. Brager & de Dear (1998). The authors claimed that in a real environment people freely utilize various adaptive approaches based on their thermal preferences to achieve comfort. Similarly, Humphreys (1994) argued that people, "… are not inert recipients of the environment, but interact with it to optimize their conditions". These arguments support the significance of non-physical factors in achieving thermal comfort and the adaptive nature of comfort.

Auliciems (1981), note that psychological adaptation could not be observed directly because invisible characteristics cannot be easily described and evaluated. He described psychological adaptation as the altered perception and reaction to existing sensory information in the environment, based on an individual's past thermal experiences and memory. In support of this idea, Liu et al. (2012) found that individuals who experienced a cool thermal environment at a given time on the previous day have warmer thermal sensations in summer yet a slightly cooler thermal sensations in winter (which is closer to thermal neutrality).

Nikolopoulou and Steemers (2003) similarly argued for the presence of a psychological aspect of thermal comfort in outdoor spaces. In an attempt to address the psychological influences on thermal comfort, Nikolopoulou and Steemers (2003) introduced several factors describing psychological adaptation including: naturalness, expectations, experience (short-/long-term), time of exposure, perceived control, and environmental stimulation. Later on, they attempted to measure how those factors impact on each other, and interrelations among them, as well as their overall impact on the experience of outdoor thermal comfort.

Expectation, as one of the psychological parameters, was defined as what the environment should be, rather than what it actually is (Nikolopoulou & Steemers, 2003). Experience, on the other hand, directly influences people's expectations of an environment both in the short and long term. These two factors seem to play a major role in the overall perception of heat in outdoor environments in accordance with adaptation levels as functions of past exposure (Knez et al., 2009).

Nikolopoulou and Steemers (2003) study added that microclimatic parameters strongly influence thermal sensations, but this variable only accounted for roughly 50% of the variation between objective and subjective comfort evaluation. They argued that the remaining portion could not be measured by physical parameters; thus, psychological adaptation seemed to play an important role, accommodating wide fluctuations in the physical environment, so that thermal discomfort is avoided. Nonetheless, the study provided a ground for understanding the presence and fundamental relationship between these psychological factors.

Since in outdoor environments, people are directly exposed to local microclimatic conditions, including solar radiation, shading, and different airflow direction and speed levels, the study of comfort in these environments becomes more important. Several attempts by researchers to assess thermal comfort in outdoor environments using existing models were unsuccessful. In a review paper by (Chen & Ng, 2012), the use of the PMV–PPD in the outdoors resulted in considerable discrepancies between the actual sensation vote (ASV), collected subjectively through questionnaires of thermal comfort, and the PMV. Another static method that has been widely used and presented better results than the PMV in outdoor environments is the Physiological Equivalent Temperature (PET) (Chen & Ng, 2012). However, static methods have the limitation of not addressing the dynamic adaptive characteristics of human beings (Chen & Ng, 2012).

In an overview by Chun et al. (2004), the authors discussed the breadth of work on human thermal response to stable environmental conditions; however, they mentioned the lack of data on response to conditions in transitional spaces. The authors noted that the PMV cannot be used for transitional space thermal comfort predictions because of its unstable and dynamic physical and MET value (Chun et al., 2004). The study's focal point was that the typical behavior observed in the transitional spaces includes walking, sitting, and standing; that is far different from standard behaviors in residential and office buildings, where the majority of thermal comfort studies focused. Their study strongly suggested that the dynamics of outdoor and semi-outdoor spaces are complex and require a more comprehensive and subjective analysis from the individual's standpoint.

Thermal Perception

Knez et al. (2009) discussed the psychological mechanisms involved in outdoor space and weather assessment. The authors used context to explore interrelationships in outdoor place-human relationship. Based on their research, there is a meaningful relationship on participants' perceptual and emotional estimations of outdoor urban places when weather parameters (air temperature, wind, and sky cover) and personal factors (environmental attitude and age) are included (Knez et al., 2009). Although the study was tested in a Nordic city, the results are in line with other studies supporting the role of psychological factors on thermal comfort.

Knez et al. (2009) study identified several vital issues. The authors found that participants from different social background rural vs. urban reported different levels of satisfaction in the same weather conditions. The research demonstrated that “rural people” compared to urban individuals estimated the weather as warmer and were more sensitive to the wind speed variations. Counter intuitively, urban individuals, independent of weather conditions, reported higher comfort levels in outdoor urban environments. In line with previous findings (Brewer & Treyens, 1981; Knez, 2005; Knez & Thorsson, 2006, 2008), Knez et al. (2009) highlighted the impact of the moderator/personal factor and environmental attitude on thermal perception and subjective weather assessment. The authors hypothesized that a place related schema stored in the long-term memory that significantly guided and interpreted the open-air and the urban persons' different experiences of and expectations towards the weather and the outdoor urban places. (Knez et al., 2009)

Several studies (Zacharias et al., 2016; Nikolopoulou et al., 2001; Thorsson et al., 2004; Eliasson et al., 2007) addressed weather conditions and thermal comfort as essential factors for use and sustainability in outdoor urban spaces. It is now evident that with global warming and climate change, the design of outdoor spaces needs to be even more considerate of meteorological factors as well as personal factors that are based on context and climate.

Nikolopoulou et al. (2001) argued that expectation and experience as human memory factors account for some of the unexplained variance in votes of thermal comfort between individuals. However, Knez et al. (2009) countered that experience could not be divided into short-term experiences related to memory and long-term related to schemata. Kenz et al. (2009) stated that experience and expectations are not only linked to psychological adaptation -- as put forth by Nikolopoulou & Steemers, (2003) – but also cognitive features that all types of "top-down" psychological processes are based upon (Knez et al., 2009).

Knez & Thorsson (2006) constructed an experiment to measure the influences of culture and environmental attitudes on thermal perception in outdoor environments. They compared the influence of culture (Swedish vs. Japanese) and environmental factors (urban vs. rural person) on thermal, emotional, and perceptual assessments of a square using Physiological Equivalent Temperature (PET). The results revealed that "Japanese participants estimated the current weather as warmer than did Swedish participants and, consistent with this, they felt less thermally comfortable on the site, although participants in both countries perceived similar comfortable thermal outdoor conditions according to the PET index" (Knez & Thorsson, 2006P#). The results highlighted that thermal, emotional, and perceptual assessments of an environment might be intertwined with psychological schema-based and socio-cultural processes, instead of thermal indices based on heat balance models on the human body.

Knez (2005) defined attitude as a psychological construct with some bearing on how people learn about and perceive the world around them. He also defined schemata as sets of knowledge structures and expectations stored in memory that may elicit behavioral, affective, and cognitive consequences (Knez, 2005). for quote Previous research argued that a person's prior knowledge would impact her or his perception, comprehension, and memory of new information (Bartlett 1932; Minsky 1975; Piaget and Inhelder 1973).

Thermo-spatial Perception

In a comprehensive literature review by Lenzholzer et al. (2018), the authors examined thermo-spatial perception in outdoor spaces. The study illustrated the importance of understanding an individual's thermal and spatial perception to design thermally comfortable outdoor spaces. Based on this study, thermo-spatial perception is impacted by several factors, including the nature and scale of that space (spatial context) as well as the kinetic state of the individual and the time span of their perception (now vs. past). Lenzholzer et al. (2018) reported that the existing qualitative methods address different dimensions of perception through a combination of momentary and long-term thermal perception in a stationary state or movement within various spatial environments.

Lenzholzer et al. (2018) discussed design guidelines that combine thermal and spatial matters; those variables are essential to achieving thermally comfortable urban environments. They're guidelines to design urban spatial features including the shapes of buildings and canopies, materials, configuration, and types of vegetation that influence human thermal perception. This study's main goal was to critically review new methods to investigate outdoor thermal perception and explore its usability for different study purposes.

Thermal Sensation

Auliciems (1981) defined the individual's physiological response to thermal conditions as "thermal sensation." He critiqued the term "thermal comfort" in studiesas not suitable to describe all types of thermal stimuli to which individuals are exposed. Later, he discussed the lack of consideration of psychological factors, including expectation and climate acclimization, as part of the thermal experience description. Auliciems (1981) suggested the term "thermal perception" to describe the physiological and psychological factors together in a neutral and inclusive fashion. Thermal perception has gained increasing interest in recent decades due to inclusion of additional criteria in a comprehensive assessment of thermal comfort in outdoor environments, and many studies have used this term in their work (Nikolopoulou et al., 2001; Nikolopoulou & Steemers, 2003; Knez & Thorsson, 2006; Knez et al., 2009).

Time Scale

Concepts from environmental psychology were brought in by several scholars to elaborate outdoor thermal perception further (Auliciems, 1981; Rohles, 1980; Nikolopoulou & Steemers, 2003). One of the most important topics relevant to the temporal character of urban climate was the duration of the experience (e.g., short- or long-term memory). There is controversy between researchers about the scale and origin of these differences and impact they make; Nikolopoulou & Steemers (2003) argued that short-term experience is connected to memory and seems to be the main reason for the variance in reported expectations of individuals from one day to the next. However, Knez et al.DATE argued that momentary and longer-term experiences should be differentiated. Figure 1 shows the relationship between outdoor thermal perception, objective and subjective aspects, and their associated components.

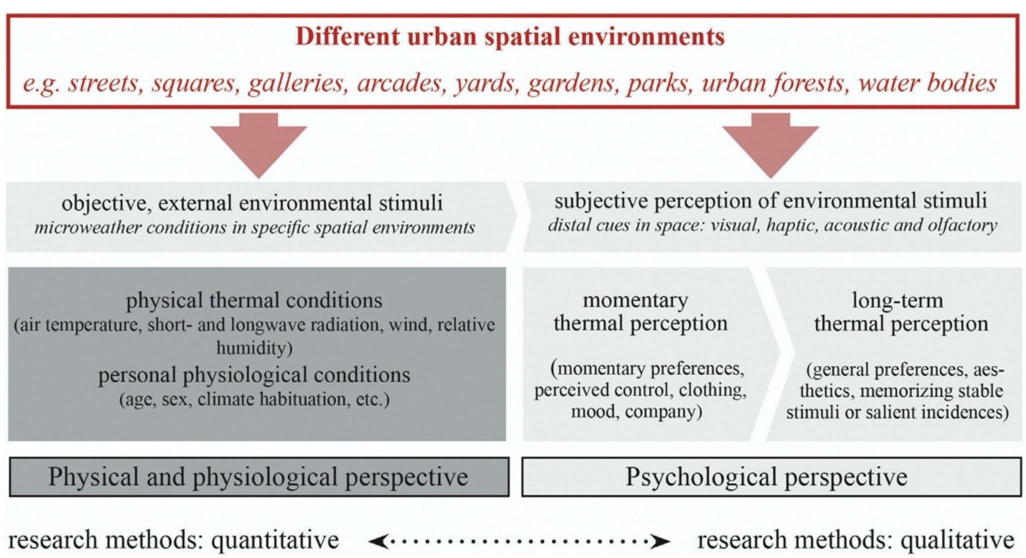

Figure 2.1. Concepts and aspects of outdoor thermal perception and related research approaches. (S. Lenzholzer et al., 2018)

Knez et al. (2009) described the momentary experience as thermal perception at a specific moment in a specific place (e.g., here and now). They claimed the span of the experience in is the range of seconds. An example of this momentary expression could be, "I feel cold right now, here in the shade of the building." Most studies of momentary thermal perception involve interviews of people in outdoor spaces similar to Nikolopoulou et al. 's (2004) work where she used the term "Actual Sensation Vote." An indirect way to gain insight over an individual's immediate behavioral response to the thermal environment is observation, used in several other studies (Nikolopoulou et al., 2004; Nikolopoulou and Lykoudis, 2006).

Perception Schemata

The term “Perception schemata” (Knez et al., 2009; Lenzholzer, 2010) was introduced to describe thermal perception over more extended time scales. These schemata could be based on experiencing repetitive familiar stimuli, or they could be biased through salient events that were ingrained in an individual's memory (Eysenck, 2006; Lenzholzer, 2010; Nikolopoulou & Steemers, 2003). It is essential to differentiate the nature of long-term and short-term memory to understand how they affect an individual's cognition of the environment. Perception schemata aid in pre-sorting information on environmental stimuli and respectively help the individual to respond appropriately. Perceptual schemata are typically linked to spatial circumstances and environmental characteristics (Brewer & Treyens, 1981). An example of a long-term thermal perception usually addresses the experience's longevity, e.g., "It is always sunny out here."

Lenzholzer et al. (2018) stated that besides the duration of experience (momentary or long-term), the spatial and material qualities of the environment impact thermal perception. Other studies like (Rohles, 1980) also indicated the influence of ambiance and material of the room on indoor thermal perception. In the late 1980s, Griffiths et al. (1987) introduced the notion of “naturalness” as a factor of spatial environment that impact thermal perception, and many researchers adopted this term and utilized it in their work (Nikolopoulou and Lykoudis, 2006; Nikolopoulou and Steemers, 2003; Eliasson et al., 2007). Griffiths (1987), for example, defined naturalness as the degree of artificiality of an environment, which entails other spatial connotations.

Further research in environmental psychology helped to shed light on qualities of urban environments such as building configuration, colors, greenery, and building materials that significantly impact individual's synesthetic experience and behavioral response (e.g., Herzog et al., 1976; Herzog, 1992; Lindal and Hartig, 2013; Smardon, 1988). There is not enough evidence about the relationship between these synesthetic experiences in spatial environment and thermal perception (Lenzholzer, 2010a; Vasilikou, 2014; Klemm et al., 2015a). Since the built environment can be modified through design interventions, while personal factors are constant in thermal perception, it is essential to understand the impact of spatial environment on thermal perception.

Kinetic State

Another dimension of thermal experience, directly related to the momentary and long-term perception, is the kinetic state of the individual's body; are they in movement or stationery (S. Lenzholzer et al., 2018). Gibson (1979) explained that human spatial perception is different in moving from a steady-state. Chen and Ng (2012) also claimed that the kinetic state (standstill or movement) could impact thermal perception in space. In other words, the momentary thermal perception is directly descriptive of a specific space at a specific time, while long term thermal perception can entail several different experiences. Figure 2 from (S. Lenzholzer et al., 2018) shows how smaller scale thermal experiences can be accumulated and create a larger scale spatial experience and ultimately build engrained mental schema. This confirms the importance of awareness of the users of a space, e.g., whether an urban environment is designed for pedestrians in motion or for people in steady-state.

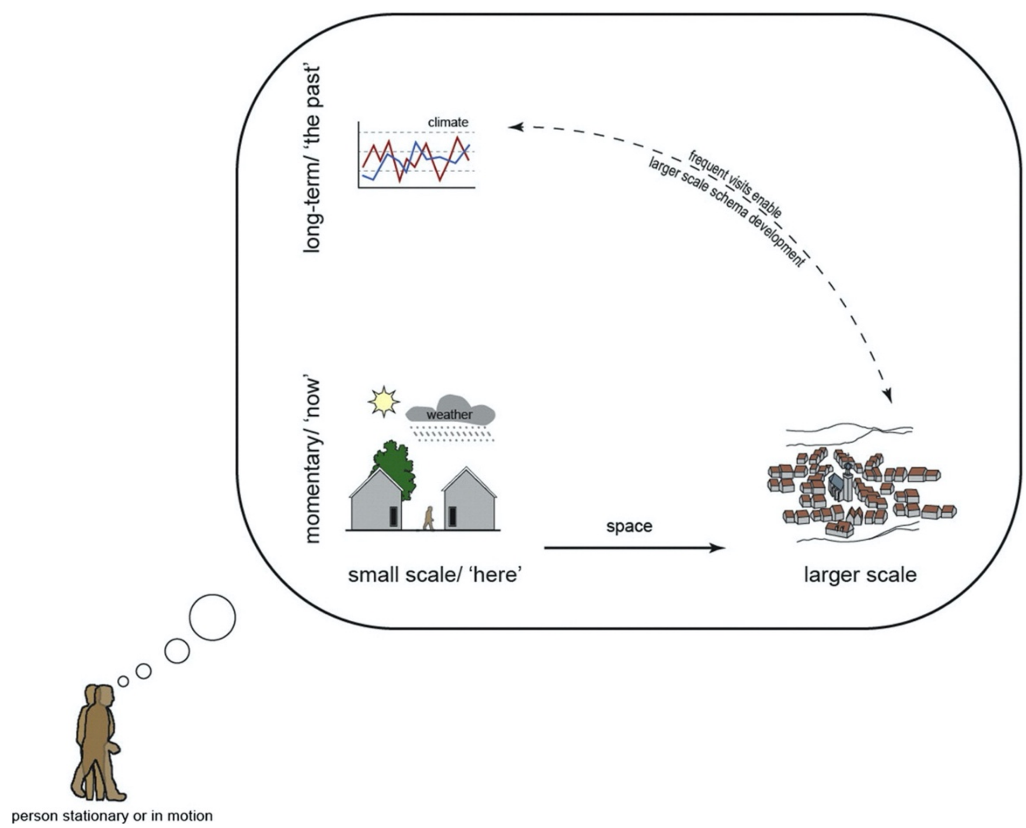

Figure 2.2. Spatio-temporal aspects of thermal perception. (S. Lenzholzer et al., 2018)

It is now evident that in order to comprehensively understand the effect of spatial aspects on thermal perception, a mixed-method approach is necessary to achieve a balanced view of the objective and subjective aspects associated with thermal perception (S. Lenzholzer et al., 2018). Qualitative methods typically entail interviews, and the quantitative methods may include meteorological measurements of physical environments and/or surveys from participants. Among many mixed-methods studies examined thermal perception from an in-motion kinetic aspect and utilized both qualitative and quantitative methods (Böcker et al., 2016; C. Vasilikou & Nikolopoulou, 201; K. Vasilikou, 2014). However, qualitative methods were limited to interviews, walks, and observations, they did not include in-depth narrative analysis focused on users' experience. My “thermal walk”research design was created to examine these rich sources of data.

Thermal Walk

Vasilikou & Nikolopoulou (2014) first used thermal walks to understand deeply pedestrians' thermal perception. In several studies, they investigated the variation in thermal perception between spaces with different geometrical characteristics in order to build a more extensive pedestrian route. The goal of their research was to identify the changes in thermal perception of pedestrians as they moved between interconnected spaces as well as identifying the thermal perception of the individuals in the movement. Each individual's thermal perception was examined in the form of thermal walks (C. Vasilikou & Nikolopoulou, 2014).

Thermal walks originated from the Sensewalking technique initially developed by Southworth (1969). Sensewalking is a systematic approach to examine and analyze how people understand, experience, and use urban space. This approach uses a multisensory input that is site-specific. It can be focused on a particular sensory experience to enable individuals to express their perception of an environmental aspect.

