CONTROLLED CLIMATES AND HUMAN VARIATION: UBIQUITOUS AIR CONDITIONING AND LOWERING HEAT THRESHOLDS IN A HOTTER WORLD

A Thesis
Presented to
The Faculty of the Department
of Comparative Cultural Studies - Anthropology
University of Houston

In Partial Fulfillment
Of the Requirements for the Degree of
Master of Arts

By
Gabriel B. Durham
May, 2016

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ABSTRACT

This project assessed how ubiquitous air conditioning is affecting human biological and cultural adaptation to heat. Big data from the “CDC Environmental Health Tracker” on morbidity and air conditioning (AC) usage was used to identify relevant Texan and Floridian populations; who were then anonymously interviewed regarding AC use, hot weather exposure, and heat related illness. IBM-SPSS was used to analyze both quantitative and qualitative variables. A final sample of 13 participants from each state between the ages of 21-28 was selected. In this population, AC usage was strongly linked to increased irritability in the heat along with resulting correlations with heat related illness ($r = .469$, $p = .005$). Qualitatively, a culture of dependency on air conditioning is shown in Texas while Floridians took advantage of “beach culture” more often. These findings link air conditioning use to the health risks of inactivity along with identified trends in biological maladaptation.

ACKNOWLEDGEMENTS

I would like to first acknowledge Dr. Janis Hutchinson, my primary advisor for this thesis and original inspiration for my passion in Human Adaptability. If I had never been challenged and fascinated by your Human Variation course I would have never formed the idea that began all of this work. Thank you for all of your guidance, patience, and insight to guide me through this process.

I would also like to thank my committee members Dr. Randolph Widmer and Dr. Whitney Breslin. Dr. Widmer was the first anthropology professor to hook my interest and show the powerful scope of the discipline. He inspired me to follow Cultural Ecology and provided constantly rich lectures that have guided my work since I entered the department. Dr. Breslin I would like to thank for taking a chance on a stranger's work and offering me such wonderful research tools.

I would like to thank my family. To my mother, I must express the deepest debt. Not only for the debt that all sons owe their mothers, but also for bringing us to Houston and giving me every professional tool I owe my college success to. To my father I only need quote a single song lyric: "But gaining oneness with our fellow man, is so useless not knowing the spirit of oneness we share with the land". That single line is what the next hundred pages will try to communicate. I don't think any book could capture all those miles.

And to Sarah, now my Fiancé. When this started we had just met. Now that it's over we are getting married. For a person to only love me more and more through one of my greatest challenges is the highest blessing of my life. While others may have gotten me ready to do this, I could never have survived without you.

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Chapter 1 – Introduction

Part 1: Food, Water, Air, and Shelter

A basic law of ecology is that organisms have three root requirements to live. These are: food, air (oxygen or not), water, and shelter (Levin, 2009). No matter how “advanced” an organism might be their day to day actions are still driven by these bare necessities across every kingdom of life, including modern humans. In fact, each demographic shift in human history is tightly knit with our increasing ability to “reign in” these basic needs in increasingly efficient and creative ways (Moran, 2008; Sutton & Anderson, 2010). Our search for food has evolved from picking berries and nuts all day to a simple trip to the supermarket once a week or so. Our search for water has evolved from a thirsty search for reliable bodies of clean water to the simple turning of a faucet. Our search for shelter has evolved from a laborious nightly nesting to a steady sturdy structure. And finally, our relationship to air has evolved from simple breathing to the rigorous control and regulation through vents, filters, humidifiers, and many more man made devices (Molnar, 2006). Of these basic requirements, one stands out as inherently different from the rest: shelter.

Historically, food, water, and air have been environmental “products” that required humans to undergo a certain degree of exposure to obtain them; however, shelter in its very nature is the removal of exposure for bodily recuperation from environmental stresses (Leslie & Little, 2003; Sutton & Anderson, 2010). So, to continue the thread, it could be said that while subsistence is an environmental exposure act, human shelter is an environmental insulation act; that is to say, it is the *removal of* natural system pressures as opposed to subsistence, which requires *immersion in*, the natural system. Shelter is warm when the environment is cold, dry when the environment is wet, and cool when the environment is hot.

Always the antithesis to the pressures of "outside". If this space of environmental insulation is removed from us, it spells death. This type of death is called "death by exposure" and is the result of our bodies being overwhelmed by the relentless forces of nature (P. Baker & Weiner, 1967; Barnes, 2005). This shows the vital nature of shelter in our continual survival and aids in illustrating the continual dance between exposure and shelter that early humans must have experienced as a common challenge of life.

For modern humans, however, a truly interesting shift has occurred. Not only have our methods of shelter greatly improved (as suggested in the first paragraph), but we have also brought all other bare necessities *into* the shelter. In developed countries, the average home has running water, ample stores of food, and a continual supply of filtered air to breathe. This has led to a very important autoecological shift for the populations of humanity that live this way; in that, the *culturally created* environment of shelter can now often become the only environment one may ever regularly experience. While shelter has always served as insulation, the degree to which it succeeds has been building in steps that grow faster every year. When before, homes were built to alleviate natural climatic pressures (high ceilings to draw and trap heat, basements for cool storage, etc) (Hacker & Holmes, 2007) a new triumph of shelter has come about removing possibly one of the last bastions of ecological pressure on the human organism: centralized heating and cooling (HVAC). With this equipment, the dwelling is now a place of total climatic insulation. What's more, this equipment extends beyond the dwelling bringing the "shelter" of temperature regulation with it. To illustrate this point, one only needs to observe the ubiquitous presence of air-conditioning in the lives of most modern day United States citizens.

What began as a simple observation of how evaporating liquid creates a cooling effect (the same physical process that human sweating employs (Molnar, 2006). has led to perhaps one of the most pivotal inventions in the modern world: air-conditioning. The term was first used by Stuart Cramer, a textile mill engineer in North Carolina to describe an invention he employed to humidify the mill under the motive of making yarn harder to break. This concept was eventually refined by Willis Haviland Carrier to make what we now understand as modern AC (Cooper, 1987). Now, only 110 years later, one is hard pressed to find developed populations that have not experienced air-conditioning in one way or another. Furthermore, it is increasingly easy to find entire populations of people that spend 100% of their time in air- conditioned spaces (Hacker & Holmes, 2007). Homes, work places, modes of transportation, places of recreation, and schools all have the potential to be air-conditioned. For the sake of elaboration, consider this hypothetical.

Cindy is a middle-class American working woman and it is summer in Houston, Texas. When Cindy wakes up in the morning, she must take of pajamas because she has been sleeping in a chilled 70 degree apartment. On her way to work, she gets in her car, and cranks the AC up because it is 98 degrees Fahrenheit today. She then parks her car in the company garage that is underground and cool all the time only to walk 10 feet to the elevator, which takes her to her air-conditioned office. She always has a light jacket with her at work because they keep it so cold. After her work day is done, she gets back in her car with AC and drives to the gym to work out for an hour or so. The gym is also air-conditioned. Afterwards, she meets her friends for a movie (another place to bring the light jacket) and then returns home to snuggle up in her pajamas in her cool apartment.

The purpose of this hypothetical is to show how commonplace it is for a “middle class” Houstonian to live a life totally devoid of natural ambient exposure due to Air-conditioning. Earlier it was shown how shelter has always represented a degree of isolation from the environment, but this degree of insulation has never before been accomplished (Seybold, 2011). Earlier it was stated that modern air-conditioning was only invented 110 years ago. This bears repeating because it shows just how little time humans have had to fully understand its ramifications both biologically and culturally. What’s more, the steady path to ubiquity that air-conditioning continues to show is permeating more and more populations of humans, some of which are only just now finding a need for it (Auliciems & Dedear, 1986; Farbotko & Waitt, 2011; Graudenz et al., 2005; Quandt, Wiggins, Chen, Bischoff, & Arcury, 2013). This growing need for air-conditioning introduces another vital contextual motif that is inseparable from the issue being described: climate change.