Although K. Vasilikou (2014) used thermal walk to generate thermal notation, which is a useful tool for urban designers, there was still a lack of consideration toward the subjective perceptual aspect of the pedestrian. The majority of studies analyzed the qualitative data (interviews) from the researcher's perspective; however, with the adequate production of data, a more in-depth analysis from the participants' perspective will create a more comprehensive understanding of the subjective aspects of thermal experience.

Vasilikou & Nikolopoulou's, (2014) use of thermal walks was also important in long-term thermal perception investigations. Their study of pedestrian thermal perception in outdoor urban centers examined thermal perception at the scale of urban sequence and the overall experience of the walk. After waking participants responded to questionnaires (based on a five choice Likert scale) to describe their walking experience and identity changes in their thermal and spatial perception during the walk.

As Lenzholzer et al. (2018) discussed, most studies conducted on outdoor thermal perception were focused on momentary perception. Most of these studies on momentary thermal perception attempted to generate actual sensation "votes" for a particular climatic region or modify and enhance existing thermal prediction indices. As a product of these studies, collective cognitive maps helped provide fundamental knowledge on how individuals assign thermal perception to spatial typologies.

My literature review identified the need to conduct studies on long-term thermal perception. Most previous studies focused on steady-state thermal perception; however, in a realistic setting, individuals move between spaces to arrive at a stationary position. Therefore, understanding thermal perception in motion is equally essential. As Lenzholzer et al. (2018) 0bserved that studying people's daily routes, specifically how they are perceived in terms of spatial and thermal conditions on a long-term basis, is useful since these daily experiences make up a large part of their overall experience of the environment.

The Use of Mixed-Methods

The use of qualitative and quantitative methods in studies of thermal perception most often verified a good match and a meaningful relationship between the two datasets. This close linkage suggested a relationship between the objectively measurable and the qualitative, subjective reality (S. Lenzholzer et al., 2018). In cases where a discrepancy between objective and subjective data was observed, the necessity for in-depth exploration in qualitative data became vital to understand the subjective aspect of the thermal environment.

Sanda Lenzholzer (2010) conducted a study on perceptual schemata of public spaces to investigate their role in thermal comfort and microclimate experiences to elaborate on the necessity for urban design to address the "perceived" problem as opposed to the "real" problem. She compared the results from microclimatic measurements with the subjective results from participants of the study and found discrepancies. The analysis revealed that individuals overestimated the influence of the wind. Therefore, the study suggested that more salient situations play a role in the microclimate schemata that people develop (long-term) about urban environments. The author claimed that this negativity bias in wind experience could produce a negative image of the public space and prevent people from using it, leading to a general neglect of that space.

In a more recent study (Sanda Lenzholzer & de Vries, 2020), the authors developed a new conceptual, more comprehensive, model that addressed thermal sensation and psychological process interaction on two-time scales. However, the authors acknowledged the necessity for further research on the effect of momentary and long-term personal preferences, and the effect of perception of spatial environment on thermal perception. The authors presented the extended model (in figure 3 below) that illustrates a conceptual framework for the relationship between the physical and psychological realms from a time perspective.

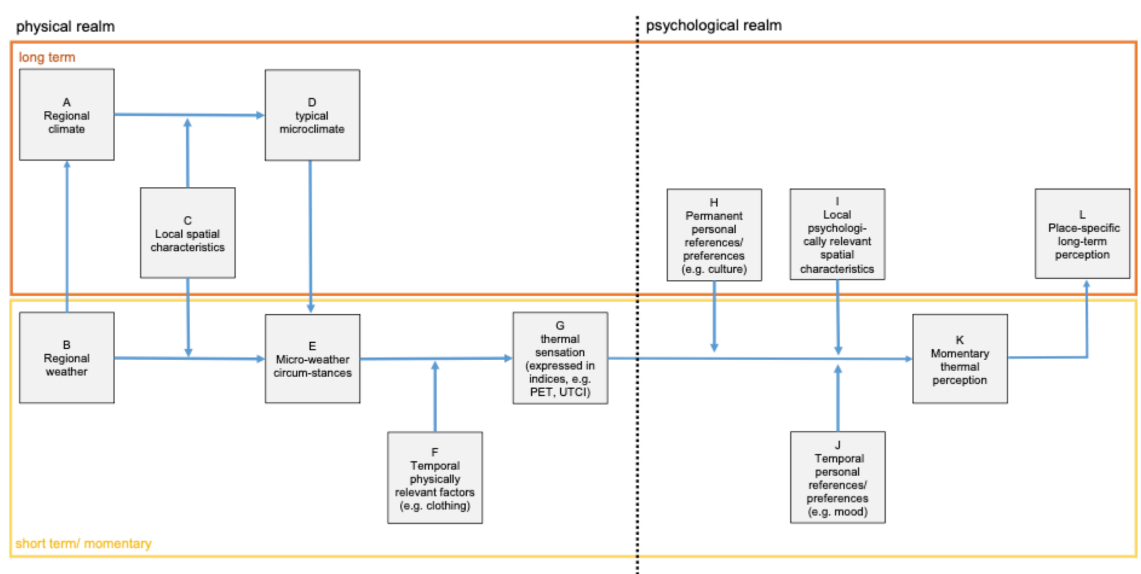

Figure 2.3. The new PhyPsy model to describe thermal perception (Sanda Lenzholzer & de Vries, 2020)

Sanda Lenzholzer and de Vries (2020) hypothesized that together with factors from physiological/physical realms of thermal sensation, psychological factors influence momentary thermal perception. The accumulation of these momentary perceptions build toward long-term perceptions for specific places, and crystalize into "mental schemata" for particular outdoor environments, which is in line with Lenzholzer's theory. Her hypothesis is supported by research in environmental psychology (Pezdek et al., 1989). An important implication of these mental schemata is that they serve as psychological mechanisms to assess unfamiliar situations. Thus, a similar process is expected to shape thermal perception in unfamiliar circumstances.

Sanda Lenzholzer and de Vries (2020) explained that interviews are necessary for examining the momentary references and preferences relevant to thermal perception, as as only participants can verbalize those experiences. In other words, it is not possible to acquire data on these references through inference since behaviors are impacted by many different factors other than thermal perception. The authors suggested that most of the existing work on momentary references and inferences mainly focus on people's mood, perceived control, and reasons for the visit. However, other factors such as vision, sound, and smellscape at a specific moment could influence thermal perception. Studies on human multisensory perception and the concept of "allisethesia" indicated that cues from one sense might affect the perception of a different sense.

Lenzholzer & Nikolopoulou (2020) highlighted the significance of subjective human parameters in thermal comfort research. They claimed that focusing on people not as mere recipients of the multiple radiation exchanges in outdoor spaces aiming to reach equilibrium with their internal thermoregulatory process, but actively engaging with the perception of these thermal process is the core of this approach. The authors added this new perspective provided a complimentary paradigm, highlighting the importance of personal, behavioral, and psychological factors in outdoor thermal perception. (Nikolopoulou et al., 2001)

In a study on pedestrians' thermal experience, C. Vasilikou and Nikolopoulou, (2020) investigated how pedestrians walking in a sequence of irregular open spaces might experience thermal variations through immediate changes with a potential reduction in thermal discomfort. Moreover, in a longitudinal inquiry, the authors studied the differences in the thermal experience of urban microclimate as walkers were impacted by a complex urban morphology in the temperature spectrum. The authors concluded that walking acted as a mediator in the juxtaposition of objective measurements of the thermal environment and the subjective human responses. The study concluded that pedestrians' perception of thermal comfort seems to derive from the opposite function of adjacent spaces. They hypothesized that it is not squares or streets that are thermally comfortable or uncomfortable. The variation created by the adjacency of a street to an open space may provide a thermally interesting transition in the urban continuum (C. Vasilikou & Nikolopoulou, 2020).

In recent years, inquiry paradigms in the investigation of human perception implied a constructivist approach that reflects upon the subjective perspective of human perception (Creswell, 2013). The main approach in this paradigm is phenomenology, which envisions human multisensory sensations and their subjective interpretation as central themes of perception (Heschong 1979; Husserl 1960; Merleau-Ponty 1992). This phenomenological approach seems essential and complementary to the existing predominantly positivist discourse in thermal perception studies (Sanda Lenzholzer & Nikolopoulou, 2020).

Summary

Based on the literature review, there is an agreement that existing models of thermal comfort are not capable of comprehensively addressing reported individual comfort levels. This is due to the complexity and constantly changing dynamics of outdoor spaces and the variations in personal factors within individuals experiencing these environments. The authors proposed the necessity to explore the subjective dimension of thermal experience in-depth, particularly for pedestrians in movement. My review also suggested that there is no evidence of the influence of different time scales of memory (short-term vs. long-term) on each other and how it may impact the thermal experience. The literature also suggested that employing a novel mixed-method approach can aid in gaining an in-depth understanding of participants' experiences to explore the subjective component of thermal comfort. Therefore, the study's main research questions consist of:

1- How does familiarity impact thermal perception, controlling for weather and physical conditions?

2- To what extent does familiarity account for thermal comfort in presence of other thermo-spatial factors?

3- How do the streetscape characteristics influence the momentary and long-term thermal perception of pedestrians?

CHAPTER 3 METHODS AND PROCEDURE

Overview

The chapter defines the research methodology used in this dissertation. I have utilized a mixed-method research framework encompassing both qualitative and quantitative methods and measures. This research aimed to explore the impact of psychological factors on thermal perception and investigate the subjective dimensions of pedestrians' comfort in urban environments in-depth concerning the effect of short-term and long-term memory. Therefore, the construction of the research design and its rationale is explained in this chapter. Additionally, the specific methods and metrics used to collect and analyze the qualitative and quantitative data is discussed. Finally, I present my role as a researcher and the ethical issues concerning the research process.

Research Design

This dissertation utilized a mixed-method design (Tashakkori & Teddlie, 2003), to enhance the examination of the research questions (Creswell & Clark, 2011). I employed a concurrent triangulation strategy, in which I collected both qualitative and quantitative data concurrently and then compared the two datasets to determine if there is convergence, differences, or some combination (J. W. Creswell, 2002, 2013; J. W. Creswell et al., 2003). This method generally uses separate quantitative and qualitative methods to offset the weakness inherent with one method with the strength and depth of the other (or conversely, the strength of one adds to the strength of the other) (John W. Creswell, 2013).

In this approach, the collection of qualitative and quantitative data is concurrently occurring at the same phase of the study; however, the mixing of datasets may happen later within interpretation or discussion sections. The mixing typically consists of merging the data, which may entail transforming one form of data to the other form of data to be simply compared or integrate or contrast the results of both datasets side by side in a discussion.

Creswell (2013) stated that the concurrent triangulation strategy is advantageous since it is familiar to most researchers and can lead to well-validated and substantiated findings. Another advantage of this model is the shorter data collection time than sequential approaches as the collection of both qualitative and quantitative happens at one time at the research site. More importantly, due to this study's nature in examining the experience of the thermal environment and the significance of time scale, this concurrent approach can provide more consistent and reliable data for analysis and more in-depth investigation. The visual model of the procedure for the concurrent triangulation mixed method design of this research is presented in figure (1).

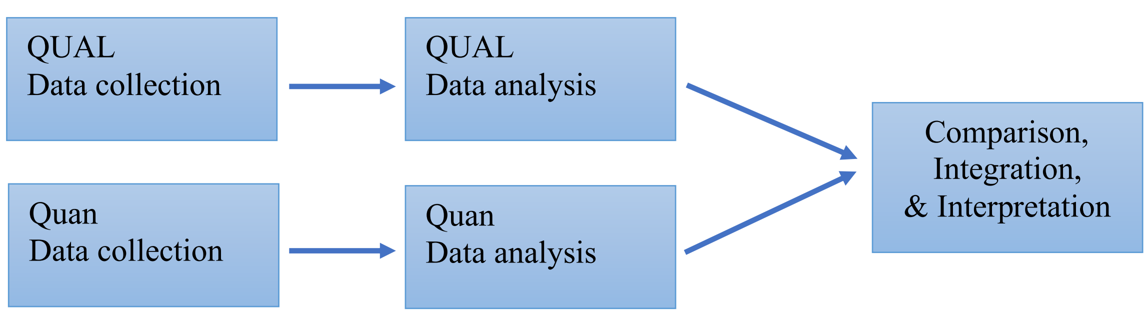

Figure 3.1. Procedural Diagram; Mixed Method – Concurrent Triangulation Approach

Role of The Researcher

My relationship with data collection in the qualitative phase took an observatory role due to my relative acquaintance of the subjects. The main goal was to attempt to help the participants describe their perception of the environment to the best of their ability and bring me into their world through what they revealed. The argument is that the quality of the information attained via the narratives is also dependent on me as a researcher and my ability to comprehend it.

I have an extensive background in architecture, urban design, and environmental psychology, including practical experience with design-build and doctoral studies at the Design School within Arizona State University and teaching Architecture at Mississippi State University. Due to my immersed knowledge and experience with architecture, I might put the narratives at the risk of bias. I attempted to avoid this by allowing the participants to describe their experience first-hand. Given the limited exposure of me to the participants, either due to online mode of instruction or the large number of students, it is highly unlikely that I might have developed friendly or supportive relations with participants. However, extensive verification procedures, including triangulation of data sources and thick and rich descriptions of the cases, were used to establish the findings' accuracy.

Research Permission and Ethical Consideration

Ethical issues were addressed at each phase in the study. In compliance with the Institutional Review Board (IRB) regulations, I obtained permission for conducting the research (see Institutional Review Board, 2001). I developed an informed consent form. The form stated that the subjects are guaranteed certain rights, voluntarily agree to be involved in the study, and acknowledge their rights are protected. Given the study was introduced in my classes as an extra credit assignment, I informed all the students that if they are interested in the extra credit opportunity but are not willing to participate in this study, I will accommodate an alternative assignment, so no obligation was implied.

The confidentiality of subjects was protected by numerically coding each answered/completed survey and keeping the responses confidential. All study data, including the surveys, interview files, and transcripts, were kept locked in my office and destroyed after a reasonable time. Subjects were told that summary data will be disseminated to the professional community.

Theoretical Lens

Since this study's concurrent triangulation strategy is highly reliant on the qualitative data, a constructivist paradigm is necessary for valuing several mindsets and a profound understanding of individuals' subjective experiences (Creswell & Clark, 2011). Fundamentally, the constructivist paradigm recognizes the positions of subjectivity and intersubjectivity encountered. In qualitative research, data collection is obtained from individuals who were engaged within the research framework regularly. At the same time, the data analysis is grounded on the values that these subjects perceive of their world (Patton, 2015). Essentially, qualitative research can comprehend the problem based on multiple contextual factors (Miller, 2000).

Therefore, for this study's qualitative component, I adopted a post-positivist approach toward the statistical tendencies. Post positivism is an "interpretive perspective that has the elements of reductionist, logical, empirical, cause and effect-oriented, and deterministic based on prior theories" (Creswell, 2012, p. 299; and see also Campbell &

Russo, 1999, p. 151). On the other hand, quantitative research depends on numerical data. I adopted a post-positivist assertion to build knowledge, in the form of causation thinking, variable reduction, hypothesis and questions, use of measurement and observations, and theories testing (Mertler, 2015).

Data Collection Procedure

In February 2018, the IRB approval was obtained for this study (IRB STUDY00007788), which can be found in appendix 1. Research consisted of five rounds of data collection from students in "Introduction to Environmental Design" and "Architecture Appreciation" lecture courses respectively at Arizona State University (ASU) and Mississippi State University (MSU) as an extra credit assignment beginning in February 2018 and ending on December 2019. For this dissertation, all data from five rounds were combined and generated into two larger datasets: a qualitative dataset (entailing visual and audible data from participants) and a quantitative dataset (entailing three-step online surveys). Below is the breakdown of the five rounds of data collection:

1- Spring 2018 (Online), ASU, Worldwide

2- Summer 2018 (Online), ASU, Worldwide

3- Fall 2018 (Session A, Online), ASU, Worldwide

4- Fall 2018 (Session C, In-Person), ASU, Tempe Campus

5- Fall 2019, (Session C, In-Person), MSU, Starkville Campus

Method of Analysis

After collecting the online survey data, I downloaded the raw data from Qualtrics and documented in a spreadsheet. Following various data cleaning, filtering, and testing, I exported the data in three cumulative spreadsheets, representing familiar, unfamiliar, and comparison surveys. I used STATA 16 SE, syllabic abbreviation of the words statistics and data, for statistical analysis due to its efficiency in using multiple methods to analyze data. To provide a snapshot of the sample from which data is collected, descriptive information including age, gender, ethnicity, educational level, and work status were included. To determine the relationship between the walking experience elements and thermal perception, I used various correlational tests such as T-tests, correlations, ANOVA, and regression analysis. The analyzed data results were used first to address the research questions and later to confirm, compare, and contrast the themes that emerged in the qualitative phase of this study and guide future research in the field.

Qualitative Data Collection and Analysis

Given the nature of qualitative data in videos that participants recorded and uploaded to Dropbox, several steps needed to be completed. I first watched the videos, carefully listened to the audible, and transcribed all the audible data to text, leading to transforming a thousand-minute-long video database to five hundred text pages for analysis.

Therefore, the qualitative data was first coded in order to be used for thematic analysis. Further, after clearing the text generated from transcribing the transcripts, I created a spreadsheet with one row and two columns of texts (familiar and unfamiliar street) for each participant. I completed the spreadsheet for all the participants (N=423). Further, I employed the Latent Dirichlet Allocation (LDA) via using R as the language program to analyze potential correlations between the narratives and participants' explanations of their experience during the walks. The rational, process, and details of thematic analysis and LDA are described below.

Thematic Analysis

In this phase, I adopted an exploratory approach with the intent of finding themes that were relevant, meaningful, and insightful. Analyzing the qualitative data typically begins with looking for common themes brought up in narratives. These themes formed the categories used for the analysis. I achieved this using 'qualitative thematic analysis," which involves searching through qualitative data to detect patterns known as themes by organizing and describing data in details (Tesch, 2013, p. 113) . The thematic analysis procedure used inductive descriptive coding techniques and analyzed the data according to this procedure (Tesch 2013:113, Aronson, 1995:1–3, and Creswell, 2002:155–156)

Table 3.3 shows the different steps I followed in order to familiarize myself with the data, generate initial codes, search for themes among code, further process and review themes, define and name theses as categories and finally reporting the final results. The results will be further explained and discussed in the next chapter.

Table 3.1
Thematic Analysis; Source: Adapted from Tesch (2013), Aronson (1995) and Creswell (2002)

Steps	Step Description	Tasks
Step 1	Familiarization with Data	• I obtained a sense of the whole by reading through the narratives independently. Ideas that come to mind were jotted down.
Step 2	Generating initial codes	• I selected one narrative and asked: "what is this about?" thinking about the underlying meaning of the information.
Step 3	Searching for themes among codes	• Each narrative was coded separately; thereafter a list was made of all the topics. • Similar topics were clustered together and formed into columns that are arranged into major topics, unique topics and leftovers.
Step 4	Reviewing themes	• The topics were abbreviated as codes and the codes were written next to the appropriate segment of the text. • I tried organizing scheme to see whether new categories and codes may emerge.
Step 5	Defining and naming themes	• I choose the most descriptive wording for the topics and turn them into categories. • I grouped together topics that related to one another then reduced the total list of categories. • I created a visual form for the structure of categories and themes
Step 6	Producing final reports	• I assembled data from each category in one place and then conduct a preliminary analysis in order to produce the final report

Latent Dirichlet Allocation and Topic Modeling

Latent Dirichlet Allocation (LDA) is a popular method in the Bayesian framework for uncovering hidden "topics" or themes that are discussed within a set of reviews or commentaries (Blei & Lafferty, 2009). The way LDA works is that it assumes all narratives share the same common topics. However, each narrative could include a different combination of the topics with specific words included in the narrative only in the presence of a latent topic. In my research setting, the LDA outputs provided information on the probability distribution of topics for a given narrative, and the probability distribution of words that are in those topics.

Text data are often voluminous and unstructured, presenting problems for traditional statistical methods designed for well-structured, quantitative data. However, due to advances in both statistical tools and computing power, text data can now be organized in a structured way so that traditional methods can be used. As such, a better picture can be constructed from these narratives, providing new and insightful information that can guide future decisions. Below is the procedure required for conducting LDA within the dataset.

Preprocessing of Text

Text is organized in a very unorganized way. In order to do any meaningful analysis, the text has to be structured in a certain way where quantitative methods can be applied. One of the most popular methodologies is transforming the text into a "bag of words" representative of the text. A standard way to achieve this is to organize the words into a matrix with columns representing the actual words and rows representing the comments in which those words appeared in. For instance, "It was a beautiful walk" would be split into a 1x5 matrix with each of the words as an individual column variable and a count for the number of times the word shows up in the commentary. In this case, each column would have a 1 in it.

However, due to the complex nature of words that contain multiple suffixes for a word, i.e. simple, simply, the matrix created can be too large for any computer to handle.

In order to address such problems, several standard preprocessing steps are considered (Boyd-Graber et al., 2014). These include: 1. Transforming all the text to lowercase; 2. Removing words composed of less than three characters and very common stop words such as “the”, “and”, “of”, etc.; 3. Stemming the words by removing any suffix of the word. In the example of simply and simple, the stemmed word would be simp; and 4. Removing words that occur too frequently or very rarely.

Preprocessing and text representation

Following the procedures outlined above, I converted narrative to lowercase, removed common stop words, stemmed the words, and removed words that occurred very frequently or very rarely. I also removed any punctuation in the narrative. Table 3.4 demonstrates this process with a comparison of the original narrative and post-processed narrative.

Table 3.2
Text processing

“So I like this one because this is really pretty with the mix of brick and I guess urban planning with the plants and such it's kind of cool outside, I’m not a big cool guy, so I like warmer weather so it’s be nice if it were warmer but I do like the feeling of sunlight but also shade at the same time. If you walk over here there’s shade and you walk over there in sunlight this water feature is pretty I think this is just such a gorgeous part of campus this route here is so pretty just the way they planned the landscape around here and bushes and the trees mix and this greenery right here but also there is some urban brick layout so this is really pretty, I probably go this way, just the architecture it’s a great great walk besides the coolness.”
lik becaus real prett mix brick guess urban plan plants such kind cool outside big cool guy lik warm weather nice warm lik feel sunlight shade same time walk over here shade walk over sunlight water featur prett think such georgous part campus route prett way plan landscap around bush tree mix green urban brick layout prett probab go way architect great walk cool
" This is my unfamiliar route I walked from Giles Hall to the student union through the junction it’s pretty cold my hands are actually frozen as I begin this video this way is actually a little warmer because i'm not walking throughout building so there's some sunlight hitting me instead of just shadow and be hidden the trees created dark shade but over there you see the buildings hanging in there small building some dorms so there are tall buildings it creates a bigger and more in depth architectural space."

Unfam rout walk Giles hall student union junction prett cold hand actual frozen begin vid way actual little warm because walk throughout building sunlight hit instead shadow hid tree creat dark shade building hang small building dorm tall building creat big depth architect spac

Quantitative Data Collection & Analysis

The qualitative part of my data collection includes a questionnaire divided into three-step surveys. Participants were asked to choose a street that they are familiar with and a street that they were not familiar with before beginning the experiment. They were then asked to take a one-minute video from their walking pathway, moving forward and describing their experience in a narrative form. The details of this description can be found in Appendix 2.

As part of the experiment, the participants were asked to fill out the first survey after they walked in their familiar street or unfamiliar street, based on a randomized order given to them in order to avoid the confirmation bias. Surveys were hosted on Qualtrics as an ASU database. Participants were asked to immediately go to their second street (unfamiliar or familiar based on the random order they were assigned to) and fill out the second survey immediately after. Once they have finished both walks and completed both surveys, they were asked to complete the third survey (comparison survey). All of this information was collected on Qualtrics and later coded and exported for statistical analysis.

Therefore, I have exported the Qualtrics survey data into multiple Excel spreadsheets first, cleaned the data, ensured accuracy and consistency between various sets and rounds of data (familiar and unfamiliar), and finally generated three spreadsheets with information from all three surveys together and ready for analysis. Since some participants completed only one survey (familiar or unfamiliar) instead of following the instructions, the total number of familiar and unfamiliar surveys are not the same. Besides, there are questions within each survey that were not answered in several cases, yet since the remaining answered questions are measurable, I included them in the statistical analysis. After clearing the data, and removing the duplicates, the number of survey entries are summarized in Table 3.1 below. The final spreadsheet was finally exported to STATA, and I prepared it to run several statistical analyses such as -tests, correlations, ANOVA, and regression analysis. These statistical analyses will be further explained and discussed in the next chapter.

Table 3.3
Breakdown of data collection cycles for familiar and unfamiliar surveys

Data Collection	University	Scale	Date Collected	Familiar	Unfamiliar
Spring 2018 (Online)	ASU	Worldwide	02/27/2018-03/01/2018	97	91
Summer 2018 (Online)	ASU	Worldwide	06/24/2018-06/27/2018	26	31
Fall 2018 (Online)	ASU	Worldwide	09/29/2018-10/05/2018	124	136
Fall 2018 (In-Person)	ASU	Tempe	11/19/2018-12/01/2018	216	214
Fall 2019 (In-Person)	MSU	Starkville	11/22/2019-12/03/2019	64	74
Total				527	546

The surveys asked participants to rate their votes for various spatial and psychological factors during their walking experience and attempted to collect these factors' relative impact on thermal comfort. Table 3.2 summarizes the correlation between various design, environmental and psychological factors on each other. Further explanation and more descriptive statistics will be provided in the following chapters.

Table 3.4
Correlations: The effect of various design, environmental, and psychological variables on each other

	Familiarity	Thermal Comfort	Overall Comfort	Safety	Pleasantness	Boringness	Duration	Clothing	Crowdedness	Surrounding Buildings	Trees	Walking Speed
Familiarity	1											
Thermal Comfort	0.0134	1										
Overall Comfort	0.2336	0.3497	1									
Safety	0.0569	0.0703	0.0142	1								
Pleasantness	0.1502	0.3962	0.6545	0.0025	1							
Boringness	0.0312	0.16	0.1622	-0.0023	0.2831	1						
Duration	0.0686	0.0385	0.053	0.1475	0.0445	-0.0266	1					
Clothing	0.0023	-0.0767	-0.0715	0.1081	-0.1257	-0.0321	-0.1044	1				
Crowdedness	0.028	0.0723	-0.0001	0.3022	-0.0167	-0.0062	0.0723	0.0662	1			
Surrounding Buildings	0.0396	0.0316	0.029	0.2439	0.0338	0.0977	0.023	0.0717	0.2528	1		
Trees	0.0484	0.1058	0.0677	0.2011	0.1303	0.13	0.032	0.0898	0.2864	0.3954	1	
Walking Speed	0.0119	-0.0775	-0.0579	-0.091	-0.0195	-0.0323	-0.0945	0.1272	0.0417	0.0248	-0.0064	1

Correlations with an absolute value greater than .067 are significant at $p < .05$

Assumptions

While exploring the impact of psychological factors on the thermal perception and walking experience, several relevant assumptions were made:

1. Participants in the surveys are assumed to give honest feedback regarding their experience and perceptions in a safe, neutral environment.
2. The instructions given to the participants (either in person during lectures or online via a PDF file) provided a sufficient understanding of the experiment's several required steps and did not generate bias for participants.
3. Subjects understood and answered the self-administered questionnaire truthfully and accurately.
4. The chosen narratives are assumed to represent the specific targeted sample population – university students primarily aged between 18-22.
5. The instrument used for collecting data, a self-administered questionnaire, accurately measured the pedestrians' perceptions regarding thermal perception and the walking experience in outdoor environments.

Advantages and Disadvantages of Concurrent Triangulation Strategy

Many researchers have argued the strength and weaknesses of the Concurrent Triangulation Strategy. The following table 3.6 combine the key advantages and disadvantages of Concurrent Triangulation Strategy according to various leading researchers in this field (J. W. Creswell et al., 1996; John W. Creswell, 2002; Greene & Caracelli, 1997; Moghaddam et al., 2003; Morse, 1991).

Table 3.5
Advantages and Disadvantages of Concurrent Triangulation Strategy

Concurrent Triangulation Strategy	
Advantages	Disadvantages
1. It is familiar to most researchers and can result in well-validated and substantiated findings.	1. Requires great effort and expertise to adequately study a phenomenon with two separate methods
2. A time-efficient method as it requires less time since both qualitative and quantitative data collection occur at the same time.	2. It can be difficult to compare the results of two analyses using data of different forms
3. Allows the opportunity to conduct additional data collection for resolving potential discrepancies	3. A research may be unclear how to resolve discrepancies that arise in comparing the results

Summary

I have utilized a mixed-method research framework encompassing both qualitative and quantitative methods and measures. During the qualitative phase, data were collected in the form of an open-ended questionnaire but importantly, self-walking interviews where participants narrated their experience of the environment while recording one-minute long videos. The visual and audible information was first processed using thematic analysis and then further analyzed via Latent Dirichlet Allocation (LDA). During the quantitative phase, information was collected from participants in the form of three-step survey questionnaires on Qualtrics. Data was analyzed using T-Test, ANOVA, regression analysis, and stepwise regression analyses with robustness check in STATA. The quantitative data helped explore and address the initial research questions. In contrast, the qualitative data helped address and explain the trends and the experiential aspects of comfort and perception in the built environment.

CHAPTER 4 ANALYSIS OF DATA

Overview

This chapter outlines the results from the analysis of both quantitative and qualitative data collected over five cycles. The chapter begins with reiterating the statement of research questions and follows with the analysis of qualitative data. I have analyzed the qualitative data first through utilizing thematic analysis and later via Latent Dirichlet Allocation (LDA). In the latter part of this chapter, I explain the quantitative data analyses, the statistical procedure and the proposed model.

Qualitative Data Findings

I divide the qualitative data analyses in two parts. In the first part, I explain the thematic analysis findings and in the second part, I explain the Latent Dirichlet Allocation findings. Finally, I compare, contrast and mix the two sets of result to prepare for final mixing and interpretation with quantitative findings.

Thematic Analysis

During the qualitative data analysis, I categorized the narratives in relevant themes. In doing so, many of the concepts, ideas, and comments by participants fell in the same categories of analyzed quantitative data. The findings from thematic analysis in the context of themes are below.

Aesthetic/Scenery. Many participants talked about the aesthetic quality of their walk, using terms such as “pretty”, “beautiful”, “gorgeous”. This theme was mostly observed in unfamiliar narratives partly due to the enhanced observation of participants in a new environment. Majority of the narratives looked at the interplay of landscape and architecture/urban design of that streetscape. Anthony (MSU, 2019) described several elements of the physical environment and claims it is pretty. He started by talking about the impact of direct sunlight on his face with the blinding effect, however, he immediately mentioned the route is very pretty. Figure 4.1a and 4.1b show snapshots of his walk. Anthony's narrative is highly relied on the presence of trees, their color, and the interplay between them and the buildings around them, as the following:

> *A lot more sun coming in here, it's almost blinding coz as I'm coming up from the north side down south, but also very pretty I've never actually walked this route before but it is pretty it's got some pretty pretty trees I mean the kinda plain wall of the stadium kind of throws off the element of pretty I guess, but these trees are really pretty it's gorgeous with the shading and the color but also kind of having not a huge trunk so it doesn't block off the aesthetic of it I guess, there is a big fence here it's and old type style of brick buildings not only is it kinda backward but it's also not as pretty, it's really pretty … it's unfamiliar walk.*

Figure 4.1a and 4.1b. Snapshots of Anthony's unfamiliar walkway (MSU, 2019), highlighting the in interplay of sun and shadow and role of tress

Hayley (ASU, 2018) also discussed her unfamiliar walkway in downtown Phoenix with elements of an urban area. She highlighted the significance of spatial elements like cars and safety associated with it, as the following:

> *This is my first walk on my unfamiliar street it is in downtown Phoenix weather is around 90, really clear weather, not a lot of clouds there's obviously a lot of skyscrapers like the chase tower in front of us. I feel slightly uncomfortable just because there's a lot more cars and so if you cross the street you have to be more vigilant but I do really like that atmosphere I like the lights on the palm trees there's a lot of landscape around us there's a lot of posters showing things to do in downtown Phoenix, I really like that this year and then there's a really nice building with a nice architecture to it.*

Hayley acknowledged her awareness of temperature, talks about the cloud cover and then focuses on elements of a city, in particular tall buildings. She pointed out the vehicular traffic and the importance of safety when walking in the street. She stated her satisfaction and comfort and talked about palm trees and the landscape surrounding. She clearly stated the importance of aesthetics in her narrative showcasing that with talking about the architecture of a building. Figure 4.2a and 4.2b show snapshots of her walkway in her unfamiliar street.

Figure 4.2a and 4.2b. Snapshots of Hayley's unfamiliar walkway (ASU, 2018), highlighting the in interplay of urban design and aesthetics and comfort

Design Elements. Many participants talked about the various spatial and design elements they observed during their walks. Again, design elements as a theme was mostly observed in unfamiliar narratives partly due to the enhance observation of participants in a new environment It appears that these elements have a paramount effect on how they perceived comfort and thermal environment in their narrative. Heath (MSU, 2019) discussed his unfamiliar route with descriptions of buildings around him along with figure 4.3a and 4.3b snapshots of his unfamiliar walk, as the following:

> *Heath went on by explaining the material of the buildings and the window sizes, the age of building and provided his comparison.*

He also talked about his clothing in order to explain his thermal perception relative to the temperature he mentioned in the beginning of the video. I’m walking my unfamiliar route it is about 38 degrees right now feels pretty cold I’m wearing some sweatshirt and sweatpants and probably could use a little more clothes there's a bunch of trees on this route this is hull hall it’s kind of an older building made of brick lots of windows lots of big windows this is a building almost I’m unfamiliar with it is made also brick with smaller windows both buildings very square really big trees really cool plaza to hang out in we got a bunch of bushes.

Figure 4.3a and 4.3b. Snapshots of Heath’s unfamiliar walkway (MSU, 2019), highlighting the role of design elements and material in perception of environment

Tayler (ASU, 2018) took his unfamiliar route in a typical Phoenix neighborhood and described her understanding of the environment. She stated her discomfort thermally with the environment, the lack of foliage and the building forms and materials, as the following:

This is my unfamiliar street I am very close to the airports around University in 52nd St, this is just a small offshoot but I'm currently going west there's not much to this place some side businesses about three stories tall, there is a wall between each business, it is extremely hot out so obviously no clouds it's about 108 degrees right now I'm actually pretty uncomfortable I don't really know what's around and there's not really any places I could go to if I needed to there's no shade anywhere and just gravel, gravel and asphalts. It's a little bit of foliage here but it doesn't look like it's been taken care of at all some streetlights but overall I'm not very comfortable here

Tayler, pointed out several relatable factors. Distance to the airport and elevated noise disturbance, not having designated paved sidewalks, the lack of mixed use urban zoning and repetitive buildings for businesses were among her observation that derived the dissatisfaction. Tayler mentioned the extremely hot weather and she directly related that to the clear sky ash she perceived the high temperature being the driver of heat. She also described her lack of awareness of what is around her somewhat a safety concern. Tayler also mentioned the lack of vegetation and abundance of gravel and asphalt is adding to her dissatisfaction with the environment. Figure 4.4. is a snapshot of her walk.

Figure 4.4. Snapshot of Tayler's unfamiliar walkway (ASU, 2018), highlighting the role of design elements and material in perception of environment

Thermal Comfort. Thermal comfort was among the themes that showed up in the majority of narratives, partly due to the instruction that I provided for the participants. The participants sometimes clearly stated their comfort or discomfort with the thermal environment and linked it to some weather-related factor, such as temperature and humidity. Other times, they connected their level of thermal comfort to factors like safety, crowdedness, and overall comfort. Lukas (ASU, 2018) described his walking experience narrating several environmental factors in a downtown area in a Lithuanian city, as the following:

> *This is the street on the other side of my aunts apartment it is close to the Lithuanian language Institute it is around the same time around six after 6. right now the weather is still cloudy slight sun it's still nice temperature but I can definitely feel a lot warmer than the last time just because of this incline which is slightly difficult to walk and so you know there's some mild discomfort and I don't right now I see lots of cars also a wall this street is a lot cleaner than the other one and the road is nicer too its made out of stones instead of just concrete and another some green too which is nice.*

Lukas talked about cloud cover and his perception of weather in consideration of the physical environment and stated his thermal comfort and satisfaction despite he felt warmed compared to the last walk, which may be partly due to his familiarity with this street. He mentioned the incline and how that as a difficulty could lead to mild discomfort. He also described cleanliness and the nicer road with more genuine material as part of the reason he liked this street better.

Figure 4.5a and 4.5b. Snapshots of Heath’s familiar walkway in Lithunia (ASU, 2018), highlighting the role of design elements, cloud cover, spatial factors and material in his thermal perception

Taylor (ASU, 2018) described her thermal discomfort in her unfamiliar walk and discussed her sense of safety recognizing her being a tiny female and “anything could happen”. Figure 4.6a and 4.6n show snapshots of her walk in Tempe, Arizona. She clearly related the hot weather to the sun and lack of shade and trees to create shading. She recognized the role of buildings on creating shade and stated she is uncomfortable, as the following:

> *I’m walking on 7th St between Wilson and Farmer and it's hot because of the sun there is not a lot of shade or trees that are really affecting the shade on the sidewalk buildings are kind of short it's there’s a little bit of clouds that’s not really helping them weather. Kinda uncomfortable I feel pretty safe but also I know there’s a lot of cars*

around and I am a small tiny female so anything could happen what else do I see I see some tall buildings right there and just lots of cars this is the kind of place I'd expect to find like a stray cat or something a new building here. This was my unfamiliar walk.