To put it simply, while human bodies are cooling off, the world is heating up in regions including Texas and Florida, to mention particulars. The global climate has been shown to go through various cycles of heating and cooling throughout its history resulting in ice ages and warming ages. Humans have been around for a number of these ages and according to many studies, we are currently experiencing an age of warming (Benestad & Schmidt, 2009; Vinnikov & Grody, 2003; Zhou & Tung, 2013). Many argue that this change is the result of human variables and this may be true; however, this paper will not be discussing the cause of this global phenomenon. Instead, it simply must be stated that the world is getting hotter in a measureable way. This phenomenon is inextricably linked to air-conditioning and human health because of the nature of shelter outlined earlier (a hot environment *imposes* a cool shelter to prevent exposure related illness). Hence, the more hot zones in the world there are, the more one can expect to find wide-spread air conditioning, and the more vital it will be to employ this technology as a simple act of sheltering oneself as opposed to the luxury image AC continues to hold for many (Rector, 2011). It is exactly this three way relationship (heat rises – climate, human shelter – AC, biological pressure – health) that make this phenomenon anthropological in nature. Just how much our health, indeed, or general biological adaptation processes, could be impacted by such ecological shifts can only be understood with a background in studies of Human Adaptability.

Part 2: Human Adaptability

Humans can be described as some of the most universal adaptors on the planet and to find evidence for this statement, all one has to do is examine the wide range of climates that humans now occupy in the world. Current evidence places our origins in hot regions of Africa; however, humans have gone on to live for thousands of years in some of the coldest, wettest, and driest places in the world in addition to any and all climates in between. While cultural measures and the resulting technologies have made many of these lifestyles possible, none can compare to the changes our bodies can make when faced with climatic pressure (Molnar, 2006; Moran, 2008).

These changes can occur in three major ways: physiological acclimatization, developmental acclimatization, and genetic adaptation (Moran, 2008). Physiological Acclimatization describes temporary changes the body can make at any time when exposed to climatic pressure. Examples include tanning in the sun, shivering in the cold, and fluctuating sweat rates in the heat. These changes will cease after the climatic pressure is removed and any healthy human body is able to make these changes throughout life.

Developmental Acclimatization refers to permanent changes that occur in a human's developmental stage (usually the first dozen or so years) as a result of climatic stress. These changes are generally far more effective than physiological acclimatization alone and can, in fact, even come close to the effectiveness of genetic adaptation (Hanna & Brown, 1983; Molnar, 2006; Moran, 2008). Finally, Genetic adaptation refers to changes that occur on the genetic level due to thousands of years of natural selection. With the help of modern genomics and studies of thermoregulation, trends have been found for human body types to be shaped genetically by climate to favor certain geometries, in addition to countless other adaptive shifts (like the ABO blood groups). Genetic adaptation usually results in the most effective climatic mitigation.

For the sake of specifics, the following are findings about various ways humans have biologically adapted to heat, so that these processes relationship to health can better be understood.

As stated earlier, human's original adaptive pressure was heat so it is only natural that human show a uniformly strong ability to compensate for heat (before air conditioning). Each climate brings with it a particular threat to human health that drives the mechanisms of the body to attempt to prevent this risk from occurring. In heat the driving threat is hyperthermia, or overheating. This ailment can manifest in a variety of ways from heat exhaustion to heat stroke. These terms refer to varying degrees of heat overload. For the sake of brevity, the most important factors are: 38 degrees Celsius core temperature is the limit for humans to continue physical activity and 42-44 degrees Celsius core temperature will result in death (Molnar, 2006). Naturally, any adaptive pathways taken are engineered to keep the core temperature in a healthy range and across the board. All humans show remarkable skill to accomplish this. Africa being our generally accepted original climate, it has been argued that thousands (or millions) of years of genetic adaptation are the cause of such uniform heat tolerance in humans. In fact, as stated earlier, it only takes a week or two for a healthy body exposed to constant heat to make the necessary metabolic adjustments (Moran, 2008). Signs of an acclimatized body to heat include: reduced heart rate, lower core temperature, and marked changes in sweat rate (to be expanded later). Core temperature is lowered by reducing the Base Metabolic Rate (rate of metabolism when at rest or BMR); this lowered rate removes stresses on respiration and results in the lowered heart rate (Molnar, 2006; Moran, 2008). Again, any human is capable of these changes, so it would seem that this particular climatic adaptation is devoid of developmental/genetic impacts for natives versus non-natives arguably due to our common history in this climate; hence, any measureable variation in heat tolerance can be solely due to the individual's rate of *physiological* acclimatization represented by exposed/unexposed (this will be very important during the methodology section of this Thesis). Before moving on, however, temperature is always compounded by humidity and a discussion on humidity acclimatization also bears delineation.

Humidity can either result in dry or wet heat with each extreme bringing a particular threat to the human organism. While before it was shown that development and genetics are not a factor in climatic fitness, humidity does seem to have some genetic/developmental factors at play. In dry climates (regardless of temperature) dehydration is the primary threat coupled with hyperthermia. Natives of exceptionally dry and hot environments show clear advantages over non-natives in the prevention of these ailments. For example, Australian Aborigines have been shown to sweat twice as much as their   this adaptation is driven primarily by the pressure of heat, the pressure of aridity is also clear; for, to make up for fluid loss, natives are able to ingest 2% of their body weight in water in 10 to 35 seconds. It takes non-natives over 100 seconds to ingest the same amount (Molnar, 2006). This exceptional rate of hydration is due to the body retaining space for extra-cellular weight gain (water weight) during development and also results in greatly increased urine flow. Furthermore, cellular function is altered so that sweat contains less sodium, allowing more to remain in the body for proper electrolyte balance. Non-natives require heavy electrolyte replenishment after a comparable amount of sweating. These aspects of cellular metabolism are present as well in any genetic backgrounds including the San of Africa and show that these changes are not genetically distributed, but instead occur during development with similar climates resulting in similar adjustments (Hanna & Baker, 1974). Further discussion of the aspects of developmental cellular metabolism will further support this point.

Moving forward, humid heat also impacts variation in heat tolerance, this time driven by the reduced effectiveness of sweating. Because the air is already saturated, sweat cannot evaporate to cool the body. In this case, natives to humid environments show greatly reduced sweat rates. Continuing with Australians, those that live in the humid north sweat five times less than non-natives (who sweat double) in the same context (Moran, 2008). Given that these come from the same genetic background as the previously mentioned “super sweaters” the effect of developmental acclimatization is even clearer. What’s more, natives also show greater vasodilation (expanding of the circulatory system in the extremities) to allow for heat to more readily leave the body (Moran, 2008). In short, while heat acclimatization is a human universal, those who grew up in extremes of humidity show clear changes in the body, which appear to be genetic or developmental in origin. Again, this background material will prove vital in my methodology section.

To bring our background into the modern day and back into the specific context of this paper, modern research has shifted from adaptation documentation, to risk assessment for heat related illness (Ramphal-Naley, 2012). As of 2012, The World Health Organization (WHO) cites 6000 hospital visits a year are due to heat related illness. Two of every 100,000 emergency room visits are due to heat related illness. Finally, most shocking of all, over the last 30 years 150,000 lives have been lost annually to heat waves (Patz, Campbell-Lendrum, Holloway, & Foley, 2005; Ramphal-Naley, 2012). It would seem given all the proposed information that we are: 1) no longer able to mitigate high heat levels due to some form of maladaptation or 2) heat levels are reaching points that humans cannot possibly tolerate naturally and therefore are becoming increasingly insulated. The work of Doug Casa is especially noteworthy in answering these questions; for, he began this work because he himself suffered a heat stroke while exercising. As a result, a great body of knowledge has emerged showing how heat is becoming an increasing problem for those who take part in outdoor activities (Armstrong et al., 2007; Armstrong, Burton, et al., 2010; Armstrong, Casa, et al., 2010; Yeargin, 2006). Additionally, if the phenomenon of Global Warming is considered, there is a clear problem emerging for the modern world that doesn’t make much sense at first. If humans are so good at dealing with heat, why is heat now making us so sick and even killing us?

Acclimatization and Potential Illness

The pathways of adaptation described above serve as an introduction to aspects of environmental determinism our bodies experience when subject to extended climatic exposure. What one must glean from this hodgepodge of information is that our body's form and functions are very much a product of physical environmental pressures and, as such, any changes to our environment will theoretically change our bodies in a related fashion. This being said, what could the repercussions of an increasingly hot climate be on our bodies? This question shifts the question at hand from an academic problem to a medical one.

Case Studies

The French Heat Wave of 2003

As early as 1980, epidemiological studies were already citing heat waves as being responsible for more U.S. deaths than hurricanes, tornadoes, lightning, and floods combined (Posey, 1980). While this shows a raising awareness of heat related illness as a major threat to post-industrialized populations worthy of "Red flags", researchers such as Poumadere note that within the epidemiological literature regarding heat waves, there is a general underperception of risk even as late at 2003. Much of this is attributed to the general acceptance of people and the media that "summer will be hot" and other cultural attitudes that downplay risk (elderly just being prone to such illness); however, the French heat wave of 2003 was the first example of "a here-and-now dangerous [hot] climate" (Poumadere, Mays, Le Mer, & Blong, 2005).

In 2003 the average overall temperature in France had already risen by 33.8°F (1^{o}C) since 1900 alone, while the Global average was also up 30^{o}F (0.6°C). This general linear increase, coupled with the most anomalously hot weather (+42.55°F) in Europe since 1543 (+39.38°F), resulted in the hottest recorded August in French history (Poumadere et al., 2005). By the end of August, nearly 15,000 (14,802 official estimate) people that month alone were registered to have died from heat related illness (Press, 2003). While this figure is alarming at first glance, it should be stated that this level of mortality was *also* initially dismissed by government health officials and the media alike. It was not until the outcry of undertakers of an inability to cope with the morgue demand that the press began widely covering the natural disaster.

By 2004, however, an exhaustive epidemiological study driven by a national assembly was called for, which officially upgraded heat waves as a clear and present danger when before the events were considered “natural hazards” (Nationale, 2004). In short, the study was able to statistically separate “excess deaths” from “expected deaths”. While a macabre subject, most governments keep tabs on when a large group of elderly people are likely to die at the same time. This phenomenon is called a “harvest effect”. While a higher than average mortality rate was to be expected for August, the new study showed that not only were all 14,802 deaths “excess deaths” (even when compared to robust expectations), but also the mortality demographics revealed an age range of 30-75 years of age (removing a harvest effect possibility). What’s more, the study also showed a clear linear relationship between extreme heat and raising death tolls, but then went beyond to show how this level of excess mortality breaks the linear model for 2003 in two orders of magnitude. They argue this was due to societal and contextual variables (Poumadere et al., 2005).

For one, the excess deaths mainly occurred in urban centers. Primarily Paris (919 Paris home deaths when it was only 135 the previous year). Most of these individuals (92%)

lived alone, and were found because of neighbors or family raising alarm due to unanswered phone calls. 41% of cases lived in a single bed room apartment, and just over half of the victims lived on the two highest floors. These data points are vital; for it begins to point out certain social (cultural) risk factors involved with heat illness beyond and contributing to physiological acclimatization. Most Paris homes at the time did not have AC. Furthermore, the type of apartment described was often lit by sun roof or large direct window exposure with bad insulation. In France, these types of rooms are most often occupied by older or lower income individuals demographically. Indeed, the mortality reflects these demographics. Finally, 70% of home victims also had pre-existing medical or psychological troubles. These factors resulted in the study claiming the "Full picture for highest at risk: living alone, small urban dwellings, sun exposure with bad insulation, poor mental or physical health" (Poumadere et al., 2005).

The findings above represent the first case study where heat waves were considered both as an issue of major climate change, and as having cultural confounding variables as opposed to being a simple relationship between temperature and mortality. However, in the context of this thesis, one may notice that the relationship between acclimatization and climate control was not addressed at all. It was mentioned that France traditionally did not have AC; however, no analysis of AC presence in homes in relation to mortality was carried out. Furthermore, in their discussions, a World Health Organization (WHO) document is cited that lauds AC as the best way to lower overall populational vulnerability (Kovats & Hajat, 2008) (year is 4 years later because of cited later addition of same study) but in no way discusses the possibility of negatives; aside from air quality and microbial spread (such as legionnaires). To their credit, the original authors of the case study conclude "while the population vulnerability in Europe can be lowered by increased use of air conditioning the energy production system itself can be vulnerable to heat wave… heat waves are felt across the economy" (Poumadere et al., 2005). This is the beginning of looking at AC useage from an adaptive perspective and positing that while it may be effective, the infrastructure is fragile. In fact, this simple line turns out to be predictive in the following case study: The 2015 Heat Wave of India and Pakistan.

2015 Heat Wave: India and Pakistan

This case study deserves a brief forward; for, I began writing this thesis in 2013 with the idea fully formed. Then after a number of delays due to weather and method, I resumed the work Spring 2015. No sooner than I had really begun to generate data for the thesis, I start to see the events below unfold on the news. The very situation (hypothetical originally) that drove me to pursue this work. I apologize in advance for the citations being news releases as opposed to fully explored studies. However, the events are simply too recent for full analysis to be completed and translated into journals.

The 2015 Heat Wave began in India around mid-April. It was not until May that a major public health problem was evident, but by then the deaths were already clogging undertakers' establishments. A strange theme already in France and India is that the first alarm is always raised by undertakers who run out of space. In the first weeks of May, the temperature in Andhra Pradesh (mid-east India) and neighboring areas was in the 110^{o}F+ range continually. Heat indexes with humidity included pushed the temperature closer to 140^{o}F. In a single week, in a single state of the Pradesh, 1636 people died of heat illness. 541

died in the neighboring state. (Agarwal, 2015a). Yet again, most of the deaths were of day laborers and elders; however, again the figures represent “Excess deaths”.

This time, the government and media responded immediately, setting up hydration stations for people and issuing statements on the role of climate change in the rise of heat waves and how to stay cool (Agarwal, 2015b). So, again we see a major heat wave with truly unprecedented deaths. This time, the results are far more concerning from an adaptive perspective; for, this region of India is historically very hot and humid. Hence, according to current human variation studies this population should have all 3 forms of acclimatization to high heat (Molnar, 2006; Moran, 2008). So, why the unprecedented levels of heat mortality? To continue, one must follow the same Heat Wave to Pakistan. This is where the role of AC becomes truly apparent along with cultural confounding variables.

Between the 14th and 21st of June 2015, yet again a cry is heard from the undertakers. “The Morgues are overflowing” was a quote that made the headline of many news releases. Apparently the outrage of Muslim undertakers to not be able to complete proper funerary rites due to overloading was the red flag in this country. Again, reports start to roll in: 822 dead in Sindh province alone, 688 bodies in one Karachi Morgue, over 10,000 heat related illnesses hospitalized, and on and on (Nauman, 2015). While these data seem strangely similar to the previous two cases, there are certain factors that make this unique.

For one, the heat index in Pakistan was only cited as “the worst in 15 years”, which seems to refer to around the time of the 2003 Heat Wave (Nauman, 2015), not the worst in recorded history. So again, why all the excess deaths? There are two primary causes in this case. The first is that the Heat Wave occurred on the religious Holiday of Ramadan, which requires abstaining from food and water during the day. While many religious officials instructed people to cease fasting if it was a threat to their health, it would seem few listened due to the high degree of dehydration cases (near 10,000) (Nauman, 2015). The second was the last aspect of modern heat risk that no other study has shown. The AC went out.

Most of the deaths occurred in Karachi. Pakistan's sprawling port city and economic hub (this parallel makes it a great case study to apply to Houston, TX). After a week of similar high temperatures preceding the deadly week, electricity demand in the city spiked. The spike was so severe, that AC usage caused prolonged blackouts in many part of the city. Naturally, this sparked protests from citizens who rallied against Karachi's private sole energy provider K-Electric. Even going so far as to blame corruption in the government as responsible for more deaths. Little was done to address the blackouts for K-Electric simply claimed that its "systems were overloaded because of the spike in demand, as well as the increased load from illegal power connections" (Nauman, 2015) and deaths continued to occur.

While France was the first case study to truly look at Heat Waves as a clear and present threat of climate change, on the level of natural disaster, the above Pakistani case is the first to see AC fail. While corruption may be to blame, the consequences of power outages are no longer a hypothetical risk and show all too well how "fragile" the infrastructure supporting AC can be. Furthermore, it also shows how extreme cultural patterns can circumvent heat risk training and exacerbate morbidity. In conclusion, given the case studies above, the exact scenario that began the thinking of this thesis is happening *here and now*. This is not research about a future hypothetical, but a real and present threat to adaptive patterns in an ever increasing area of the world. Now the discussion can return to research question at hand.