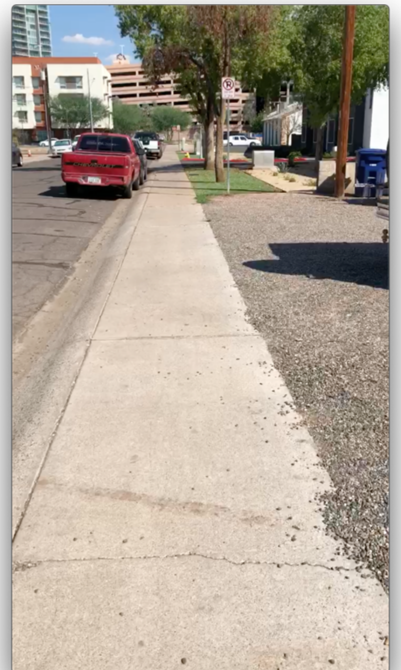

Figure 4.6a and 4.6b. Snapshots of Tayler's unfamiliar walkway in Tempe (ASU, 2018), highlighting the role of design elements, cloud cover, safety and cars in her thermal perception

Thermal Choice/Preference. Several participants discussed notions of choice and preference as a personal factor and described how they preferred the weather to be. Often, these preferences were slight adjustments so there were not merely thermal discomfort. For example, Anthony (MSU, 2019) described the spatial environment and stated what "kind" of person he is, as the following:

So I like this one because this is really pretty with the mix of brick and I guess urban planning with the plants and such it's kind of cool outside,

> *I'm not a big cool guy, so I like warmer weather so it's be nice if it were warmer but I do like the feeling of sunlight but also shade at the same time. If you walk over here there's shade and you walk over there in sunlight this water feature is pretty I think this is just such a gorgeous part of campus this route here is so pretty just the way they planned the landscape around here and bushes and the trees mix and this greenery right here but also there is some urban brick layout so this is really pretty, I probably go this way, just the architecture it's a great great walk besides the coolness.*

Anthony acknowledged the aesthetic aspect of his familiar walk with his explanation of material use and urban planning and landscape. He further stated the weather condition and said "I'm not a big cool guy" which clearly shows his personal judgement about his subjective perception of weather and comfort. He mentioned he likes warmer weather and therefore, he preferred the weather to be warmer. This is in line with literature suggesting personal factors are influential on thermal comfort. Anthony added he liked to have a combination of sunlight and shade, where he could choose which side to walk. He further elaborated his perception of the walk by stating the details of landscape and architecture and finally restated his thermal comfort with a slight preference of warmness, while he suddenly turned around and chose to walk on a sunnier pathway. Figure 4.7a and 4.7b shows snapshots of Anthony's familiar walk.

Figure 4.7a and 4.7b. Snapshots of Anthony's familiar walkway in Starkville (MSU, 2019), highlighting the role of design elements, shade, aesthetics and thermal preference in his thermal perception

Vijaya (ASU, 2018) described her unfamiliar in Phoenix near the airport with an explanation of cloud cover and stating that she had just left an air-conditioned space, so the change is uncomfortable. She continues with describing the buildings and landscape around her. She described her clothing type and finally mentioned her slight discomfort with the weather and said she "would like it if it was a little more cool". Here, a slight change is preferred to arrive at thermal comfort, whether that is clothing adjustment or other forms of acclimation or adaptation. Figure 4.8 show snapshots of Vijaya unfamiliar walk and below is her narrative:

Hi this is the unfamiliar street that I chose to walk in I'm walking outside the airport right now and it's quit sunny right now and I just left an air conditioned room so this switch is uncomfortable there are a few trees on the sides there are some buildings around I think they are parking buildings so there are not more than the two Storey buildings and there is very airport property over here and I'm wearing jeans and a top so I think I would feel a little uncomfortable here because it 's likely sunny I would like it if it was a little more cool and the time right now is 12:00 o'clock yeah.

Figure 4.8. Snapshot of Vijaya's unfamiliar walkway (ASU, 2018), highlighting the role of design elements, AC exposure, clothing type, and thermal preference in perception of environment

Nostalgia and Memory. Several participants talked about their experience in their familiar walk bringing up memories and certain feelings of nostalgia, in particular relative to events that happened in those environments to them in the past. This generally influence their perception of the environment in some way. For example, Seth (MSU, 2019) talked about his experience, as the following:

Right now it's 35 degrees nice wind cloudy no rain but not sunny either I've noticed along the walk on the architecture side there seems to be a little older buildings a lot of big trees that part of campus seems a little bit older gives more of a nostalgic feel this is my familiar route coming through the Chapel I take this most days of the week this section right here with the fountains kinda makes you feel at home, might be a place to come and relax and calm down this is a nice quiet area campus you can come any time to think the trees do not have leaves right now we get into winter but there's plenty of trees so during the summer it'd be nice lots of shade

Seth (MSU, 2019) began his narrative with explanation of weather condition, cloud cover, then he talked about his walk moving by buildings and trees in an attempt to describe the landscape. He further said this part of campus give a nostalgic feel as at home and pointed out at fountains and elements that promote calamity and relaxation when it is needed. Figure 4.9a and 4.9b shows snapshot of Seth's familiar walk.

Figure 4.9a and 4.9b. Snapshots of Seth familiar walkway in Starkville (MSU, 2019), highlighting the role of design elements, calamity and nostalgia in walking experience.

Surya (ASU, 2018) explained his overall experience walking on his familiar route describing sports events. Figure 4.10a and 4.10b show snapshots of his pathway. He pointed out his memories with his friends who hang out there, and he added he feels very comfortable because of landscape and scenery and he would like to revisit, as the following:

> *Hey guys I'm on E veterans way Tempe and it's kind of warm right now which is really good at Tempe at around 23 Celsius degrees and the time is 8:15 in the morning and this place is kind of close to me I visit this place quite frequently because I live nearby and this is consistent football stadium another student athletic centers there's really well filled centers and you can see them yeah and this place always brings me good memories because it's where most of friends hang out and the plantation too that eye catching and I really feel comfortable when I am in the space it's good to be back here*

Figure 4.10a and 4.10b. Snapshots of Surya familiar walkway in Tempe (ASU, 2018), highlighting the role of design elements, events, and memories in walking experience.

Expectation. Another common theme in narratives was expectation. Several participants discussed their thermal experience in comparative context showing they either have a similar expectation about how warm or cool the weather should be or did not expect to experience the weather how they actually did. Nathan (ASU, 2018) described his experience of his familiar walk by the cloud cover, the sun and shade, the built form and he explained his expectation of the humidity in Arizona as the following:

> *Here I am walking in downtown Scottsdale a little short description of this is the familiar street that I know it is sunny not cloudy it's about 5:15-5:30 pm and so the sun is not right up in the air setting a little bit in terms of temperature it's actually really hot 95 degrees there is not a lot humidity but you can't expect that with Arizona, what do I see I see a lot of trees so a lot of shade, buildings are actually 1 story 2 stories not very tall building like huge cities such as , New York, LA but yeah it was comfortable.*

Figure 4.11a and 4.11b. Snapshots of Nathan familiar walkway in Scottsdale (ASU, 2018), highlighting the role of design elements, sun and shade, and expectation of humidity and comfort in walking experience.

Alejandra (ASU, 2018) also explained her experience walking in her familiar street with a rare event as she said it is very rare to have an extremely cloudy and windy weather in that environment. Figure 4.12a and 4.12b show snapshots of her walk in her familiar street. She stated comfort with the thermal environment while she talked about safety and no car activity and having the breeze, as the following:

> *Today is September 30th it is 2:00 o'clock in the afternoon right now it's kind of cloudy and a little windy and it's very rare that it is to have this kind of weather at this time I feel very comfortable walking there's no cars and so there is no traffic there is no one here actually I can see some breeze at the end of the street and walking ways towards Primrose street in Avondale I can also see some flowers as I said there's no one here and I don't feel the wind in my face so I feel good right now walking.*

Figure 4.12a and 4.12b. Snapshots of Alejandra familiar walkway in Scottsdale (ASU, 2018), highlighting the role of design elements, cloud cover, wind, and expectation of comfort in walking experience.

Latent Dirichlet Allocation and Topic Modeling

Latent Dirichlet Allocation (LDA) is a popular method in the Bayesian framework for uncovering hidden "topics" or themes that are discussed within a set of reviews or commentaries (Blei & Lafferty, 2009). The way LDA works is that it assumes all narratives share the same common topics. However, each narrative could include a different combination of the topics with specific words included in the narrative only in the presence of a latent topic. In my research setting, the LDA outputs provided information on the probability distribution of topics for a given narrative, and the probability distribution of words that are in those topics.

Preprocessing and text representation

Following the procedures outlined above, I converted narrative to lowercase, removed common stop words, stemmed the words, and removed words that occurred very frequently or very rarely. I also removed any punctuation in the narrative. Table 4.1 demonstrates this process with a comparison of the original narrative and post-processed narrative.

Table 4.1
Text processing

"So I like this one because this is really pretty with the mix of brick and I guess urban planning with the plants and such it's kind of cool outside, I'm not a big cool guy, so I like warmer weather so it's be nice if it were warmer but I do like the feeling of sunlight but also shade at the same time. If you walk over here there's shade and you walk over there in sunlight this water feature is pretty I think this is just such a gorgeous part of campus this route here is so pretty just the way they planned the landscape around here and bushes and the trees mix and this greenery right here but also there is some urban brick layout so this is really pretty, I probably go this way, just the architecture it's a great great walk besides the coolness."
lik becaus real prett mix brick guess urban plan plants such kind cool outside big cool guy lik warm weather nice warm lik feel sunlight shade same time walk over here shade walk over sunlight water featur prett think such georgous part campus route prett way plan landscap around bush tree mix green urban brick layout prett probab go way architect great walk cool

" This is my unfamiliar route I walked from Giles Hall to the student union through the junction it's pretty cold my hands are actually frozen as I begin this video this way is actually a little warmer because i'm not walking throughout building so there's some sunlight hitting me instead of just shadow and be hidden the trees created dark shade but over there you see the buildings hanging in there small building some dorms so there are tall buildings it creates a bigger and more in depth architectural space."

Unfam rout walk Giles hall student union junction prett cold hand actual frozen begin vid way actual little warm because walk throughout building sunlight hit instead shadow hid tree creat dark shade building hang small building dorm tall building creat big depth architect spac

---

Topic Modeling

Using the LDA model described above, I applied Gibbs sampling for the main computation. Running the LDA algorithm gave me the posterior probabilities of words appearing in each topic. These probabilities capture how likely a word would belong to a specific topic. One crucial caveat in utilizing the LDA model is that users are required to decide on the number of topics in which the algorithm will run. I varied the number of topics and reviewed the output for a specified number of topics. I then applied my judgment and intuition and decided that two topics gave me the best estimates. The LDA algorithm's output is in table 4.2, which includes the top 10 words for a specific topic. From this table, I interpret the topics as follows:

Topic 1 (Internal, Subjective Perception and Experience). The terms "comfort, cozy, safe, familiar, sunny, nice" are all associated with a person's experience.

Topic 2 (External, Weather and Environmental judgments). The terms "trees, shade, outside, downtown, neighborhood" describes the weather and environmental dimensions.

Table 4.2
LDA output

TERM	TOPIC 1	TOPIC 2
1	comfort	tree
2	walking	street
3	familiar	weather
4	feel	Story
5	sunny	car
6	hot	house
7	shading	apartment
8	warm	plants
9	pretty	palm
10	nice	sky

Summary

After reviewing the transcripts (N=423) and completing thematic analysis on the data, certain themes appeared. I explained a number of those themes in this chapter, however, there are more such as, Landscape/Greenery**,** Openness, Distance, Interplay of Sun and Wind, Safety, Clothing, Crowdedness, Shade, Temperature, Humidity, Quietness, Nostalgia, Cloud Cover, AC Exposure, Physiological Response, Cleanliness**,** Presence of Parking an Cars.

The results from LDA suggest two dimensions to the narrative; a subjective internal dimension, and an objective external dimension. This is in line with findings from thematic analysis as the themes discovered are consistent. Topics such as aesthetic/scenery, design characteristics from thematic analysis fall in the category of objective external dimension of LDA. Topics including thermal choice/preference, nostalgia and memory, and expectation fall in the category of subjective internal dimension of LDA. Therefore, the two forms of analyses (although different in nature) supported the influence of subjective psychological factors on thermal perception.

Quantitative Data Findings

The purpose of quantitative phase of this research is to investigate the main research question regarding the impact of familiarity (long term vs short term memory) on thermal perception. The design and inquiry for the quantitative survey was revolved around answering the below questions:

1- Does familiarity impact thermal perception, controlling for weather and physical conditions?

2- Does long-term memory affect short-term thermal sensation?

3- What physical and spatial elements of the streetscape influence the momentary and long-term thermal perception of pedestrians?

Therefore, through designing a three-step survey questionnaire, I collected survey data on familiar, unfamiliar, and comparison conditions. The breakdown of data collections, the academic institution, the scale of data collection, the time period, when data collection occurred and the number of entries for the quantitative data can be seen in table 4.3.

Table 4.3
Breakdown of data collection cycles with familiar and unfamiliar surveys

Data Collection	University	Scale	Date Collected	Familiar	Unfamiliar
Spring 2018 (Online)	ASU	Worldwide	02/27/2018-03/01/2018	97	91
Summer 2018 (Online)	ASU	Worldwide	06/24/2018-06/27/2018	26	31
Fall 2018 (Online)	ASU	Worldwide	09/29/2018-10/05/2018	124	136
Fall 2018 (In-Person)	ASU	Tempe	11/19/2018-12/01/2018	216	214
Fall 2019 (In-Person)	MSU	Starkville	11/22/2019-12/03/2019	64	74
Total				527	546

Statistical Procedures

In processing the quantitative data, I have employed several different statistical analyses in order to find relationships amongst sets of data. These statistical operations include correlations, T-Test, ANOVA, and regressions. I start by discussing the demographic.

Demographic Characteristic

Table 4.4 shows the sample for this study (N=507) and different dimension of demographics of them. As noted in the previous chapter, since this experiment was conducted as an extra credit assignment, the population is rather young with over 83% under 23 years old, and more than 93% under 28 years old. The sample also is made of 43% Caucasian and 31.95% Asian. The other races do not have robust presence in this sample. All participants were by default university students, however, some self-reported having college degrees prior to completing this assignment. The sample also includes 64.09% male participants and 35.52% female participants, and a total of 0.40% who prefer not to indicate their gender. In terms of work status, more than half of the population (55.82%) were not employed, full time student. The second largest group 23.67%) is the full-time students who were part time employed.

Table 4.4
Demographic information: Age, Ethnicity, Degree, Gender, and Work Status

Age	Frequency	Percent
<18	3	0.59
18-22	419	82.64
23-27	49	9.66
28-32	22	4.34
>32	14	2.76
Total	507	100.00
Ethnicity		
Caucasian	218	43.00
Hispanic	61	12.03
Native American	7	1.38
African American	22	4.34
Asian	162	31.95
Middle Eastern	9	1.78
Caribbean	18	3.55
Mixed	10	1.97
Total	507	100.00
Degree		
Some College	393	77.51
Bachelor’s Degree	56	11.05
Other	58	11.44
Total	507	100.00
Gender		
Male	323	64.09
Female	179	35.52
Prefer not to say	2	0.40
Total	504	100.00
Work Status		
Employed Full-time, Student Full-time	56	11.05
Employed Full-time, Student Part-time	18	3.55
Employed Part-time, Student Full-time	120	23.67
Employed Part-time, Student Part-time	16	3.16
Not Employed, Full-time Student	283	55.82
Not Employed, Part-time Student	12	2.37
Other	2	0.39
Total	507	100.00

The Impact of Familiarity (Long-Term Memory) on Thermal Comfort

The first research question in my study is whether familiarity (long-term memory) has an impact on thermal comfort. In order to answer this question, I employed a T-Test to compare the means of thermal comfort collected from participants in two conditions: the familiar street and unfamiliar street. The question representing this statement in the survey reads as "How comfortable do you rate this walk-in terms of temperature?" Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled for. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.5 shows the result of the T-Test analysis between the familiar and unfamiliar group.

Table 4.5
T-Test: Difference in Reported Thermal Comfort

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	3.6337	0.0555045	1.296955	3.524671	3.742729
Familiar	526	3.910646	0.0506628	1.161936	3.81112	4.010173
Combined	1,072	3.76959	0.0378647	1.239744	3.695292	3.843887
diff		-0.2769468	0.0753035		-0.424706	-0.1291875

Based on T-Test output from STATA, ($t = -3.6777$, degrees of freedom=1070), there is a significant difference between the means of familiar and unfamiliar group in their thermal comfort $Pr(|T| > |t|) = 0.0002$. In this case, the p value is much lower than the standard significance of 0.05, revealing a strong evidence in line with my prediction that pedestrians are generally thermally more comfortable in familiar environment.

The Impact of Familiarity on Pleasantness

In order to assess other perceptual factors influential on overall walking experience, I included a number of questions aiming at measuring the degree of these spatial factors in different streetscapes and find potential differences in familiar vs unfamiliar streets. Pleasantness was one the questions on the survey. In other words, my goal was to find out whether perception of pleasantness has an impact on overall walking experience. Here, I employed a T-Test to compare the means data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as "How pleasant do you rate your overall experience in this one-minute walk?". Given the setting of the experiments, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.6 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of pleasantness.

Table 4.6
T-Test: Difference in Pleasantness

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	3.822344	0.0465125	1.086842	3.730979	3.91371
Familiar	526	4.220532	0.0402967	0.924192	4.14137	4.299695
Combined	1,072	4.017724	0.031437	1.029292	3.956039	4.079409
diff		-0.398188	0.0617255		-0.519305	-0.2770713

The results from the T-Test (t = -6.4509, degrees of freedom=1070) shows that there is a significant difference between the means of familiar and unfamiliar group in their vote of pleasantness Pr (|T| > |t|) = 0.0000. In this case, the p value is much lower than the standard significance of 0.05.

The Impact of Familiarity (Long-Term Memory) on Overall Comfort

Another dimension explored in the survey was the impact of psychological factors on overall walking experience. The question representing this topic in the survey was "How comfortable do you rate your overall one-minute walking experience?". In this case, the independent variable is familiarity (Long-term memory) and the dependent variable is overall comfort. Table 4.7 shows the T-Test descriptive statistics between familiarity and overall comfort levels reported by the participants.