Synthesizing a Research Question

As explained in the previous section, after around two to three weeks exposed to a climate, the body has become physiologically acclimatized to its surroundings and can deal with far greater stress loads than a non-acclimatized body (Molnar, 2006). Normally this would be in relation to the natural climate of the area; thus, providing the appropriate biological buffers to prevent harmful exposure when shelter is not available. However, given the previous paragraphs regarding air conditioning use, I argue that the prevailing climatic pressure on the bodies of those who live in climate controlled space is no longer in relation to the natural environment but instead shaped solely by the shelter environment (cultural) that is, in its very nature, the opposite of actual (natural) climatic stresses. Furthermore, if something were to occur that removed the shelter environment suddenly from this individual (like what occurred in Pakistan), that the risk for exposure would be highly elevated due to the body no longer having proper acclimatization (Alana Hansen, December 2011; Hanna & Brown, 1983; Kenney, DeGroot, & Alexander Holowatz, 2004; Vanos, Warland, Gillespie, & Kenny, 2012).

It is in the above relationship that the true question of this thesis develops: will a body in a thoroughly air conditioned environment be acclimatized to a cool/temperate environment despite subsisting in a naturally hot environment? If the answer to this question proves significant it could have manifold repercussions. The most immediate impact would be the exponentially increased risk for serious climatic shock in the form of hyperthermia (overheating) or heat stroke should an insulated individual become suddenly exposed (power outage). The more this potential becomes a reality, the more evident it becomes that a true physiological dependency on climate control can potentially develop (AC as life support from extreme heat). In short, if humans continue to improve our shelter’s ability to insulate us from the environment without paying head to the surrounding environment, there may be disastrous adaptive consequences (Auliciems & Dedear, 1986).

Chapter 2 Theoretical Background and Method

Part 1: Theoretical Background

Developing Cultural Ecology

Throughout the previous chapter, various principles of ecology were discussed: basic needs of subsistence, environmental determinism, adaptive pressure, and so on. However, as the history of anthological theory and method have shown, the laws of ecology alone are insufficient to capture properly framed questions of human behavior, culture, and adaptability (Erickson, 2010; Moberg, 2013). Instead, various thinkers such as Julian Stewart and his students have spent their careers furthering theoretical orientations, “which distinguish different kinds of sociocultural systems and institutions, recognize both cooperation and competition as processes of interaction, and postulate that environmental adaptations depend on the technology, needs and structure and on the nature of the environment. Also including analysis of adaptation to the cultural environment” (Steward, 1968). This statement defining the anthropological theoretical orientation of Cultural Ecology, is the distillation of a long running debate between geologists and anthropologists alike between the models of ecological determinism, cultural determinism, and posibilism.

Throughout the 19th century the success of the natural sciences, such as physics and chemistry, spurred many a researcher on to seek equally powerful laws of causation for aspects of human behavior (Moberg, 2013). Coupled with the also growing success of evolutionary models (grounded in ecological pressure) in discovering adaptive pathways, it seemed the only course forward to better understand “a science of humanity” would be to find any way possible to make the same models applicable to human populations. Hypothesis were constructed that numbers of lightning strikes could predict the inception of language for a cultural group, that a certain point of heat and humidity would stall or halt the development of civilization due to work load reduction, and many other such claims of the environments direct *cause* of otherwise uniquely human traits. Studies such as these come from the branch of "environmental determinism" (Sutton & Anderson, 2010). While many researchers have moved on from this perspective, there were certainly successes. Indeed, findings from such a view were included throughout the introduction to this paper: the direct effect heat exposure has on vasodilation for example. All one must do to experience environmental determinism in action is to go out in the snow with no clothes on. The shivering that sets in is *determined* by your environmental temperature. However, the human element has already muddied this perspective in something as seemingly mundane as clothing. People wear clothes in the snow. Thick clothes to keep warm. This means the climatic pressure is no longer in direct relationship with the individual's biology. Such climatic mitigation as well was mentioned in the previous chapter but for the sake of reminders: any human behavior (technology in this case) that alters natural pressures is considered "cultural". These kinds of points raised by early 20th century anthropologists such as Franz Boas (Briggs & Bauman, 1999), led to an equal and opposing theoretical reaction: cultural determinism.

Cultural Deterministic perspectives in an ecological sense hold that cultural practices directly shape the environment more significantly than the reverse (Moran, 2008; Sutton & Anderson, 2010). A clear example of this would be the Roman Aqueducts. These human made (cultural) structures dynamically crosscut the landscape and brought fresh water to where there was previously none. This act not only physically changed the landscape with the construction of the aqueducts themselves, but also in that it creates an artificial ecotone where the water is delivered; thus illustrating how a cultural positive feedback (good hydration/hygiene) has effectively triumphed and removed the “natural ecological pressure” (negative feedback) of insufficient clean water.

Yet again, one can see how this perspective fails to account for the entire picture of human adaptation. The Ecological Determinist would immediately respond with something along the lines of how the ecological pressure of need for more water began the entire cultural process of aqueduct construction in the first place and therefore is the more valuable perspective for understanding the formation of Roman society. Luckily, such disagreements are exactly why the concepts are called “theoretical perspectives” as opposed to full theory (Erickson, 2010).

Eventually, coming first from the discipline of geography, the idea of possibilism was posited to reconcile the impasse between the determinisms. The perspective is exactly what it sounds like; i.e. ecological (or cultural) pressures will determine *possible* causalities for populations exposed to them (Moberg, 2013). While this position accounts for the variability and indirect nature of human adaptation to environments, it quickly fell out of favor because it in no way can predict or guide research (Sutton & Anderson, 2010). This brings the history of thought back to Cultural Ecology.

Influenced by Marx, Julian Steward was able to adapt the Marxist pyramid of Infrastructure – Structure - Superstructure into more cultural and ecological terms. Where Marx made the base of the pyramid infrastructure (all the physical means of moving goods, energy, people), Steward instead placed the Natural Environment. This category would include subsistence resources, seasonal rounds, and climatic pressure. Next, where Marx placed Structure (all the buildings to contain goods sent by the infrastructure, the sociopolitical organization of people and resources, etc.) Steward coined the term “Culture

Core”. Aspects of the culture core include all technology that are in direct interface with the environment and, therefore, are in a more ecological deterministic relationship. A prime example would be that of an earthenware jug. The material the jug is made out of is determined by what environmental resources are available and the *need* of the jug is determined by the ecological pressure of transporting and storing water/food. Finally, where Marx calls the top of his pyramid “Superstructure”, Steward calls his “Ideology”; however, the two thinkers converge here in subject matter, both placing religion and other ideologies in this category (Erickson, 2010). This final category leaves room for aspects of humanity that are more culturally determined and even allows for some feedback. For example, the culture core that is the need for the earthenware jugs *function* is altered by ideology of *style*, which is often influenced by religious or political pressures as opposed to ecological ones (Moberg, 2013; Sutton & Anderson, 2010). In summary this pyramid model of Cultural Ecology is good for showing the gradient of ecological pressure and how it is increasingly confounded the more removed from basic subsistence the aspect in study can be placed.

While the above model was a breakthrough for many anthropological studies, especially in archaeology, the sub-discipline of physical anthropology continued to put forth new findings that introduced variables like mutation, genetic drift, and developmental morphology in the conversation of human adaptability. These still very much “natural science” ideas, though confounding at first, actually provide the missing link to fully develop the research model this thesis will employ.

Laws of Physics and the Body

The study of various climates' physical relationship to the form and function of bodies has been a long standing interest of various scientific fields and some surprisingly mathematical relationships have been found. The following laws all share a root law of the natural sciences known as Fourier's Law. This law states that any physical body with internal heat generation will dissipate heat directly proportional to the surface area of the body in addition to the amount of difference between internal and external temperatures. In other words, more surface area results in greater dissipation of heat (long lean) and less surface area (short thick) results in greater retention of heat; all of this is compounded if there is a large difference between body heat and environmental heat (Austin & Lansing, 1986; Molnar, 2006). The first particularly biological application of Fourier's Law to be mentioned is Bergmann's Law. Over a century ago, Carl Bergmann pointed out that mammalian body size was somehow related to mean annual temperature. He went on to show that cold climate dwellers tend to be larger and heavier and those inhabiting warmer areas tended to be smaller and leaner (Molnar, 2006). Skipping forward thirty years a zoologist by the name of John Allen furthered this idea to apply to bodily proportions. He illustrated that colder climates tended to produce short squat forms and hotter climates tended to produce long narrow forms (Molnar, 2006; Nudds & Oswald, 2007; Serrat, King, & Lovejoy, 2008). These two relationships are known as Bergmann's and Allen's rules respectively and together they provided the groundwork for environmental determinism of biological form. The infamous examples of these rules are the polar bear and the giraffe. In humans, the juxtaposition can be seen in native Swedish mean body types versus native Kenyan mean body types (Moran, 2008). Already the relationship of air conditioning becomes clear because the differential of temperature (delta) between the air conditioned body and the actual environment is greatly increased. Thus, according to Fourier's Law, the rate of temperature exchange will be exacerbated when climate control is removed.

To bring the discussion back to anthropology, after decades of measuring human bodies with the laws and techniques of Biological Sciences (known as the work of anthropometry) it became increasingly clear that a great deal of human variation is the result of climate, but this goes far beyond body measurements. Researchers such as Paul T. Baker have conducted extremely thorough studies to see how climatic stress alters even our very metabolic processes (in addition to new understandings of bodily measurements). While Baker focused primarily on Quechua peoples in high altitude, he also produced a good deal of knowledge on human thermoregulation that was furthered by many other researchers (P. Baker & Weiner, 1967; Hanna & Baker, 1974; Little, Thomas, Mazess, & Baker, 1971). Examples of this work were included in the Introduction to human adaptability to heat studies.

Once all of the theoretical work of the determinists and possibilists detailed above came to fruition, and the laws of biology were showing continued success, the theoretical orientation that this thesis will employ was finally synthesized (McElroy, 2009).

The Ecological Model

If the deterministic models can be illustrated as straight arrows of cause and effect, and Cultural Ecology as a pyramid with up and down feedback between levels, the Ecological Model can be best understood as a 3 circle intersecting Venn diagram (McElroy, 2009).

The first circle of the diagram is the natural environment: air quality, food resources, substrate, climate, etc. The second circle is human Culture: technology, ideology, behavior, architecture, all things human made. The third circle is human biology and physiology: genetic mutation, acclimatization, disease, physical evolution, etc. Each of these circles intersects and has feedback connections with the others to allow for dynamic interchange of cause and effect (McElroy, 2009). A famous example of how this model can be used to conceptualize and analyze complex problems of adaptation is in the case of Sickle Cell Anemia.

Originally, humans were not the prime host of mosquitoes (the vector of malaria). It was only after deforestation and migration into swamp like areas, that humans became exposed to mosquitoes and malaria with them (Barnes, 2005). Sickle Cell Anemia's distribution in modern populations is the result of a heterozygote advantage that carriers have to contracting Malaria. For a full discussion of this adaptation see (Barnes, 2005; Molnar, 2006). To employ the model, in this case the ecological circle would include the natural pressure (over population, lack of food) that pushed humans to settle in areas with endemic malaria. The cultural circle would then include adaptations and alterations to the new environment (cutting down trees causing swamp water and over hunting mosquito's natural blood source) and ideology (new notions of home and place) of the people. Finally, the biological circle would include the new pressure of malaria (increased mortality and morbidity) on human survival. When the first sickle cell mutation occurred, the model begins its second rotation this time beginning with biology. The biological phenomenon of heterozygote advantage now impacts ecology because the malaria parasite now has a new adaptive pressure of its own: human immunity. This feedback continues; for, with more members of the community surviving, more malaria endemic land can be occupied and altered by human behavior. Many years later, the cultural circle picks the feedback chain back up and researchers publish works on Sickle Cell Heterozygote advantage. This then changes human biology yet again once expecting parents begin to screen their children for sickle cell before carrying to term, or when gene therapy offers to alleviate Sickle Cell symptoms (Barnes, 2005). Already, the level of analysis of adaptive pathways has reached more nuanced detail and cross cutting influence can be accurately represented. So how does this orientation help the methodology of this thesis?

Firstly, there is the ecological pressure of heat. The particular cultural response in this case is Air Conditioning. Given the flow of the model *along with* the notions of Fourier’s, Bergmann’s, and Allen’s laws, it would then follow to look for changes in either morphology or metabolism as a response to the new cultural technology of AC. Furthermore, should such biological phenomenon be identified, the Ecological Model allows for predictions for future research; i.e. less area of the world will be livable if climatic adaptation is hampered, which then will change the distribution of culture around the world as people migrate or change building style to alleviate heat in other ways.

In short, the dynamic feedback between ecology, culture, and biology that the Ecological Model allows makes it the most applicable to guide the research of this particular question of adaptability presently available. With this in mind, the discussion of research method can begin.

Part 2 – Method

Given that this particular question of the present state of human adaptation has yet to be assessed by previous more empowered researchers, I was faced with the challenge of having no previous research methods on which to base my own. As shown in the previous chapter, many detailed clinical studies exist regarding human thermoregulation in natural temperatures, and many studies exist regarding various kinds of disease resulting from air-conditioning; however, no studies have yet to be carried out to assess the intersection of climate, Climate Control, and adaptive changes in the human body. This is precisely why the Ecological Model is best to guide the construction of a method of this thesis.

The first method proposed to address this intersection was simply to re-apply the research design of the first human adaptability studies to assess heat into the Ecological Model. In short, identify 3 populations: acclimatized (live with no AC), migratory (moved recently from use to non-use or vice versa), non-acclimatized (live with AC all the time). This would exactly mirror the high-altitude studies of Baker and others (P. T. Baker, Buskirk, Kollias, & Mazess, 1967; Hanna & Baker, 1974; Little et al., 1971). Given known key markers of human heat tolerance as outlined in the previous chapter (lower heart rate in heat, lower core temperature when exerting energy, and variations in sweat rate - though confounded by genetics), once one had identified a strong sample base of each three populations, a basic heat stress test could be carried out. Naturally, one would have to control for variables of Body Mass Index (BMI), hydration, clothing, general physical fitness, and previous heat related illness (Alana Hansen, December 2011; Armstrong, Burton, et al., 2010; Armstrong, Casa, et al., 2010; González-Alonso, 2012; Yeargin, 2006); however, with the proper pre-test survey factors of AC in variations of shown heat stress could be identified.

For example, those that spend over 2 weeks in air-conditioned space could be expected to show the same metabolic response when exposed to a heat stress test as a person acclimatized to temperate temperatures if the established relationships of the human body to heat still stand. This would have huge implications for modern studies of Human Variation.

After the first proposal for this thesis, which included this method, I began attempting to collect a population and acquire permission to use a heat stress testing facility. While finding a population was already proving difficult (this will be significant in the discussion of the results), I quickly found that using a heat stress chamber would not be possible given the level of access to technology the university would allow. This turned me to thinking more anthropologically, and I began looking for people naturally exposing themselves to extended hot temperatures. I found an 18 day long folk festival in the middle of June.

I had the method set to use surveys to identify my three populations, and to carry out heat stress tests near the end of the festival. Differences between campers who had been there all 18 days (no AC) and campers who had only been there for the week end (still acclimatized to AC living) could then be assessed with heart rate monitors and a very good ear thermometer. However, various climatic events put this research on hold.

Record breaking floods occurred the very day the research was cleared to begin. These floods were so heavy, the campsite was separated from the nearest city by a river that had overtaken the central bridge. What’s more, these floods were due to an el Nino event, which also resulted in unusually low temperatures for the remainder of June (Patel, 2015; Wang, Huang, Hsu, & Gillies, 2015). With temperatures never breaking 90^{o}F, the study simply could not be carried out. This led me to pursue a more exploratory scope in the face of such challenges.

This very minimal outline of the original method is included because it is vital to the full scope of the findings of the research soon to be discussed. For one, the original study design can still be carried out with the support of a more robust research facility. This could be done in future Ph.D work on the same question, or later with grant funding. Secondly, the challenges faced in actualizing this research method are indicative of the very problem. Though a year was spent searching for a population that lived with no air-conditioning, none was found. Already an indicator of how widespread its use is, even in rural populations. Once a population was found that could possibly achieve the level of exposure to designate a "heat acclimatized population" this population was impermanent. Finally, the weather itself was so unstable, no true acclimatization could occur (even more significant when one is reminded this was the same summer as record breaking heat waves later that August). Already this anecdotal evidence is suggesting that previous understanding of human biological relation to heat is no longer valid for modern populations.