Table 4.7
T-Test: Difference in Overall Comfort

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	3.545788	0.0534257	1.248379	3.440842	3.650733
Familiar	526	4.203422	0.0475827	1.091294	4.109946	4.296898
Combined	1,072	3.86847	0.0372193	1.218613	3.795439	3.941501
diff		-0.6576345	0.0717219		-0.798366	-0.516903

The results from the T-Test ($t = -9.1692$, degrees of freedom=1070) shows that there is a significant difference between the means of familiar and unfamiliar group in their vote of overall comfort $Pr(|T| > |t|) = 0.0000$. In this case, the p value is much lower than the standard significance of 0.05.

The Impact of Familiarity on the Perception of Safety

An integral aspect of my research entailed exploring the choice of walkway from spatial and environmental factors. In order to investigate the effect of environmental factors on choice, I included several questions in the survey aiming to find out any potential difference that these environmental factors can make. Safety was one the questions on the survey. Therefore, I employed a T-Test to compare the means data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as "To what extent Safety was a reason for you to choose this walkway?”. Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.8 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of safety. The independent variable is safety and the dependent variable is familiarity (long-term memory).

Table 4.8
T-Test: Difference in Safety

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	454	1.72467	0.0355956	0.758446	1.654717	1.794623
Familiar	527	2.049336	0.049116	1.127531	1.952848	2.145823
Combined	981	1.899083	0.0315178	0.987167	1.837232	1.960933
diff		-0.3246663	0.0623861		-0.447092	-0.2022403

The results from the T-Test ($t = 5.2041$, degrees of freedom=979) shows that there is a significant difference between the means of familiar and unfamiliar group in their thermal comfort $Pr(|T| > |t|) = 0.0000$. In this case, the p value is much lower than the standard significance of 0.05.

Factors with no Significant Relationship

Among the factors explored in the surveys, several questions resulted in p values larger than 0.05 which shows no significant relationship with any factors. The following factors provide T-Tests analyses with no significant differences.

The Impact of Familiarity on the Perception of Weather

Another dimension explored in the survey was the impact of psychological factors on the perception of weather. The question representing this topic in the survey was “How do you rate the weather in this one-minute walk?”. In this case, the independent variable is the perception of weather and the dependent variable is familiarity (Long-term memory). Table 4.9 shows the T-Test descriptive statistics between familiarity and overall comfort levels reported by the participants.

Table 4.9
T-Test: Difference in Perception of Weather

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	455	4.487912	0.089039	1.899272	4.312932	4.662892
Familiar	429	4.582751	0.091413	1.893368	4.403077	4.762424
Combined	884	4.533937	0.063767	1.895928	4.408784	4.659089
diff		-0.09484	0.127622		-0.34532	0.155639

The results from the T-Test (t = -0.7431, degrees of freedom=882) shows that there is no significant difference between the means of familiar and unfamiliar group in their perception on weather, Pr (|T| > |t|) = 0.4576. In this case, the p value is much higher than the standard significance of 0.05. Therefore, any thermal comfort difference between the familiar and unfamiliar conditions are not due to perception of weather as participants generally perceived the weather in both conditions very similarly.

The Impact of Familiarity on Thermal Preference

Another dimension explored in the survey was the impact of psychological factors on thermal preference. The question representing this topic in the survey was "How do you prefer this weather to be? In other words, in what condition do you think you would feel more comfortable?". In this case, the independent variable is familiarity (Long-term memory) and the dependent variable is thermal preference. Table 4.10 shows the T-Test descriptive statistics between for thermal preference by familiarity reported by the participants.

Table 4.10
T-Test: Difference in Thermal Preference

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	455	3.830769	0.062927	1.342272	3.707106	3.954433
Familiar	429	3.780886	0.06448	1.335535	3.654148	3.907623
Combined	884	3.806561	0.045018	1.338481	3.718206	3.894916
diff		0.049883	0.09011		-0.12697	0.226739

The results from the T-Test (t = 0.5536, degrees of freedom=882) shows that there is no significant difference between the means of familiar and unfamiliar group in their thermal preference Pr (|T| > |t|) = 0.5800. In this case, the p value is much higher than the standard significance of 0.05.

The Impact of Familiarity on Boringness

Another dimension explored in the survey was the impact of psychological factors on thermal preference. The question representing this topic in the survey was “How boring do you rate your overall experience in this one-minute walk?”. In this case, the independent variable is familiarity (Long-term memory) and the dependent variable is boringness. Table 4.11 shows the T-Test descriptive statistics for boringness by familiarity reported by the participants.

Table 4.11
T-Test: Difference in Boringness

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	3.844322	0.0473006	1.105256	3.751409	3.937236
Familiar	527	3.857685	0.0502634	1.153871	3.758943	3.956427
Combined	1,073	3.850885	0.0344628	1.128887	3.783263	3.918508
diff		-0.0133627	0.0689674		-0.148689	0.1219639

The results from the T-Test (t = 0.1938, degrees of freedom=1071) shows that there is no significant difference between the means of familiar and unfamiliar group in their boringness, Pr (|T| > |t|) = 0.0000. In this case, the p value is much higher than the standard significance of 0.05.

The Impact of Familiarity on Perception of Health

Another dimension explored in the survey was the impact of physiological condition on reported thermal comfort. Therefore, I included a question in the survey to find out any possible difference that this physiological factor can make. Here, I employed a T-Test to compare the means of data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as "How do you rate your overall health-related mood?". Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.12 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of health condition.

Table 4.12
T-Test: Difference in Health Condition

Group	**Obs**	**Mean**	**Std. Err.**	**Std. Dev.**	**[95% Conf.**	**Interval]**
Unfamiliar	455	4.103297	0.035076	0.748192	4.034366	4.172228
Familiar	430	4.113953	0.038499	0.798332	4.038283	4.189624
Combined	885	4.108475	0.025969	0.77254	4.057507	4.159442
diff		-0.01066	0.051986		-0.11269	0.091374

The results from the T-Test (t=-0.2050, degrees of freedom=883) shows that there is no significant difference between the means of familiar and unfamiliar group in their health condition, Pr (|T| > |t|) = 0.0000. In this case, the p value is higher lower than the standard significance of 0.05.

The Impact of Familiarity on the Perception of Crowdedness

In order to investigate the effect of psychological factors, I included several questions in the survey to find out any possible difference that these psychological factors can make. Thus, I employed a T-Test to compare the means of data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as "To what extent crowdedness was a reason for you to choose this walkway?". Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.13 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of crowdedness.

Table 4.13
T-Test: Difference in crowdedness

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	2.558608	0.062291	1.455533	2.436248	2.680968
Familiar	527	2.565465	0.064283	1.475717	2.439181	2.691748
Combined	1,073	2.561976	0.044718	1.464801	2.474232	2.64972
diff		-0.00686	0.089491		-0.18245	0.16874

The results from the T-Test ($t = -0.0766$, degrees of freedom=1071) shows that there is no significant difference between the means of familiar and unfamiliar group in their vote of crowdedness. $Pr(|T| > |t|) = 0.9389$. In this case, the p value is much higher than the standard significance of 0.05.

The Impact of Familiarity on the Perception of Cloud Cover

In order to investigate the effect of psychological factors, I included several questions in the survey aiming at finding out any possible difference that these psychological factors can make. Cloud cover as an meteorological factor (whether there is overcast or not) was differentiated from "shading" which is a spatial factor caused by trees, buildings, and shade structures. Thus, I employed a T-Test to compare the means of data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as "What side of the pathway (Sunny vs Shady) did you choose to walk in?". Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.14 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of cloud cover.

Table 4.14
T-Test: Difference in Street Side

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	544	3.272059	0.056822	1.325299	3.160441	3.383676
Familiar	518	3.233591	0.05603	1.275218	3.123517	3.343665
Combined	1,062	3.253296	0.039911	1.300643	3.174982	3.33161
diff		0.038468	0.079875		-0.11826	0.1952

The results from the T-Test ($t = 0.4816$, degrees of freedom=1060) shows that there is no significant difference between the means of familiar and unfamiliar group in their thermal comfort $Pr(|T| > |t|) = 0.6302$. In this case, the p value is much higher than the standard significance of 0.05.

The Impact of Familiarity on the Perception of Scenery

In order to investigate the effect of spatial design factors, I included several questions in the survey aiming at finding out any possible difference that these psychological factors can make. Safety was one the questions on the survey. In other words, my goal was to find out whether perception of scenery has an impact on people choosing a pathway and using that for an extend period of time. Here, I employed a T-Test to compare the means data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as "Was Scenery a reason for you to choose this walkway?". Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.15 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of scenery.

Table 4.15
T-Test: Difference in Perception of Scenery

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	0.507326	0.021415	0.500405	0.465259	0.549393
Familiar	528	0.528409	0.021745	0.499666	0.485691	0.571127
Combined	1,074	0.517691	0.015255	0.49992	0.487759	0.547623
diff		-0.02108	0.030521		-0.08097	0.038804

The results from the T-Test ($t = -0.6908$, degrees of freedom=1072) shows that there is no significant difference between the means of familiar and unfamiliar group in their thermal comfort $Pr(|T| > |t|) = 0.4899$. In this case, the p value is much higher than the standard significance of 0.05.

The Impact of Familiarity on the Perception of Shading

In order to investigate the effect of spatial design factors, I included several questions in the survey aiming at finding out any possible difference that these psychological factors can make. Safety was one the questions on the survey. In other words, my goal was to find out whether perception of shading has an impact on people choosing a pathway and using that for an extend period of time. Here, I employed a T-Test to compare the means data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as “Was shading a reason for you to choose this walkway?”. Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.16 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of safety.

Table 4.16
T-Test: Difference in shading

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	0.35348	0.020477	0.478488	0.313256	0.393704
Familiar	528	0.369318	0.021023	0.483078	0.328019	0.410618
Combined	1,074	0.361266	0.014665	0.480591	0.332492	0.390041
diff		-0.01584	0.029343		-0.07342	0.041738

The results from the T-Test (t =-0.5398, degrees of freedom= 1072) shows that there is no significant difference between the means of familiar and unfamiliar group in their thermal comfort $Pr(|T| > |t|) = 0.5895$. In this case, the p value is much higher than the standard significance of 0.05.

The Impact of Familiarity on the Perception of Access to Retail Store

In order to investigate the effect of psychological factors, I included several questions in the survey aiming at finding out any possible difference that these psychological factors can make. Access to retail store was one the questions on the survey. In other words, my goal was to find out whether perception of safety has an impact on people choosing a pathway and using that for an extend period of time. Here, I employed a T-Test to compare the means data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as “Was access to retail store was a reason for you to choose this walkway?”. Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.17 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of safety

Table 4.17
T-Test: Difference in Access to Retail Store

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	0.100733	0.012892	0.30125	0.075408	0.126057
Familiar	528	0.104167	0.013307	0.305766	0.078026	0.130308
Combined	1,074	0.102421	0.009256	0.303342	0.084259	0.120583
diff		-0.00343	0.018523		-0.03978	0.032912

The results from the T-Test (t=-0.1854, degrees of freedom=-0.1854) shows that there is no significant difference between the means of familiar and unfamiliar group in their thermal comfort Pr (|T| > |t|) =0.8530. In this case, the p value is much higher than the standard significance of 0.05.

The Impact of Familiarity on the Perception of Other Spatial Factors

Other Spatial Factors was another question on the survey. In other words, my goal was to find out whether perception of other spatial factors has an impact on people choosing a pathway and using that for an extend period of time. Here, I employed a T-Test to compare the means data collected from participants in two streets; the familiar street and unfamiliar street. The question representing this issue in the survey reads as "Was other environmental design factors a reason for you to choose this walkway?". Given the survey asked the students to walk in these two streets one after the other, the premise is that the weather and personal factors in thermal comfort are controlled. Therefore, any significance between the means of these two groups will indicate a meaningful statistical relationship. Table 4.18 shows the T-Test descriptive statistics between the familiar and unfamiliar group and their vote of other spatial factors.

Table 4.18
T-Test: Difference in other spatial factors

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
Unfamiliar	546	0.278388	0.019199	0.448617	0.240675	0.316101
Familiar	528	0.284091	0.019645	0.451408	0.245499	0.322683
Combined	1,074	0.281192	0.013725	0.44979	0.254261	0.308122
diff		-0.0057	0.027466		-0.0596	0.04819

The results from the T-Test (t = -0.2076, degrees of freedom=1072) shows that there is no significant difference between the means of familiar and unfamiliar group in their thermal comfort Pr (|T| > |t|) = 0.8356. In this case, the p value is much higher than the standard significance of 0.05.

Examining the Role of Time and Location on the Effect of Familiarity on Thermal comfort: Comparison Across Rounds of Data – ANOVA

Given the data was collected during five cycles, I conducted ANOVA (Analysis of variance) to compare the thermal comfort among data cycles. Table 4.19 shows the means of thermal comfort for each data collection cycle, standard deviation and frequencies. Table 4.20 shows the Analysis of Variance for the entire dataset looking at every subset of data.

Table 4.19
Means of Thermal Comfort for each collection cycle

Code	Mean	Std. Dev.	Freq.
FALL_18_A	3.884615	1.153371	260
FALL_18_C	4.139535	1.096326	430
FALL_19	3.210145	1.275559	138
SPRING_18	3.304813	1.19952	187
SUM_18	3.333333	1.573592	57
Total	3.76959	1.239744	1,072

Table 4.20
ANOVA: Analysis of Variance: Difference between sub-samples per familiarity and comfort

Source	SS	df	MS	F	Prob > F
Between groups	156.7241	4	39.18103	28.07	0
Within groups	1489.365	1067	1.395843		
Total	1646.089	1071	1.536964		

Bartlett's test for equal variances: chi2(4) = 17.8333 Prob>chi2 = 0.001

`A one-way between subjects ANOVA was conducted to compare the effect of familiarity on thermal comfort for all five data collection cycles. There was a significant effect of familiarity on thermal comfort at the $p<.05$ level for the five conditions [$F(4, 1067) = 28.07$, $p = 0.001$]. This result indicates that temporal and spatial factors may play a role in how pedestrians perceive the temperature in the environment they walk into. As a result, I control for these factors in the main model specification.

Linear Regression Models

In order to investigate the relationship between each variable individually on thermal comfort and collectively on thermal comfort, linear regression model would work best. I have gone through various strategies including randomization of familiar and unfamiliar surveys, and here I have provided linear regression tables with descriptive statistics, with every step adding several variables to ensure the p value is still significant.

It is crucial to incorporate the factors in the regression model that may impact thermal comfort in order to better delineate a relationship between familiarity and thermal comfort. Therefore, I control for a wide variety of factors that can potentially impact the familiarity-thermal comfort relationship. I propose the following model specifications:

$$
\begin{aligned}
\text{Thermal\_Comfort}_t = {} & \\
& \beta_0 + \beta_1 \text{ Familiarity\_Dgree}_t + \\
& \beta_{2\text{-}5} \text{ Semester}_t + \beta_{6\text{-}9} \text{ Time\_Walked}_t + \\
& \beta_{10} \text{ AC\_5min} + \beta_{11} \text{ AC\_30min}_t + \beta_{12} \text{ Clothing\_Layers}_t + \beta_{13\text{-}15} \text{ Clothing\_Type}_t + \\
& \beta_{16} \text{ Cloud\_Cover}_t + \beta_{17} \text{ Crowdedness}_t + \beta_{18} \text{ Buildings}_{t\,+} \beta_{17} \text{ Trees}_t + \\
& \beta_{18} \text{ Walking\_speed}_{t\,+} \beta_{19} \text{ Accompany}_t + \\
& \beta_{20\text{-}23} \text{ Reasons}_t + \varepsilon_{it}
\end{aligned}
$$

where t represents respondents and ε_t is the i.i.d error capturing the idiosyncratic shocks.

Table 4.21 through 4.26 shows the linear regression for the effect of different variables on thermal comfort. Explanation of the regressions are provided following the tables.

Table 4.21
Linear Regression: The effect of familiarity degree on each other on thermal comfort

LINEAR REGRESSION				NUMBER OF OBS		1,072
				F(1, 1070)		12.6
				Prob > F		0.0004
				R-squared		0.0119
				Root MSE		1.2329
Thermal Comfort	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf.**	**Interval]**
Familiarity	0.152271	0.042894	3.55	0	0.068106	0.236436
_cons	3.648284	0.05278	69.12	0	3.544719	3.751849

Results of the multiple linear regression indicated that there was a collective significant effect between the familiarity degree and thermal comfort, (F(1, 1070) =12.6, p < . 0004, R2 = 0. 0119).

Table 4.22
Linear Regression: The effect of Familiarity & Data collection cycle &Walk time on Thermal Comfort

LINEAR REGRESSION				NUMBER OF OBS		1,049
				F(9, 1039)		14.87
				Prob > F		0
				R-squared		0.1189
				Root MSE		1.163
Thermal Comfort	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf.**	**Interval]**
Familiarity	0.114268	0.040426	2.83	0.005	0.034942	0.193595
Data Set						
FALL_18_C	0.227088	0.090226	2.52	0.012	0.050042	0.404134
FALL_19	-0.70548	0.137004	-5.15	0	-0.97431	-0.43664
SPRING_18	-0.57565	0.111783	-5.15	0	-0.795	-0.3563
SUMMER_18	-0.60741	0.228376	-2.66	0.008	-1.05554	-0.15928
Walk Time						
10am-12pm	-0.30633	0.149112	-2.05	0.04	-0.59893	-0.01374
12-2pm	-0.45026	0.14163	-3.18	0.002	-0.72817	-0.17235
2-4pm	-0.15262	0.12935	-1.18	0.238	-0.40644	0.101194
After 4pm	-0.2555	0.13094	-1.95	0.051	-0.51244	0.001437
_cons	4.062188	0.133994	30.32	0	3.799257	4.325118

Results of the multiple linear regression indicated that there was a collective significant effect between the familiarity degree, data collection cycle, walk time and thermal comfort, ($F(9, 1039) = 14.87$, $p < 0$, $R2 = 0.\ 11$

Table 4.23
Linear Regression: The effect of Familiarity & Data collection cycle &Walk time &AC Exposure & Clothing Layers & Clothing Type on Thermal Comfort

LINEAR REGRESSION	NUMBER OF OBS	1,018
	F(15, 1002)	10.79
	Prob > F	0
	R-squared	0.1379
	Root MSE	1.147

Thermal Comfort	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Familiarity	0.135422	0.040303	3.36	0.001	0.056335	0.214509
Data Set						
FALL_18_C	0.214292	0.099344	2.16	0.031	0.019346	0.409239
FALL_19	-0.69203	0.146863	-4.71	0	-0.98023	-0.40384
SPRING_18	-0.824	0.152048	-5.42	0	-1.12237	-0.52563
SUMMER_18	-0.83769	0.34164	-2.45	0.014	-1.5081	-0.16727
Walk Time						
10am-12pm	-0.26748	0.150831	-1.77	0.076	-0.56346	0.028503
12-2pm	-0.43124	0.143523	-3	0.003	-0.71288	-0.1496
2-4pm	-0.11975	0.132263	-0.91	0.365	-0.37929	0.139797
After 4pm	-0.20724	0.132312	-1.57	0.118	-0.46688	0.052404
AC Exposure						
AC_5min	-0.20453	0.089889	-2.28	0.023	-0.38092	-0.02814
AC_30min	-0.21543	0.097312	-2.21	0.027	-0.40639	-0.02447
Clothing Layers	-0.07958	0.063604	-1.25	0.211	-0.2044	0.045229
Clothing Type						
Woolen	-0.18264	0.145709	-1.25	0.21	-0.46857	0.103289
Leather	0.107643	0.159254	0.68	0.499	-0.20487	0.420152
Other	-0.17394	0.157961	-1.1	0.271	-0.48391	0.136035
_cons	4.404022	0.176754	24.92	0	4.057171	4.750873

Results of the multiple linear regression indicated that there was a collective significant effect between the familiarity degree, data collection cycle, walk time, AC exposure, clothing layers, clothing type and thermal comfort, ($F(15, 1002) =10.79$, $p < 0$, $R2 = 0.\ 1379$).