The following will detail how the use of two major governmental databanks coupled with contextual interviews will be used to assess the relationship between health, AC use, and climate change (Ecological Model criteria); specifically global warming and temperature destabilization. Each aspect will be addressed in detail along with the reasoning behind each choice.

Population and Timeframe

The primary populations assessed by this thesis are the entire state populations of Texas and Florida to allow for cross state comparison; however, the primary subject for discussion will be the population of Houston, Texas with the Floridian population to be used as a comparison. Each of these populations will be identified along with their chosen variables to measure by means detailed below. Furthermore, once analysis was completed on this statewide level, more nuanced interviews (also detailed later) were carried out on random representative samples, N = 13, from each state.

Following this narrowing of analysis, the timeframe used for the governmental data will be summer months (May-September) 2001 – 2012 to allow for longitudinal background of heat and illness to be assessed. These dates were chosen because they represent the most recent 10 year span of analysis currently available from the CDC (CDC, 2016). Next, the interview participants will be asked to report on the summer of 2015. Because acclimatization is fairly rapid, data from this particular summer will be the most applicable to their present acclimatized state (Molnar, 2006). However, background information in the interviews can come from 2001-2012 to critique and inform the CDC data and the individual's "heat history". Further details regarding the interview process aside from timeframe will be detailed in the following section; however, let us now return to the method of the inclusion of the governmental databases.

Databases: Etic

An established research principle in anthropology is the division between emic and etic data. In current research, the same division is often referred to as qualitative and quantitative data research; however, the original anthropological definitions are a bit more subtle. Etic data are data that are from the researcher's perspective, or "outsider view". Often these represent statistical demographics, biological processes, and other more "mathematical" datasets designed to give context at least somewhat removed from subjective bias (Layton, 1997; Moberg, 2013). In this research, the etic (quantitative, large scope) data will come from two major governmental databases: The Center for Disease Control Heat Stress Illness Tracking Network (HSTN), and The United States Energy Information Administration Surveys. Each of these databases represents longitudinal research efforts by each government office and allow for detailed analysis described below.

In 1988 the Institute of Medicine published a report titled “The Future of Public Health”. This piece noted that “the removal of environmental health authority from public health agencies has led to fragmented responsibility, lack of coordination, and inadequate attention to the health dimensions of environmental problems.” (p. 16). Nearly 20 years later, the Pew Environmental Health Commission issued another report "America's Environmental Health Gap: Why the Country Needs a Nationwide Health Tracking Network." calling for the creation of a nationwide health tracking network as the title suggests. Without such a network, understanding the relationship between global warming (an environmental phenomenon that will impact health) and heat related illness would be impossible. Given that no such system existed at the time, in 2002 Congress provided the CDC with funds assigned the task of developing a system. This pilot funding continued until 2006, when data from local health departments, federal partners, and community groups was amassed. Funding continued and as of 2014, 25 states now support the HSTN; including Texas (Control, 2016).

With the above research completed, the CDC compiled an interactive reporting tool specifically for heat related illness across the United States. The tool begins with asking the user for a number of criteria. For example: 1. Select a content area (climate change), 2. Select indicator (1. Future Projections of Extreme Heat, 2. heat stress emergency department cases, 3. heat stress hospitalizations, 4. heat vulnerability, 5. heat related mortality, 6. historical extreme heat days, 7. Temperature distribution). Each of the data points listed in the previous sentence can then be measured on a state to state and year to year basis.

Another example: I want to assess health risks of climate change (truly the primary research question of this thesis). I then want to know how many people died from heat related illness. So, I select the “number of summertime deaths (May-September)” as my measure. I then get to choose any state I need the data to come from (in this case Texas). Finally, I select the year(s) I want the data pulled from (in this example 2004). By clicking on the state of Texas on the generated map, I can now see that there were 59 heat related deaths in Texas for 2004, let alone hospitalizations. Furthermore, I can also double-click on the state for census information (race, gender, age, etc.). This will be vital in my analysis; for I can use this data to compensate for any confounding variables such as an aged or statistically dissimilar population between states. Finally, I can then access an “about these data” tab that supplies all of the reports that the data for the map came from; thus allowing for further analysis and citation. In summary, the HSTN contains sufficient data to survey secular trends in heat related illness (data range from 2004 to 2014).

For the purpose of this thesis I will be gathering data on the following variables from this survey: the year the data are from (year), the state the data are from (State), heat related mortality (heatMORT), extreme heat days (Xheat), state population by year (population), and the percentage of people in poverty (poverty). The numerical data from the original CDC datasheets was directly imported to IBM-SPSS 26 to prevent clerical errors and to allow for robust statistical analysis. Each variable’s SPSS label is included in parenthesis above.

The State variable was coded as nominal with Texas being coded as 1 and Florida being coded as 2. This allows for the sorting of data points by state; for, each line of data was entered twice (one line for each year of each state). This variable was mentioned first, because all other variables are either sorted into 1 or 2 criteria. The year variable was coed as a scale variable and was included to allow for the separation of other data points over time. Again, each year was given two separate data lines; one Texas, one Florida. The population variable was coded as a scale variable and directly input. Finally, the poverty variable was also input as a scale variable. These data points are directly explanatory, however, the final two variables require background because they are the product of specific mathematical calculations.

The CDC data on heat related mortality was nationally derived by the Environmental Health Tracking Branch using National Center for Health Statistics mortality data with appropriate ICD-10 codes to calculate the total number of deaths by year during summer (May – September) period. Deaths from excessive heat exposure were defined based on codes from the tenth revision of International Classification of Diseases (ICD-10). Such deaths included those in which exposure to excessive natural heat (code X30) was reported as either the underlying or a contributing cause of death. Deaths due to exposure to excessive heat of man-made origin were excluded; hence, all deaths recorded here are due to exposure to the natural environment (CDC, 2016). The resulting heatMORT variable accounts for all recorded heat exposure deaths for each year and state. It was coded as a scale variable and the deaths from each state over the years was entered.

Extreme heat days are a very useful data measure when assessing problems of heat related illness. North American Land Data Assimilation System (NLDAS) data, available at the 1/8th-degree grid (approximately, 14x14 km), consist of 103936 grid cells that cover the entire United States, excluding Alaska and Hawaii. Daily maximum temperatures were selected from hourly NLDAS data by this grid. Daily maximum heat index was also calculated, taking into account relative humidity and temperature; thus, this variable alone can represent geographic distribution, temperature, and humidity. This grid-level data was also converted to county-level estimates to determine population exposure to extreme heat and enable linkage with health datasets. The CDC data collectors also used a 3-step, geo-imputation approach to convert grid-level meteorological data to county-level estimates. First, they created a population-weighted centroid (geographic center) for each county in every state, except Alaska and Hawaii. Next, they identified the grid cell that contained the population-weighted centroid. Then, for each grid cell containing the population-weighted centroid, we identified all the adjacent grid cells. Daily county-level maximum temperature and heat indices were then calculated by averaging values from all the adjacent grid cells and calculated the 90th, 95th, 98th percentile values for daily maximum temperature and maximum heat index for 2000-2010. Extreme heat days were then identified for each combination of the following parameters (1) temperature or heat index and (2) absolute (e.g., 90°F, 95°F, 100°F, 105°F) or relative (e.g., 90th, 95th, 98th percentile values) thresholds (CDC, 2016). For these data, the relative 90^{th} percentile was used because it most fit the original Human Variation studies levels of heat exposure (around 90^{o}F heat index – humidity and heat), allows for the relative adaptive response of humans living in different geographical areas, and allows for examination of heat and humidity simultaneously. The resulting thesis variable, Xheat, was coded as a scale variable and can be used to graph correlations between extreme natural heat and heat mortality as well as other potential correlations.

While the above offers insight into the trends of heat related illness in the U.S. in relation to heat, how can these data be linked to Air Conditioning use? This will be done with assistance from a second government database, The United States Energy Information Administration Surveys.