Table 4.24
Linear Regression: The effect of Familiarity & Data collection cycle &Walk time &AC Exposure & Clothing Layers & Clothing Type & Environmental Design Factors on Thermal Comfort

LINEAR REGRESSION	NUMBER OF OBS	1,018
	F(19, 998)	9.15
	Prob > F	0
	R-squared	0.146
	Root MSE	1.1438

Thermal Comfort	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Familiarity	0.132298	0.040224	3.29	0.001	0.053365	0.211231
Data Set						
FALL_18_C	0.198263	0.099669	1.99	0.047	0.002679	0.393847
FALL_19	-0.69211	0.144852	-4.78	0	-0.97636	-0.40786
SPRING_18	-0.81449	0.153587	-5.3	0	-1.11588	-0.5131
SUMMER_18	-0.8337	0.347296	-2.4	0.017	-1.51521	-0.15218
Walk Time						
10am-12pm	-0.25641	0.150586	-1.7	0.089	-0.55191	0.03909
12-2pm	-0.43497	0.143139	-3.04	0.002	-0.71586	-0.15409
2-4pm	-0.11413	0.131682	-0.87	0.386	-0.37253	0.144275
After 4pm	-0.2383	0.133163	-1.79	0.074	-0.49961	0.023012
AC Exposure						
AC_5min	-0.20782	0.089753	-2.32	0.021	-0.38395	-0.03169
AC_30min	-0.20116	0.097482	-2.06	0.039	-0.39245	-0.00986
Clothing Layers	-0.09137	0.064157	-1.42	0.155	-0.21727	0.034527
Clothing Type						
Woolen	-0.18631	0.14853	-1.25	0.21	-0.47778	0.105155
Leather	0.092619	0.15876	0.58	0.56	-0.21892	0.40416
Other	-0.1636	0.156549	-1.05	0.296	-0.4708	0.143601
Spatial Factors						
Cloud Cover	0.040225	0.030653	1.31	0.19	-0.01993	0.100375
Crowdedness	0.009972	0.026951	0.37	0.711	-0.04292	0.06286
Surrounding Building	-0.02726	0.028834	-0.95	0.345	-0.08384	0.029325
Trees	0.072151	0.028523	2.53	0.012	0.016178	0.128123
_cons	4.122265	0.216678	19.02	0	3.697068	4.547462

Results of the multiple linear regression indicated that there was a collective significant effect between the familiarity degree, data collection cycle, walk time, AC exposure, clothing layers, clothing type, environmental design factors and thermal comfort, ($F(19, 998)=9.15$, $p < 0$, $R2 = 0.146$).

Table 4.25
Linear Regression: The effect of Familiarity & Data collection cycle &Walk time &AC Exposure & Clothing Layers & Clothing Type &Spatial Factors &Walking Speed & Accompanying on Thermal Comfort

LINEAR REGRESSION	NUMBER OF OBS	1,018
	F(21, 996)	8.57
	Prob > F	0
	R-squared	0.1503
	Root MSE	1.1421

Thermal Comfort	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Familiarity	0.134448	0.040081	3.35	0.001	0.055796	0.213099
Data Set						
FALL_18_C	0.199656	0.101505	1.97	0.049	0.000467	0.398844
FALL_19	-0.67127	0.145309	-4.62	0	-0.95642	-0.38613
SPRING_18	-0.8253	0.154327	-5.35	0	-1.12815	-0.52246
SUMMER_18	-0.82322	0.347638	-2.37	0.018	-1.50541	-0.14103
Walk Time						
10am-12pm	-0.25503	0.148806	-1.71	0.087	-0.54704	0.03698
12-2pm	-0.44755	0.142752	-3.14	0.002	-0.72768	-0.16743
2-4pm	-0.12776	0.13099	-0.98	0.33	-0.38481	0.129288
After 4pm	-0.25309	0.132237	-1.91	0.056	-0.51259	0.006404
AC Exposure						
AC_5min	-0.22126	0.089263	-2.48	0.013	-0.39642	-0.04609
AC_30min	-0.20043	0.097512	-2.06	0.04	-0.39178	-0.00908
Clothing Layers	-0.08195	0.064267	-1.28	0.203	-0.20807	0.044164
Clothing Type						
Woolen	-0.21665	0.149696	-1.45	0.148	-0.5104	0.077105
Leather	0.028012	0.164821	0.17	0.865	-0.29542	0.351447
Other	-0.19167	0.156415	-1.23	0.221	-0.49861	0.11527
Spatial Factors						
Street Side (Sunny)	0.039157	0.030691	1.28	0.202	-0.02107	0.099384
Crowdedness	0.011827	0.027045	0.44	0.662	-0.04124	0.064899
Surrounding Building	-0.02902	0.028714	-1.01	0.312	-0.08537	0.027326
Trees	0.07411	0.028536	2.6	0.01	0.018112	0.130108
Walking Speed	-0.06737	0.052963	-1.27	0.204	-0.17131	0.036558
Accompanying	0.140219	0.078496	1.79	0.074	-0.01382	0.294256

_cons	4.291189	0.271951	15.78	0	3.757526	4.824852

Results of the multiple linear regression indicated that there was a collective significant effect between the familiarity degree, data collection cycle, walk time, AC exposure, clothing layers, clothing type, spatial factors, walking speed, accompanying, and thermal comfort, ($F(21, 996)=8.57$, $p < 0$, $R2 = 0.1503$).

Table 4.26
Linear Regression: The effect of Familiarity & Data collection cycle &Walk time &AC Exposure & Clothing Layers & Clothing Type & Spatial Factors &Walking Speed & Accompanying & Environmental Factors on Thermal Comfort

NUMBER OF OBS	**1,018**	
	F(25, 992)	8.34
	Prob > F	0
	R-squared	0.1601
	Root MSE	1.1378

Thermal Comfort	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf.**	**Interval]**
Familiarity	0.132646	0.039912	3.32	0.001	0.054325	0.210968
Data Set						
FALL_18_C	0.218849	0.102667	2.13	0.033	0.01738	0.420319
FALL_19	-0.65329	0.144533	-4.52	0	-0.93692	-0.36966
SPRING_18	-0.79523	0.156154	-5.09	0	-1.10166	-0.4888
SUMMER_18	-0.86162	0.345794	-2.49	0.013	-1.54019	-0.18305
Walk Time						
10am-12pm	-0.25194	0.149076	-1.69	0.091	-0.54448	0.040597
12-2pm	-0.44526	0.142581	-3.12	0.002	-0.72506	-0.16547
2-4pm	-0.13406	0.130877	-1.02	0.306	-0.39089	0.122765
After 4pm	-0.24539	0.132608	-1.85	0.065	-0.50562	0.014832
AC Exposure						
AC_5min	-0.22502	0.089165	-2.52	0.012	-0.39999	-0.05005
AC_30min	-0.20142	0.096832	-2.08	0.038	-0.39144	-0.0114
Clothing Layers	-0.0857	0.064156	-1.34	0.182	-0.2116	0.040195
Clothing Type						
Woolen	-0.23991	0.150063	-1.6	0.11	-0.53439	0.054564
Leather	0.055152	0.165699	0.33	0.739	-0.27001	0.380313
Other	-0.16681	0.159267	-1.05	0.295	-0.47935	0.14573
Spatial Factors						

Street Side (Sunny)	0.033737	0.030638	1.1	0.271	-0.02639	0.093859
Crowdedness	0.00462	0.027161	0.17	0.865	-0.04868	0.057919
Surrounding Building	-0.03592	0.029205	-1.23	0.219	-0.09323	0.021395
Trees	0.070562	0.029691	2.38	0.018	0.012298	0.128825
Walking Speed	-0.0632	0.052859	-1.2	0.232	-0.16693	0.040531
Accompanying	0.121564	0.078203	1.55	0.12	-0.0319	0.275025
Environmental Factors						
Scenery	0.156941	0.087516	1.79	0.073	-0.0148	0.328679
Shading	0.285065	0.083362	3.42	0.001	0.121479	0.448651
Retails Access	0.143101	0.122117	1.17	0.242	-0.09654	0.382737
Other	0.192357	0.102776	1.87	0.062	-0.00933	0.39404
_cons	4.085535	0.282466	14.46	0	3.531237	4.639834

Results of the multiple linear regression indicated that there was a collective significant effect between the familiarity degree, data collection cycle, walk time, AC exposure, clothing layers, clothing type, spatial factors, walking speed, accompanying, Environmental Factors, and thermal comfort, ($F(25, 992)$)=8.34, $p < 0$, $R2 = 0.1601$).

Robustness Check

As a robustness check, I re-run all the regression models using a binary familiarity variable, where Familiarity takes the value of 1 if the participant is in a familiar environment and takes the value of 0 if the participant is in an unfamiliar environment. The results remain consistent across all the models indicating further support for this newly investigated effect.

CHAPTER 5 DISCUSSION

Upon completion of thematic analysis and Latent Dirichlet Allocation on the qualitative data, results suggest that there are two main dimensions to thermal perception and thermal comfort. One of these dimensions is an objective external aspect, where participants observed, explored and perceived and responded to. These parameters are typically quantifiable. Meteorological factors including temperature, humidity, cloud cover, wind speed and design characteristics including landscape design, scenery, building form, and material make up this category.

The other dimension is the subjective internal aspect that varies from one individual to another. Several participants discussed their expectation of a thermal environment and some described notions of nostalgia and stated how that affected their experience of the environment. The findings clearly suggest a linkage between the subjective aspect of thermal perception and reported thermal comfort. This is in line with previous research conducted by (Vasilikou, 2014; Lenzholzer & de Vries, 2020).

The quantitative findings suggest that several factors are influential on thermal comfort. Familiarity (Long-term memory), pleasantness and safety are among the psychological factors that have a correlation based on my population. Results of the multiple linear regression indicated that there was a collective significant effect between the familiarity degree, data collection cycle, walk time, AC exposure, clothing layers, clothing type, spatial factors, walking speed, accompanying, Environmental Factors, and thermal comfort, $(F(25, 992))=8.34$, $p < 0$, $R2 = 0. 1601$). This means that among the various variables tested for changes in thermal comfort, familiarity maintained its effect in the presence and absence of other variables.

Results revealed that spatial familiarity (as a psychological adaptation factor) has a significant relationship for both overall comfort and thermal comfort within outdoor environments. Moreover, the findings revealed that long-term memory (familiarity) affects the momentary thermal sensation, consistent with research in environmental psychology (Pezdek et al., 1989). The statistical analyses also shed light on the relationship between several design characteristics such as safety, pleasantness, and various spatial factors and overall comfort level.

The findings from the narrative analysis highlight the importance of weather conditions and thermal comfort as essential factors for use and sustainability in outdoor urban spaces, in line with previous research (Zacharias et al., 2016; Nikolopoulou et al., 2001; Thorsson et al., 2004; Eliasson et al., 2007). It is now evident that with global warming and climate change, the design of outdoor spaces needs to be even more considerate of meteorological factors as well as personal factors that are based on context and climate. My dissertation focused on bridging this gap to address the significance and relevance of both meteorological and personal factors together.

This study as an effort to use mixed-method in order to comprehensively understand the effect of spatial aspects on thermal perception, showed a balanced view of the objective and subjective aspects associated with thermal perception, consistent with literature (S. Lenzholzer et al., 2018). Qualitative methods typically entail interviews, and the quantitative methods may include meteorological measurements of physical environments and/or surveys from participants. Among many mixed-methods studies examined thermal perception from an in-motion kinetic aspect and utilized both qualitative and quantitative methods (Böcker et al., 2016; C. Vasilikou & Nikolopoulou, 201; K. Vasilikou, 2014). However, qualitative methods were limited to interviews, walks, and observations, they did not include in-depth narrative analysis focused on users' experience. My “thermal walk” research design was created to examine these rich sources of data. The findings from my thermal walk research shed light on how these personal factors impact the thermal perception of individuals in outdoor spaces.

Findings of this study suggest that creating a set of design guideline that combine thermal and spatial aspects is to achieve thermally comfortable urban environments is possible, in line with finding from Lenzholzer et al. (2018). Lenzholzer et al. claimed these are guidelines to design urban spatial features including the shapes of buildings and canopies, materials, configuration, and types of vegetation that influence human thermal perception. My research introduced a number of factors from spatial realm along with temporal and design realms with different coefficients influential on thermal comfort.

Another important issue discussed in my study is the investigation into the long-term thermal perception, which is not much studied so fat. As Lenzholzer et al. (2018) discussed, most studies conducted on outdoor thermal perception were focused on momentary perception. Most of these studies on momentary thermal perception attempted to generate actual sensation “votes” for a particular climatic region or modify and enhance existing thermal prediction indices. As a product of these studies, collective cognitive maps helped provide fundamental knowledge on how individuals assign thermal perception to spatial typologies. The new “thermal walk” method I used helped collect data that can be used to make assessments for both short term and long-term purposes. Findings from my study highlighted the impact of long-term memory on thermal comfort in different settings.

Results from my analysis also supported findings from Lenzholzer et al. (2018) noting that besides the duration of experience (momentary or long-term), the spatial and material qualities of the environment impact thermal perception. Other studies like (Rohles, 1980) also indicated the influence of ambiance and material of the room on indoor thermal perception. In the late 1980s, Griffiths et al. (1987) introduced the notion of "naturalness" as a factor of spatial environment that impact thermal perception, and many researchers adopted this term and utilized it in their work (Nikolopoulou and Lykoudis, 2006; Nikolopoulou and Steemers, 2003; Eliasson et al., 2007). Griffiths (1987), for example, defined naturalness as the degree of artificiality of an environment, which entails other spatial connotations.

The findings from the qualitative analysis also confirm the importance of the complex urban morphology and how that might influence the momentary and long0thermal thermal perception of pedestrians. This is in line with findings from (C. Vasilikou & Nikolopoulou, 2020) ,who investigated how pedestrians walking in a sequence of irregular open spaces might experience thermal variations through changes with a potential reduction in thermal discomfort. Moreover, in a longitudinal inquiry, the authors studied the differences in the thermal experience of urban microclimate as walkers were impacted by a complex urban morphology in the temperature spectrum. The authors concluded that walking acted as a mediator in the juxtaposition of objective measurements of the thermal environment and the subjective human responses. The study concluded that pedestrians' perception of thermal comfort seems to derive from the opposite function of adjacent spaces. They hypothesized that it is not squares or streets that are thermally comfortable or uncomfortable. The variation created by the adjacency of a street to an open space may provide a thermally interesting transition in the urban continuum (C. Vasilikou & Nikolopoulou, 2020).

This study took a step in using self-narrating interviews as a robust method to collect subjective aspects of thermal experience suggest by Sanda Lenzholzer and de Vries (2020). They explained that interviews are necessary for examining the momentary references and preferences relevant to thermal perception, as only participants can verbalize those experiences. In other words, it is not possible to acquire data on these references through inference since behaviors are impacted by many different factors other than thermal perception. The authors suggested that most of the existing work on momentary references and inferences mainly focus on people's mood, perceived control, and reasons for the visit. However, other factors such as vision, sound, and smellscape at a specific moment could influence thermal perception. Studies on human multisensory perception and the concept of "allisethesia" indicated that cues from one sense might affect the perception of a different sense.

Limitation

Overall, the methods and procedure of the study allowed for addressing the research questions. However, some limitations need to be acknowledged.

1- The study sample was a relatively young group (mostly between 18-22), and therefore, the results cannot be directly generalized to all age groups. Also, the participants only represent a sample from ASU and MSU undergraduate students and therefore cannot be fully representative of their entire age group.

2- The experiment(s) were completed during several consecutive days, and no significant extreme weather condition was observed. Therefore, the potential effect of psychological factors on the perception of extreme weather events is still unknown.
3- No meteorological data was collected throughout the data collection. Therefore, the analysis is relied on the survey and qualitative data collected.
4- Given that the participants received the instruction document with information on how to provide their narrative, the confounding bias and priming effect could play a role but were addressed in the qualitative data analysis.

Future Research

This study's analyses revealed that thermal perception is influenced by the long-term memory (perception schemata) for in-movement pedestrians. However, to develop a more comprehensive model, more extensive data on meteorological variables, spatial environmental factors, and extended subjective data from pedestrians (both in movement and stationery) is needed to examine overall thermal experience in the urban environment. Another line of research would entail introducing other psychological factors in the assessment of thermal perception, and measure what extent those factors influence overall thermal comfort of pedestrians.

Furthermore, place-based research projects, where the study only focuses on one particular site, can help explore the more in-depth subjective dimensions of thermal experience. And lastly, the use of mixed methods approaches and employing novel qualitative methods, e.g., grounded theory and phenomenology as complementary approaches to quantitative statistical methods, can provide new insights over how pedestrians perceive the thermal and spatial environments.

REFERENCES

Ahmed, K. S. (2003). Comfort in urban spaces: Defining the boundaries of outdoor thermal comfort for the tropical urban environments. Energy and Buildings, 35(1), 103–110. https://doi.org/10.1016/S0378-7788(02)00085-3

Auliciems, A. (1981). Towards a psycho-physiological model of thermal perception. International Journal of Biometeorology, 25(2), 109–122.