The U.S. Energy Information Administration (EIA) came about in the 1970's as a response to the energy crisis at the time. While this was primarily petroleum focused, the crisis expressed a direct need for the federal government to collect data on energy-related information. This need resulted in the 1974 Federal Energy Administration Act, which created the Federal Energy Administration (FEA). Tasked to "collect, assemble, evaluate, and analyze energy information; provide energy information and projections to the Federal Government, State Governments, and the public; and provide Congress with an annual report summarizing these activities", this was the first government body with the authority to enforce the mandatory gathering of data from energy consuming firms. Since then FEA has grown in scope to include the EIA in its office and pass regulatory acts (RECS, 2015).

This thesis will analyze data from a major recurring survey conducted by the Energy Information Administration: The Residential Energy Consumption Survey (RECS). This survey provides detailed information regarding electricity consumption for residential spaces, including reports specifically on Air Conditioning. The data for each survey is first generated by a physical building survey phase followed by data collection from building energy suppliers directly. These data are then used to generate consumption and expenditure estimates. These estimates are then made sure to be from a nationally representative sample so that usage patterns can be analyzed. Furthermore, even the dollar amount spent on energy usage is captured to allow for economic analysis. A more detailed description of the EIA's method will be included in the thesis and can also be found at eia.gov/consumption.

The RECS was chosen for a number of reasons. Primarily, understanding heat thresholds during rest hours is far more vital to understanding heat stress than work hours (Quandt et al., 2013). Pulling from the 2009 Residential Electricity Consumption Survey (RECS), one can see that Texas (in the South West regional report) of the 8.5 million surveyed homes, 8.2 million use AC equipment. Furthermore, 5 million residents are confirmed to leave the AC on all summer. Already one can see just how widespread AC use is in Texas, every hour of the day.

For the purposes of this thesis, the following variables will be assessed: the number of households using AC (homeUSE), the millions of homes that have natural shade to insulate (TREEcov), the total number of households in the United States (homeTOTAL), the average temperature people leave the AC (acAVE), and the millions of homes that have no climate control equipment (noAC). Each of these variables was coded as a scale variable in SPSS due to their strictly numerical nature.

With the data above properly input and coded, analysis will be able to show a reliable quantitative picture of AC usage and heat mortality. However, as many people I met with often noted “How are you going to link the two?”. Originally my answer was biological testing driven by the temperature the people lived in, as outlined at the beginning of this section. The following, however, will detail how the use of interviews properly transcribed and coded can begin to identify trends before biological pathways can be thoroughly researched.

Interviews: Emic

The use of both emic and etic perspectives has continually been a strength of applied anthropology and, just so, this thesis would be incomplete without an emic understanding of the etic data detailed above. Emic, in anthropological research, refers to the “insider’s view”, or, the version of things the people being studied self-report to you. An important saying in statistics is that “correlation is not causation” and this is a major fallacy for which, these interviews will be designed to compensate. Certainly one could observe similarities of trends in the above databases, however, such a view could not compensate for the lifestyles of living people (emic data). Does the person camp often even though they have AC at home? Do they play outdoor sports? Do they have a special sensitivity to heat? All of these questions offer valuable information to understanding the lived reality of rising temperatures and how they affect people’s lives. As such, this thesis will also employ semi-structured interviews focused around participant’s personal history with hot weather and Air Conditioning.

Potential participants were anonymously recruited via email flyer, which was sent through two listservs. The first was an academic advising listserv provided by the Comparative Cultural Studies academic advisor. The second was an independently made listserv of former Disney College Program participants. This second list also ended up including a handful of non-Disney program participants; however, they resided in the same region of Florida. No policy was violated in the use of these listservs. See Appendix One for the recruitment flyer.

One notified via flyer, participants were instructed to email my official UH email address to express interest in the program and receive an anonymous cover letter consent form (see Appendix 2) if they matched the inclusion criteria. Given the “state wide” demographics of the CDC and RECS surveys, the only inclusion criteria expressly stated were to have been a resident of either Texas or Florida for the entirety of the past summer. Given the criteria of acclimatization outlined in the introduction (most importantly that humans have universal developmental and genetic acclimatization to heat, so two weeks of climatic exposure is enough to generate adaptive heat acclimatization (Molnar, 2006)), an entire summer of residence is ample time to report on personal experience of heat acclimatization. This criteria may seem overly wide, however, in the Results chapter of this thesis, you will see the descriptive actually represent a fairly homogenous demographic sample for comparison. Moving on, one this process was cleared an anonymous phone conversation was then scheduled to conduct the interview. The script of questions can be found in **Appendix 3**; however, please note that these questions were conversational guides, in keeping with the semi-structured nature of the interview. As each interview unfolded certain additional questions were asked to garner more contextual information. This information was well documented in the process below.

Each anonymous interview was recorded via digital tape recorder live as the interview unfolded. Additionally, notes were taken on copies of the question sheet. One for each subject. After each interview was completed, the recording was then re-listened to and transcribed in full using the same Microsoft Word Document the live notes were taken. With transcriptions in hand, guided by the live notes, key themes could then be generated via textual analysis. For example: One major question was “If Air Conditioning did not exist, what would be alternative ways you would stay cool?” Many participants would respond loosely with “Oh, I don’t know, I’d really try to stay inside as much as I could. Turn on lots of fans, you know that kind of stuff." From this response I can then pull the theme of "Fans", and "Stay Indoors". This style of analysis was used for all question that do not require a direct response, such as: "How old are you?" These questions were simply directly input into SPSS. This brings the discussion to the method of quantifying the qualitative interviews.

At the completion of the data collection phase, 13 interviews per state were completed for a total sample size of 26. From these 26 interviews, the following 39 variables were collected: age, state, raceID, H20, AC, Usage, COOL1, COOL2, COOL3, longerSUM, avTEMP, heatRISE, coldSLEEP, outHOURS, HEATexpo, COLDexpo, HEATsic, sicFAM, HEATbugs, effectLIFE, goACstay, altcool1, altcool2, altcool3, acclimABLE, moreACu, moreACthem, atlHOU, altFLO, BILLimpact, Parental, Humidity, heatRISK, heatTRAIN, ACculture1, ACculture2, ACpols, Deal, and cogDIS.

The age variable is how old the participant is and was simply coded as a scale variable. The state variable was coded to match the government datasheet (Texas = 1, Florida = 2) and coded as nominal.

The receID variable was an open ended self-reported racial identity question. The resulting criteria were coded (1= Black, 2=White, 3=Asian, 4=Hispanic, 5=Vietnamese, 6=Syrian).

The H20 variable was coded to measure levels of hydration in the subject. This was coded as ordinal to allow responses such as "3 water bottles a day" as opposed to pressing for exact fluid ounces (1=dehydrated, 2=average, 3=hydrated). Those who claimed to "only drink coffee and tea", or outright said "not enough" were coded to "1". Those that showed average levels of water consumption (usually in the form of "about 2 or 3 bottles a day") were coded as average. Those that were able to report specific consumption levels in healthy measures or simply reported constant consumption of water were coded to “3”.

The AC variable was tied to the “Do you have Air Conditioning in your home?” question. This was a simple yes or no question, so the variable was coded as such and was nominal (1=no, 2=yes).

The usage variable was tied to the “How Often do you use the AC in summer months?” question. This generated more qualitative responses than hourly estimates so the variable was coded as ordinal (1=never use, 2=less than 8 hours, 3=more than 8 hours, 4=all day).

The longerSUM variable was to assess whether or not the participant felt the summer, and resulting AC use, was longer than May-September. The resulting responses resulted in a nominal breakdown (1=no, 2=yes, 3=unstable). “Unstable” responses were those that said the temperature has become too unstable to say from summer to summer.

The avTEMP variable contains the average temperature that the participant left the AC. This was a scale variable with simple numerical entry.

The COOL1,2, and 3 variables all mirror each other and are the product of key themes regarding how people stay cool in the summer (1=AC, 2=stay inside/inactive, 3=cold drinks, 4=breeze, 5=ice, 6=fans, 7=clothing, 8=pools/beach). These variables are nominal.

The heatRISE variable was to assess whether or not the participant personally felt that summers were getting hotter. This coding mirrored the longerSUM variable as nominal (1=no, 2=yes, 3=unstable). “Unstable” responses were those that said the temperature has become too unstable to say from summer to summer.

The coldSLEEP variable was created because many participants reported turning the AC down when they slept. This was also recorded on governmental surveys. coldSLEEP was coded as nominal (1=no, 2=yes).

The outHOURS variable was to record how many hours outside the participant spent per day during the summer. This was coded as a scale variable to allow for direct numerical input.