Böcker, L., Dijst, M., & Faber, J. (2016). Weather, transport mode choices and emotional travel experiences. Transportation Research Part A: Policy and Practice, 94, 360–373. https://doi.org/10.1016/j.tra.2016.09.021

Brager, G. S., & de Dear, R. J. (1998). Thermal adaptation in the built environment: A literature review. Energy and Buildings, 27(1), 83–96. https://doi.org/10.1016/S0378-7788(97)00053-4

Brager, G., Paliaga, G., & De Dear, R. (2004). Operable windows, personal control and occupant comfort.

Brewer, W. F., & Treyens, J. C. (1981). Role of schemata in memory for places. Cognitive Psychology, 13(2), 207–230. https://doi.org/10.1016/0010-0285(81)90008-6

Campbell, D. T., & Russo, M. J. (1999). Social experimentation (Vol. 1). Sage Publications, Inc.

Chen, L., & Ng, E. (2012). Outdoor thermal comfort and outdoor activities: A review of research in the past decade. Cities, 29(2), 118–125.

Chun, C., Kwok, A., & Tamura, A. (2004). Thermal comfort in transitional spaces—basic concepts: Literature review and trial measurement. Building and Environment, 39(10), 1187–1192. https://doi.org/10.1016/j.buildenv.2004.02.003

Creswell, J. W. (1999). Mixed-method research: Introduction and application. Handbook of Educational Policy, 455–472.

Creswell, J. W. (2002). Educational research: Planning, conducting, and evaluating quantitative. New Jersey: Upper Saddle River.

Creswell, J. W. (2012). Qualitative inquiry and research design: Choosing among five approaches. Sage.

Creswell, J. W. (2013). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Creswell, J. W. (2013). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Creswell, J. W., & Clark, V. L. P. (2011). Designing and Conducting Mixed Methods Research. SAGE.

Creswell, J. W., Plano Clark, V. L., Gutmann, M. L., & Hanson, W. E. (2003). Advanced mixed methods research designs. Handbook of Mixed Methods in Social and Behavioral Research, 209–240.

de Dear, R. J., & Brager, G. S. (1998). Developing an adaptive model of thermal comfort and preference. 104(Pt 1A), 145–167. Scopus.

Eliasson, I., Knez, I., Westerberg, U., Thorsson, S., & Lindberg, F. (2007). Climate and behaviour in a Nordic city. Landscape and Urban Planning, 82(1), 72–84. https://doi.org/10.1016/j.landurbplan.2007.01.020

Eysenck, M. W. (2006). Fundamentals of cognition.

Fanger, P. O. (1970). Thermal comfort. Analysis and applications in environmental engineering. Thermal Comfort. Analysis and Applications in Environmental Engineering.

Fowler Jr, F. J. (2013). Survey research methods. Sage publications.

Gibson, J. J. (1979). The Theory of Affordances in the Ecological Approach to Visual Perceptual. Houghton Mifflin.

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. Educational Evaluation and Policy Analysis, 11(3), 255–274.

Griffiths, I. D., Huber, J. W., & Baillie, A. P. (1987). Integrating the environment. Proc., Eur. Conf. in Arch.

Höppe, P. (2002). Different aspects of assessing indoor and outdoor thermal comfort. Energy and Buildings, 34(6), 661–665. https://doi.org/10.1016/S0378-7788(02)00017-8

Houghten, F. C., & Yaglou, C. P. (1923). Determining lines of equal comfort. ASHVE Trans, 29, 163–176. Scopus.

Humphreys, R. M. (1994). An adaptive approach to the thermal comfort of office workers in North West Pakistan. Renewable Energy, 5(5–8), 985–992.

Kenny, N. A., Warland, J. S., Brown, R. D., & Gillespie, T. G. (2009). Part B: Revisions to the COMFA outdoor thermal comfort model for application to subjects performing physical activity. International Journal of Biometeorology, 53(5), 429. https://doi.org/10.1007/s00484-009-0227-2

Knez, I. (2005). Attachment and identity as related to a place and its perceived climate. Journal of Environmental Psychology, 25(2), 207–218. https://doi.org/10.1016/j.jenvp.2005.03.003

Knez, I., & Thorsson, S. (2006). Influences of culture and environmental attitude on thermal, emotional and perceptual evaluations of a public square. International Journal of Biometeorology, 50(5), 258–268. https://doi.org/10.1007/s00484-006-0024-0

Knez, I., Thorsson, S., Eliasson, I., & Lindberg, F. (2009). Psychological mechanisms in outdoor place and weather assessment: Towards a conceptual model. International Journal of Biometeorology, 53(1), 101–111. https://doi.org/10.1007/s00484-008-0194-z

Lenzholzer, S., Klemm, W., & Vasilikou, C. (2018). Qualitative methods to explore thermo-spatial perception in outdoor urban spaces. Urban Climate, 23, 231–249. Scopus. https://doi.org/10.1016/j.uclim.2016.10.003

Lenzholzer, Sanda, & de Vries, S. (2020). Exploring outdoor thermal perception—A revised model. International Journal of Biometeorology, 64(2), 293–300. https://doi.org/10.1007/s00484-019-01777-z

Lenzholzer, Sanda, & Nikolopoulou, M. (2020). Foreword to the Special Issue on Subjective Approaches to Thermal Perception. International Journal of Biometeorology, 64(2), 167–171. https://doi.org/10.1007/s00484-019-01857-0

Lenzholzer, Sanda. (2010). Engrained experience—A comparison of microclimate perception schemata and microclimate measurements in Dutch urban squares. International Journal of Biometeorology, 54(2), 141–150. https://doi.org/10.1007/s00484-009-0262-z

Liu, J., Yao, R., & McCloy, R. (2012). A method to weight three categories of adaptive thermal comfort. Energy and Buildings, 47, 312–320. https://doi.org/10.1016/j.enbuild.2011.12.007

Matzarakis, A., Mayer, H., & Iziomon, M. G. (1999). Applications of a universal thermal index: Physiological equivalent temperature. International Journal of Biometeorology, 43(2), 76–84. Scopus. https://doi.org/10.1007/s004840050119

Maxcy, S. J. (2003). Pragmatic threads in mixed methods research in the social sciences: The search for multiple modes of inquiry and the end of the philosophy of formalism. Handbook of Mixed Methods in Social and Behavioral Research, 51–89.

Mayer, H., & Höppe, P. (1987). Thermal comfort of man in different urban environments. Theoretical and Applied Climatology, 38(1), 43–49.

McIntyre, D. A. (1980). Design requirements for a comfortable environment Bioengineering: Thermal Physiology and ComfortCena, K and JA Clark. Amsterdam: Elsevier.

Mertler, C. A. (2015). Introduction to educational research. SAGE Publications.

Miller, D. (2000). Qualitative research course packet. University of Nebraska-Lincoln.

Nagano, K., & Horikoshi, T. (2011). Development of outdoor thermal index indicating universal and separate effects on human thermal comfort. International Journal of Biometeorology, 55(2), 219–227.

Nicol, J. F., & Humphreys, M. A. (2002). Adaptive thermal comfort and sustainable thermal standards for buildings. Energy and Buildings, 34(6), 563–572. https://doi.org/10.1016/S0378-7788(02)00006-3

Nikolopoulou, M. (2011). Outdoor thermal comfort. Frontiers in Bioscience (Scholar Edition), 3, 1552–1568.

Nikolopoulou, M., & Steemers, K. (2003). Thermal comfort and psychological adaptation as a guide for designing urban spaces. Energy and Buildings, 35(1), 95–101. https://doi.org/10.1016/S0378-7788(02)00084-1

Nikolopoulou, M., Baker, N., & Steemers, K. (2001). Thermal comfort in outdoor urban spaces: Understanding the human parameter. Solar Energy, 70(3), 227–235. https://doi.org/10.1016/S0038-092X(00)00093-1

Oliveira, S., & Andrade, H. (2007). An initial assessment of the bioclimatic comfort in an outdoor public space in Lisbon. International Journal of Biometeorology, 52(1), 69–84. https://doi.org/10.1007/s00484-007-0100-0

Patton, M. Q. (2015). Qualitative Research & Evaluation Methods (Forth Edition). Sage Pupblications, inc.

Pezdek, K., Whetstone, T., Reynolds, K., Askari, N., & Dougherty, T. (1989). Memory for real-world scenes: The role of consistency with schema expectation. Journal of Experimental Psychology: Learning, Memory, and Cognition, 15(4), 587–595. https://doi.org/10.1037/0278-7393.15.4.587

Rohles, F. H. (1980). Temperature or temperament: A psychologist looks at thermal comfort. ASHRAE Transactions, 86(1), 541–551. Scopus.

Rupp, R. F., Vásquez, N. G., & Lamberts, R. (2015). A review of human thermal comfort in the built environment. Energy and Buildings, 105, 178–205.

Southworth, M. (1969). The sonic environment of cities. Environment and Behavior, 1(1), 49–70. Scopus. https://doi.org/10.1177/001391656900100104

Tashakkori, A., & Teddlie, C. (2003). Handbook of mixed methods in social & behavioral research (Wageningen UR Library). Sage.

Thorsson, S., Lindqvist, M., & Lindqvist, S. (2004). Thermal bioclimatic conditions and patterns of behaviour in an urban park in Göteborg, Sweden. International Journal of Biometeorology, 48(3), 149–156. https://doi.org/10.1007/s00484-003-0189-8

Vasilikou, C., & Nikolopoulou, M. (2014). Degrees of environmental diversity for pedestrian thermal comfort in the urban continuum, a new methodological approach. Bridging the Boundaries: Human Experience in the Natural and Built Environment and Implications for Research, Policy and Practice. Hogrefe Publishing, Göttingen.

Vasilikou, C., & Nikolopoulou, M. (2020). Outdoor thermal comfort for pedestrians in movement: Thermal walks in complex urban morphology. International Journal of Biometeorology, 64(2), 277–291. https://doi.org/10.1007/s00484-019-01782-2

Vasilikou, K. (2014). The role of urban morphology and pedestrian movement in the perception of thermal comfort in historic city centres: Spatial sequences in Rome and London. University of Kent.

w Creswell, J. (2009). Research design: Qualitative, quantitative, and mixed methods approaches. SAGE Publications, Incorporated.

Zacharias, J., Stathopoulos, T., & Wu, H. (2016). Microclimate and Downtown Open Space Activity: Environment and Behavior. https://doi.org/10.1177/0013916501332008

APPENDIX A

INSTITUTIONAL REVIEW BOARD RESEARCH OF HUMAN SUBJECTS APPROVAL

ASU Knowledge Enterprise Development
ARIZONA STATE UNIVERSITY

SOCIAL BEHAVIORAL INSTRUCTIONS AND TEMPLATE		
NUMBER	DATE	PAGE
HRP-503a	9/27/2019	1 of 7

Instructions and Notes:

- Depending on the nature of what you are doing, some sections may not be applicable to your research. If so, mark as "NA".
- When you write a protocol, keep an electronic copy. You will need a copy if it is necessary to make changes.

1 **Protocol Title**
Include the full protocol title: **Exploring Individuals' Perception and Experience in Urban Environments**

2 **Background and Objectives**
Provide the scientific or scholarly background for, rationale for, and significance of the research based on the existing literature and how will it add to existing knowledge.

- Describe the purpose of the study.
- Describe any relevant preliminary data or case studies.
- Describe any past studies that are in conjunction to this study.

Describe the purpose of the study.
This study is a first part of a larger study that aims at exploring the relative importance of perceptual factors in comparison to physiological factors influencing the perception of heat and overall walking experience. The study will investigate whether individuals have a different (thermal) experience in similar urban environment with respect to familiarity to that environment. The study consists of multiple phases: the first phase will include participants choosing two streets in urban areas in their proximity and uploading google map images of them. In the next phase, the participant will be asked to walk in those two streets, record a video, and explain their overall experience on voice. Following that, the participants will be asked to fill out one survey for each one of their walking experiments.
This first part will be repeated in summer and fall. The goal of this portion of the study is to inform the structure and study design for both the future parts (summer and fall of 2018) of this study as well as other later component to allow a more in-depth data collection. Therefore, the research team will update the protocol and other documents after the data analysis of the first part, and submit to the IRB. No further action will be taken, until IRB approves the changes to the second part of the study.

Describe any relevant preliminary data or case studies:
Increasing urban heat has become a prevailing issue concerning all climate zones, particularly because urban heat affects the thermal comfort of outdoor environments. Identifying the drivers of urban heat is essential since thermal comfort creates patterns of use in the built environments. Over the past few decades, researchers conducted many studies to understand the impact of urban design on microclimate conditions. (Middel, Häb, Brazel, Martin, & Guhathakurta, 2014). It is now evident that the built environment characteristics, namely vegetation level, material, shading features, and so forth, have a significant impact on the thermal environment. However, a part of this study proposes a new method for obtaining a finer human-scale understanding of distribution of heat in the microclimate scale and its relative impact on human thermal comfort. This proposed method uses the visual images from cross sections of three dimensional simulation of the thermal environment in ENVI-Met.
Studies by Nikolopoulou, Baker, & Steemers (2001), Nikolopoulou & Steemers (2003), and Shooshtarian & Ridley (2017) introduced factors in addition to the classical Fanger's model impacting thermal sensation. Nikolopoulou et al. (2003) introduced several factors as psychological adaptation parameters in an attempt to address the psychological influences on thermal comfort namely, naturalness, expectations, experience (short-/long-term), time of exposure, perceived control and environmental stimulation. However, it is yet unclear as to what extent these psychological factors account for overall thermal comfort level.

Describe any past studies that are in conjunction to this study:
This is a new line of research activity for Desert Urban Environments and there are no past studies that are in conjunction to this study.

Literature Cited

Middel, A., Häb, K., Brazel, A. J., Martin, C. A., & Guhathakurta, S. (2014). Impact of urban form and design on mid-afternoon microclimate in Phoenix Local Climate Zones. Landscape and Urban Planning, 122, 16–28.
Nikolopoulou, M., Baker, N., & Steemers, K. (2001). Thermal comfort in outdoor urban spaces: understanding the human parameter. Solar Energy, 70(3), 227–235. https://doi.org/10.1016/S0038-092X(00)00093-1
Nikolopoulou, M., & Steemers, K. (2003). Thermal comfort and psychological adaptation as a guide for designing urban spaces. Energy and Buildings, 35(1), 95–101. https://doi.org/10.1016/S0378-7788(02)00084-1
Shooshtarian, S., & Ridley, I. (2017). The effect of physical and psychological environments on the users thermal perceptions of educational urban precincts. Building and Environment, 115, 182–198.

3 Data Use
Describe how the data will be used. Examples include:
- Dissertation, Thesis, Undergraduate honors project
- Publication/journal article, conferences/presentations
- Results released to agency or organization
- Results released to participants/parents
- Results released to employer or school
- Other (describe)

The data will be used in publications, conferences, and a dissertation project. The results will help inform future studies for the purpose of a dissertation, and other environmental projects happening in the Design School at ASU.

4 Inclusion and Exclusion Criteria

Describe the criteria that define who will be included or excluded in your final study sample. If you are conducting data analysis only describe what is included in the dataset you propose to use.

Indicate specifically whether you will target or exclude each of the following special populations:

- Minors (individuals who are under the age of 18)
- Adults who are unable to consent
- Pregnant women
- Prisoners
- Native Americans
- Undocumented individuals

The study will include adults who are students and over the age of 18. However, to ensure the consent age, since participants are ASU students and there might be students under 18, we ask the question in the survey so we can exclude them from the study after data collection. We will not specifically target or exclude pregnant women, Native Americans, prisoners and undocumented individuals. After IRB approval, the study will include all consenting participants involved with courses at The Design School at Arizona State University (ASU).

5 Number of Participants

Indicate the total number of participants to be recruited and enrolled*:*

For the first part of the study, we anticipate to recruit students from the following courses:

1) ALA 100, Introduction to Environmental Design, Spring 2018, with 206 students
2) ALA 102, Landscapes and Sustainability, Spring 2018 with 251 students

For future parts of the study, depending on the logistics, the research team will update the protocol to reflect the recruitment pool changes. All the updated documents will be submitted to IRB prior to data collection and no recruitment will happen until after the IRB approval is obtained.

6 Recruitment Methods

- Describe who will be doing the recruitment of participants.
- Describe when, where, and how potential participants will be identified and recruited.
- Describe and attach materials that will be used to recruit participants (attach documents or recruitment script with the application).

The project will not begin until after IRB approval is obtained. For ALA 100 course participants, Mohsen Garshasby will introduce the study at earliest class period after IRB approval for ASU courses ALA 100. For Spring 2018, PI Cheng will distribute to her class of ALA 102. Only after IRB approval, we will send a class announcement about the instructions and a link to an online survey. Participants may choose not to participate in the research study at any stage. Participants will be contacted via email to solicit voluntary participation in the study via an email (email solicitation and informed consent attached). The email will have a consent form and a link to an online survey (see the three surveys attached). The consent form will serve as the recruitment script. All surveys will be given through Qualtrics. Participants are informed of the voluntary nature of their participation and that they may withdraw from the study at any point and for any reason. The research team intends to conduct the study later in summer and fall of 2018, based on the analysis of data collected in spring. For that future portion of the study, all potential changes to the survey questionnaire and methods will be submitted to IRB in time and no recruitment will happen until IRB approval is obtained.

7 Procedures Involved

Describe all research procedures being performed, who will facilitate the procedures, and when they will be performed. Describe procedures including:

- The duration of time participants will spend in each research activity.
- The period or span of time for the collection of data, and any long term follow up.
- Surveys or questionnaires that will be administered (Attach all surveys, interview questions, scripts, data collection forms, and instructions for participants to the online application).
- Interventions and sessions (Attach supplemental materials to the online application).
- Lab procedures and tests and related instructions to participants.
- Video or audio recordings of participants.
- Previously collected data sets that that will be analyzed and identify the data source (Attach data use agreement(s) to the online application).

The timeline below describes important dates in the five-month study. In order to answer the main research questions, we propose a multiple phase study, where participants will be asked to do several small tasks in one day. For a complete list of tasks, please see the instruction for participants to the online application. It is expected that the total time required for completing all the tasks in the study be less than 60 minutes.

The study asks participants to complete a series of tasks during the same day in the day-time and report their answers to the online survey (Qualtrics). They will be asked to walk in both streets, record a video at the same time, and explain their overall experience based on a series of questions that will be provided for them. The video recording will have the participants voice, and display the street environment. Following shows the complete list of tasks that need to be completed by participants.

Tasks:

Prior to your Walk
1- Take a google image screenshot from both streets.
2- Print out the google image screenshots from both street and bring them along to the street locations.
3- If you don't have access to internet on your smartphone while you are outside, print two copies of the survey questionnaire and bring them along with a pen to the street location.

During your Walk
1- Using your smartphone/digital camera, record 1 minute of footage, describe your overall experience
a. In your 1-minute long video simply talk about the followings:
i. Start with a short description of time, place, and condition
1. Whether it is sunny, cloudy, rainy etc.
ii. How do you feel?
1. Do you feel comfortable? Uncomfortable?
iii. What do you see?
1. Do you see shadings around? Any trees planted along the street? Are the buildings tall or one-story?
2- Be mindful of your safety and any potential danger along the road

Immediately after your Walk:
1- Fill out the survey questionnaire on your smartphone (if possible) or on paper if you have printed them in advance.
2- Mark down both areas of the street that you approximately walked on the google image screenshot you created before,
3- Take a screenshot of the weather app on your smartphone (if possible) for that specific location, and upload it to the cloud later.

Within 24 hours after your Walk:
1- If you have filled out the surveys on paper, please transfer your already responded survey to our online survey using the link provided.
2- Upload the below files in the form of a zip folder named (first name, last name) to Dropbox link: https://www.dropbox.com/request/626qOF7dX0XAvLBva3Y5
a. 2 video recordings (REQUIRED), Video 1: familiar street, Video 2: unfamiliar street
b. 2 google image screenshots, Image 1: familiar street, Image 2: unfamiliar street
c. 2 weather app screenshots, weather 1: familiar street, weather 2: unfamiliar street

Time line:

Date to be determined only after IRB approval	Information about the study will be sent to ASU students enrolled in ALA 100 online course.
February, 2018- March, 2018	Recruitment email circulated to all ASU students enrolled in ALA 100 online course.
March, 2018	Begin data collection.
April, 2018- August, 2018	Begin analysis and paper for submission.
June 2018	Second data collection begins
July – August, 2018	Begin analysis and paper for submission.

8 Compensation or Credit

- Describe the amount and timing of any compensation or credit to participants.
- Identify the source of the funds to compensate participants
- Justify that the amount given to participants is reasonable.
- If participants are receiving course credit for participating in research, alternative assignments need to be put in place to avoid coercion.

Participants are expected to finish the survey in 20 minutes. Students who are willing to complete the survey will receive extra credits in ALA 100 and ALA 102 courses. This means that all students already have a 100% of their grade in class, and this study is an additional opportunity for them to both expand on their knowledge and awareness of the class content as well as increasing their grade, only if they wish. For students who are not capable of participating in this study or wish to decline to participate, an individual alternative assignment will be introduced.
For future data collection, depending on the logistics, the research team will update the protocol and instruction if the recruitment pool changes. All the updated documents will be submitted to IRB prior to data collection and no recruitment will happen until after the IRB approval is obtained.

9 Risk to Participants

List the reasonably foreseeable risks, discomforts, or inconveniences related to participation in the research. Consider physical, psychological, social, legal, and economic risks.

The risks from the survey will be rare as the information is obtained will be collected and stored via the secure Qualtrics online survey website. The questions do not pertain to personal information. All personal information will be explicitly excluded from the study. Participants are free to decide whether they wish to participate in this study. For all student participants, not participating in the study will not affect their regular grade.

10 Potential Benefits to Participants

Realistically describe the potential benefits that individual participants may experience from taking part in the research. Indicate if there is no direct benefit. Do **not** include benefits to society or others.

There is no direct benefit to the participants from the research. The information asked during the survey involves the participants' experience. However, possible benefits are indirect and may impact them through changes made to future environmental studies.

11 Privacy and Confidentiality

Describe the steps that will be taken to protect subjects' privacy interests. "Privacy interest" refers to a person's desire to place limits on with whom they interact or to whom they provide personal information. Click here for additional guidance on ASU Data Storage Guidelines.

Describe the following measures to ensure the confidentiality of data:

- Who will have access to the data?
- Where and how data will be stored (e.g. ASU secure server, ASU cloud storage, filing cabinets, etc.)?
- How long the data will be stored?
- Describe the steps that will be taken to secure the data during storage, use, and transmission. (e.g., training, authorization of access, password protection, encryption, physical controls, certificates of confidentiality, and separation of identifiers and data, etc.).
- If applicable, how will audio or video recordings will be managed and secured. Add the duration of time these recordings will be kept.
- If applicable, how will the consent, assent, and/or parental permission forms be secured. These forms should separate from the rest of the study data. Add the duration of time these forms will be kept.
- If applicable, describe how data will be linked or tracked (e.g. masterlist, contact list, reproducible participant ID, randomized ID, etc.).

If your study has previously collected data sets, describe who will be responsible for data security and monitoring.

Efforts will be made to limit the use and disclosure of your personal information, including research study records, to people who have a need to review this information. We cannot promise complete secrecy. The results of this study may be used in reports, presentations or publications but your name will not be used. Data will be de-identified for all reports, presentation, and publications. Data will be de-identified by giving each participant a proxy code to represent their case.

We will not have participants fill out their name on the survey (see updated surveys). Only the consent form will contain the printed and signed name and this will be detached from the survey. We will de-identify the online surveys within ten days after administering the survey by giving each survey a code (such as 1s, 2s, 3s, 4s, etc., a number for the number of participants and that delinks the survey answers to the consent form. Since all surveys are online, the de-identification will occur online as part of the process. Identifying information associated with consent forms will be destroyed at the end of the study, by July 30, 2018. The de-identified data will not be directly linked to other data collected as part of this study.

Only the PI and Co-PI's will have access to the survey data. The primary and output data will be stored on a password protected Cloud server at Arizona State University. All data will be stored for five years from the start of the study. To protect confidentiality, we will use deidentified data to protect participants' personal information.

12 Consent Process

Describe the process and procedures process you will use to obtain consent. Include a description of:

- Who will be responsible for consenting participants?
- Where will the consent process take place?
- How will consent be obtained?
- If participants who do not speak English will be enrolled, describe the process to ensure that the oral and/or written information provided to those participants will be in that language. Indicate the language that will be used by those obtaining consent. Translated consent forms should be submitted after the English is approved.

Participants will be given a consent form with a signature line to agree to be part of the study. For ASU students enrolled in ALA 100 in Spring 2018, Mohsen Garshasby will introduce the study in an announcement sent to the entire class with information about the study and the procedure. For students enrolled in ALA 102 in Spring 2018, PI Cheng will introduce the survey to the entire class with information and procedures in an announcement. The PI and Co-PI's phone number and email address is enclosed in case anyone has questions or concerns at any time during the process (before, during, and after the study). For future studies, depending on the characteristics of the participants, PI or Co-PI will utilize the same consent process for the participants.

13 Training

Provide the date(s) the members of the research team have completed the CITI training for human participants. This training must be taken within the last 4 years. Additional information can be found at: Training.

Chingwen Cheng, CITI training for human participants completed on 4/26/2016
Paul Coseo, CITI training for human participants completed on 04/22/2015
Mohsen Garshasby, CITI training for human participants completed on 2/15/2018

Short Consent Template

Study title: ***Experiences and Preferences related to CAP LTER Group Collaborative Projects***

We are professors and a PhD student at Arizona State University. We are conducting a research study to understand your experiences and perception of Urban Environments.

We invite your participation, which will involve taking two 10-15-minute survey as well as providing two one-minute long video recording with your voice over. All participants must be 18 or older. You have the right not to answer any question, and to stop participation at any time.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty. For all students, non-participation will not affect your grade. The questions do not pertain to personal information. There are no foreseeable risks or discomforts to your participation. Possible benefits are indirect and your participation may help us improve future collaborative experiences.

Your responses will be anonymous for the survey. We will not ask you for your name on the survey. Only the consent form will contain the printed and signed name and this will be detached from the survey. We will de-identify the surveys within ten days after administering the survey by giving each survey a code that delinks the survey answers from the consent form to protect confidentiality; we will use de-identified data to protect participants' personal information. The results of this study may be used in reports, presentations, or publications but your name will not be used.

We are also asking your permission to use the video recording you will provide. Only the research team will have access to the recordings. The recordings will be deleted immediately after being transcribed and any published quotes will be anonymous. To protect your identity, please refrain from using names or other identifying information during you recording. Let me know if, at any time, you do not want the information you provided or the video you recorded be used; you also can change your mind after the survey starts, just let me know.

If you have any questions concerning the research study, please contact the research team at: Mohsen Garshasby, Mohsen.Garshasby@asu.edu; Paul Coseo, pcoseo@asu.edu; Chingwen Cheng, Chingwen.Cheng@asu.edu; If you have any questions about your rights as a participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788. Please let me know if you wish to be part of the study.

By signing below, you are agreeing to be part of the study.

Name:

Signature: Date:

Exploring Individuals' Perception and Experience in Urban Environments

Description:

This study aims at obtaining a better understanding of your experience and perceptions of urban environments, if you wish to participate in this study, you will receive extra credit.

This research study is also aligned in conjunction to your learning objectives in our class. You will be observing the environments you live in and tell us how you see your environment, what you experience in it and how you feel in these environments.

You will have until March 1st to participate in this study. This means that you may choose any day between now and March 1st to complete a series of task and submit your assignment.

Simply, you are asked to choose two nearby streets (or different sections of one street) with **the same direction** (both needs to be South-North OR West-East). The main criteria for choosing these streets are your **familiarity** with them. In other words, you must be familiar with one of these streets and unfamiliar with the other streets. See below for further clarification:

1- Street No.1: You are familiar with this street and this is not the first time you are walking there.
2- Street No. 2: You are not familiar with this street and this is the first time you are walking there.

The study asks you to complete a series of tasks during the same day in the day-time, report your answers to the online survey and upload your recorded videos and files to dropbox. You are asked to walk in both streets, record a video forward (the pathway you are walking ahead), and speak about your overall experience based on a series of questions that will be provided for you. It is imperative that you first walk in the familiar street and then the unfamiliar street, and you will fill out the survey 1 (familiar street) and survey 2 (unfamiliar street) immediately after walking in. In addition to the online survey, you will need to upload 6 files in the form of a .zip file to the dropbox link provided. Please see below for the complete list of tasks that needs to be finished in order to complete the assignment. Please note that you will need to complete all the tasks in order to receive the extra credit in our class.

Tasks:

Prior to your Walk

1- Take a google image screenshot from both streets.

2- Print out the google image screenshots from both street and bring them along to the street locations.
3- If you don't have access to internet on your smartphone while you are outside, print two copies of the survey questionnaire and bring them along with a pen to the street location.

During your Walk

1- Using your smartphone/digital camera, record 1 minute of footage, describe your overall experience
    a. In your 1-minute long video simply talk about the followings:
        i. Start with a short description of time, place, and condition
            1. Whether it is sunny, cloudy, rainy etc.
        ii. How do you feel?
            1. Do you feel comfortable? Uncomfortable?
        iii. What do you see?
            1. Do you see shadings around? Any trees planted along the street? Are the buildings tall or one-story?
2- Be mindful of your safety and any potential danger along the road

Immediately after your Walk:

1- Fill out the survey questionnaire on your smartphone (if possible) or on paper if you have printed them in advance.
2- Mark down both areas of the street that you approximately walked on the google image screenshot you created before,
3- Take a screenshot of the weather app on your smartphone (if possible) for that specific location, and upload it to the cloud later.

Within 24 hours after your Walk:

1- If you have filled out the surveys on paper, please transfer your already responded survey to our online survey using the link provided.
2- Upload the below files in the form of a zip folder named (first name, last name) to Dropbox link: https://www.dropbox.com/request/626qOF7dX0XAvLBva3Y5
    a. 2 video recordings (REQUIRED), *Video 1: familiar street, Video 2: unfamiliar street*
    b. 2 google image screenshots, *Image 1: familiar street, Image 2: unfamiliar street*
    c. 2 weather app screenshots, *weather 1: familiar street, weather 2: unfamiliar street*

Notes:

*** You must hold your video recording device down (not in front of your face), and maintain vision and eyesight in front of you for your safety while walking. Please try to avoid video recording other individuals on the street, and try to include your pathway and urban environment surrounding you.**
*** You may ask a friend or family member to accompany you during your walk, if that makes you more comfortable. However, please note, you should not have any interaction with any individual during the walk. We are solely interested in your personal individual experience.**

***Please note you must not drink, smoke, eat or do any other activity while you are on your one-minute walk.**
*** If you live in a rural environment, you are asked to commute to the closest urban area and conduct the experiment there.**
*** If you are not capable of participating in this study or wish to decline to participate, an individual alternative assignment will be introduced. You must contact Prof. Garshasby in order to find an alternative form of assignment.**

APPROVAL: EXPEDITED REVIEW

Chingwen Cheng
The Design School
-
Chingwen.Cheng@asu.edu

Dear Chingwen Cheng:

On 2/26/2018 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Exploring Individuals' Perception and Experience in Urban Environments
Investigator:	Chingwen Cheng
IRB ID:	STUDY00007788
Category of review:	(6) Voice, video, digital, or image recordings, (7)(b) Social science methods, (7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Survey Questionnaire.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • EnvironmentalExperienceandPerception- TEMPLATE CONSENT DOCUMENT -SHORT FORM.pdf, Category: Consent Form; • EnvironmentalExperienceandPerception_PROTOCOL_SocialBehavioral_Rev2.docx, Category: IRB Protocol; • Instructions_rev2, Category: Recruitment Materials;

The IRB approved the protocol from 2/26/2018 to 2/25/2019 inclusive. Three weeks before 2/25/2019 you are to submit a completed Continuing Review application and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 2/25/2019 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc: Mohsen Garshasby Moakhar
Chingwen Cheng
Mohsen Garshasby Moakhar
Paul Coseo

Questionnaire 1 – Familiar Street

Comfort and experience
How comfortable do you rate your overall one-minute walking experience?
1- Quite Uncomfortable
2- Somewhat Uncomfortable
3- Neutral
4- Somewhat Comfortable
5- Quite Comfortable

How pleasant do you rate the pleasantness of your one-minute walk?
1- Quite Unpleasant
2- Somewhat unpleasant
3- Neutral
4- Somewhat pleasant
5- Quite pleasant

How boring do you rate your overall experience in this one-minute walk?
1. Extremely Boring
2. Boring
3. Not decided
4. Somewhat Boring
5. Not Boring at all

How entertaining do you rate your overall experience in this one-minute walk?
1- Extremely Entertaining
2- Entertaining
3- Not decided
4- Somewhat Entertaining
5- Not Entertaining at all

Logistics
Please indicate the exact time you finished your one-minute walk in this street?

What time of the day you walked in this street?
1- Before 10am
2- Between 10am-12pm
3- Between 12-2pm
4- Between 2-4pm
5- After 4pm

Did you have any individual accompanying you during your walk?
1- Yes
2- No
3-

How often do you walk or use this street?

1- Less than once a month
2- 1-4 times every month
3- 2-5 times a week
4- Once everyday
5- Multiple times everyday

Please write down the name of the city, state, and country, followed by the zip code of the streets you walked in the box below.

Choice of Pathway
What side of the street did you choose to walk in?
1- Extremely Sunny Side
2- Sunny Side
3- Not decided
4- Somewhat Sunny Side
5- Not Sunny at all (Shaded) Side

What was the reason you choose to walk in that specific walkway?
1- Scenery
2- Shading
3- Sun exposure
4- Retail access and availability
5- Safety
6- Lighting
7- Less Crowded pathway
8- More Crowded pathway
9- Others (please identify)
10- N/A

Clothing
Please identify the type of your outwear clothing.
1- Cotton
2- Woolen
3- Leather
4- Not listed, Please Identify
5- N/A

Please check all shading devices you were using in this walk.
1- Sunglasses
2- Hat or cap
3- Umbrella
4- No shading object
5- N/

How many layers of clothing do you currently have?
1- 1 layer
2- 2 layer
3- 3 layer
4- 4 layer
5- 5 layer and more
6- N/A

Walking intensity
How would you consider your walking speed?
1- Quite slow
2- Somewhat slow
3- Average
4- Somewhat fast
5- Quite fast

Demographics
What is your gender?
1- Male
2- Female

3- Do not identify with either (please identify)
4- Prefer not to say

How old are you?
1- Younger than 18
2- 18-22
3- 23-27
4- 28-32
5- Older than 33

What is your ethnicity?
1- Caucasian
2- Hispanic
3- Native American
4- African American
5- Asian
6- Middle Eastern
7- Caribbean
8- Mixed
9- Other (Please identify)

What is your highest level of education completed?
1- Some College
2- Bachelor Degree
3- Master Degree or Higher
4- Others (Please identify)

What is your work status?
1- Employed Full-time, Student Full-time
2- Employed Full-time, Student Part-time
3- Employed Part-time, Student Full-time
4- Employed Part-time, Student Part-time
5- Not Employed, Full-time Student
6- Not Employed, Part-time Student
7- Other (please identify)

Please write your major and degree program you are pursuing currently at ASU.

Questionnaire 2 – Unfamiliar Street

Comfort and experience

How comfortable do you rate your overall one-minute walking experience?
1. Quite Uncomfortable
2. Somewhat Uncomfortable
3. Neutral
4. Somewhat Comfortable

5. Quite Comfortable

How pleasant do you rate the pleasantness of your one-minute walk?
1. Quite Unpleasant
2. Somewhat unpleasant
3. Neutral
4. Somewhat pleasant
5. Quite pleasant

How boring do you rate your overall experience in this one-minute walk?
1. Extremely Boring
2. Boring
3. Not decided
4. Somewhat Boring
5. Not Boring at all

How entertaining do you rate your overall experience in this one-minute walk?
1- Extremely Entertaining
2- Entertaining
1- Not decided
2- Somewhat Entertaining
3- Not Entertaining at all

Logistics

Please indicate the exact time you finished your one-minute walk in this street?

What time of the day you walked in this street?
1- Before 10am
2- Between 10am-12pm
3- Between 12-2pm
4- Between 2-4pm
5- After 4pm

Did you have any individual accompanying you during your walk?
1- Yes
2- No

Please write down the name of the city, state, and country, followed by the zip code of the streets you walked in the box below.

Choice of Pathway

What side of the street did you choose to walk in?
1- Extremely Sunny Side
2- Sunny Side
3- Not decided
4- Somewhat Sunny Side
5- Not Sunny at all (Shaded) Side

What was the reason you choose to walk in that specific walkway?
1- Scenery

2- Shading
3- Sun exposure
4- Retail access and availability
5- Safety
6- Lighting
7- Less Crowded pathway
8- More Crowded pathway
9- Others (please identify)
10- N/A

SPECIFIC TO THE SECOND QUESTIONNAIIRE

Was your experience in the familiar street any different compared to the unfamiliar street?

1- Yes
2- No
3- N/A

Which one of the following best explain the reason you walk in the first street? (Mark all that applies)

1- Ease of access
2- Scenery
3- Shorter distance
4- Thermally comfortable environment
5- Shade
6- Lighting
7- Safety
8- Retail access and availability
9- Others (please identify)
10- N/A

In a few sentence, please describe how your experience in two streets was different or indifferent.