The HEATexpo variable was coded to assess whether or not the person had occupational continued exposure to heat, such as a baker or furnace worker. Reponses allowed this variable to simply be a yes or no (1=no, 2=yes).

The COLDexpo variable was coded to assess whether or not the person had occupational continued exposure to cold, such as a grocery stocker or butcher. Reponses allowed this variable to simply be a yes or no (1=no, 2=yes).

The HEATsic variable captures the level of heat related illness the person has experienced. This was coded as ordinal to allow for open responses but still capture hierarchical scaling (1=none, 2=mild, 3=exhaustion, 4=stroke/extreme, 5=child event/lasting severe sensitivity). None is for those that show no history or sensitivity. Mild is for those that had mild negative reactions to heat such as headaches or notable discomfort. Exhaustion is for those that had a clear heat exhaustion event in the timeframe of the study (summer 2001 – Summer 2015). Stroke/Extreme is for those participants who suffered a clear heat stroke or otherwise extreme heat illness (vomiting, loss of consciousness, extreme delirium). Child Event/lasting sensitivity is for those participants that had an extreme event between the ages of 13 and 18 (normally resilient stages of life to heat) and then had a lasting sensitivity to the heat to the point of medical danger. This represents the highest level morbidity for the sample because it combines an intense event with a lifelong hampered adaptation ability.

The sicFAM variable was coded to assess the degree to which the participant has witness heat related illness in their surroundings (family cases or otherwise). This variable was also coded to be ordinal (1=none, 2=only me, 3 = mild trend, 4=population sensitivity). None is for those that had no reported heat related illness. Only me is for those that only suffered a personal case. Mild Trend is for those that reported heat related illness as a common danger in their lives (either working outdoors and have witnessed multiple times, or say it runs in the family). Population sensitivity was for those that reported everyone they knew had some sensitivity to heat.

The HEATbugs variable was to assess psychological stress brought on by the heat. This was also able to be coded as ordinal due to the escalating severity of responses (1=no, 2=human norm, 3=mild, 4=irritable, 5=hate). No was for those that had no irritability or discomfort in heat. Human norm was for those that responded with responses like “yeah it makes me irritable, but that’s just a person in the heat”, or generally expressed a normality to being uncomfortable in heat. Mild was for those participants that expressed mild irritability or aggravation due to heat but do not actively avoid it. Irritable was for those participants who expressed a known aversion to heat and could “deal with heat” but would avoid for the sake of their mood. Hate was for those participants that expressed an above average dislike of being hot, either in fervor of response or total behavioral change to avoid any kind of heat discomfort.

The effectLIFE variable was to assess how the feelings from HEATbugs might affect the participant’s behavior or lifestyle. These were also coded as ordinal (1=no, 2=plan around, 3=cancel/decline outdoors, 4=extreme). No was for those that had no aversion to heat. Plan around was for those that would plan their day to avoid heat in a mild way (such as planning stops in a long day to sit in AC and cool off). Cancel/decline was for those that explicitly stated that they will not attend plans if they are held outdoors due to heat. Extreme ws for those that took excessive measures to avoid heat (one such example is a person who moved into a hotel for over a month when their AC broke to avoid summer heat).

The goACstay variable was to assess whether or not the participant would live in the state in which they lived if AC did not exist. This was coded as nominal (1=no, 2=yes). This is a bit counter intuitive; for, no is a statement that they would NOT live in the state.

The three altCOOL variables all mirror on another in coding and are nominal. Each category for these variables was generated from participant responses (1=fans, 2=stay inside, 3=drinks, 4=ice, 5=misters, 6=breeze, 7=building change, 8=cold showers, 9=pools, 10=other).

The acclimABLE variable was to document whether or not the participant had ever experienced the sensation of acclimatization. This was a simple yes or no nominal response (1=no, 2=yes).

The moreACu variable was to assess whether or not the participant has increased their average AC usage over the last few years. This was a simple yes or no nominal response (1=no, 2=yes).

The moreACthem variable was to assess whether or not the participant has witnessed a rise in AC use or instillation in their general surroundings. This was a simple yes or no nominal response (1=no, 2=yes).

The atlHOU variable was designed to capture qualitative responses regarding how Texans see others keeping cool differently than themselves. This was an open ended response but major themes were coded to SPSS as nominal to allow for descriptives to be run (1=dry vs hot, 2=misters, 3=building change, 4=more watersports, 5=shade, 6=ecology, 7=people acclimatized, 8=fans (hand and ceiling).

The atlFLO variable was designed to capture qualitative responses regarding how Floridians see others keeping cool differently than themselves. This was an open ended response but major themes were coded to SPSS as nominal to allow for descriptives to be run 1=dry vs hot, 2=misters, 3=building change, 4=more watersports, 5=shade, 6=breeze catching, 7=drinks, 8=ecology, 9=people acclimatized, 10=more AC than us, 11=parasols).

The BILLimpact variable was to capture the level of economic stress AC placed on the subject. This was coded as ordinal to capture levels of severity (1=don't pay bills, 2=not a cost issue, 3=leave on but think about cost, 4=adjust for economy, 5=turn off due to cost).

The heatRISK variable is a vital one to this study and the product of various other variable responses. This variable is made to gauge how high of risk for further heat related illness the participant represents and is an ordinal variable (1=exposed, 2=seasoned, 3=commuter, 4=insulated, 5=illness present). Exposed is for those participants that are out in the heat often but have had no illness; i.e. they are exposed to heat and acclimatized safely. Seasoned are for those who have been in long exposure to heat recently but have AC at home; hence, they are "seasoned" from heat exposure but are beginning to re-insulate. Commuter was for those participants that are in and out of AC and a hot climate; i.e. they walk around town in heat every day but it is from one AC space to another. Insulated are for those people who spend the majority of their time in climate controlled space. Illness present was for those cases that had a previous extreme heat related illness that has required them to totally avoid heat exposure due to medical risk; thus, due to an already documented inability to adapt, they represent the most at risk.

The ACculture variables (1 and 2) were to capture qualitative responses about cultural motifs of AC that participants had noticed. This data is best assessed in the discussion, however, for the sake of descriptives the following nominal criteria were set (1=necessary, 2=courtesy, 3=necessary courtesy, 4=cold hearth/blessing, 5=modernity, 6=US only modernity, 7=taken for granted, 8=other).

The remaining variables are the product of prominent themes that became evident as the study went on. They are coded as nominal (1=no, 2=yes) simply to capture descriptives on how often the themes appeared in the interviews. heatTRAIN was whether or not the person had training to prevent heat illness. ACpols was to capture the theme of "AC politics" or general interpersonal stress or policing that occurred over AC temperature. "Deal" was to capture the general sentiment of some that psychological preparation, or knowing that the heat is inescapable somehow helped then deal with heat better. CogDis was for those that expressed cognitive dissonance regarding temperatures; e.g. "its December now, its *supposed to be* cold!"

With all of the above variables captured and coded into SPSS, a description of statistical procedures can begin.

Statistical Procedures

Naturally, the first procedure to be run in SPSS was descriptives. This will be run on both the REC&CDC datasheets and the Survey information datasheets. This procedure will allow for simple graphing along with general surface analysis (number counts, percentages, skewness, standard deviation etc.)

Further statistical analysis will be started with the RECS and CDC datasheets. Because this dataset includes variables such as population, extreme heat days, and heat mortality, Levene tests along with independent samples t-tests can be run to determine if any of these variables represent statistically significantly different populations in terms of variance and means. For one, while Texas has a larger population than Florida, if there is no significance found in a Levene test of the population variable, the two states can be considered statistically similar populations (equality of variance can be assumed). Most notably, if there is no statistical significance in extreme heat days (a measure of both geography, and relative heat) the climates of the two states can be considered comparable for the purposes of this heat stress study even though aspects of their general ecology and simple state acreage may differ. Vice versa, if they are significantly different, a more in depth ecological comparison may be needed.

Once justification for comparison can be made via t-tests, the next procedure to be run will be correlations. Whether or not bivariate Kendal's tau, Pearsons, or Spearman Rho will be run will depend on the results of descriptive analysis. Any correlations between variables can then be further pursued. Most notably, any positive correlations between extreme heat days and heat mortality would support established trends in heat and excessive death (Poumadere et al., 2005), and any positive correlations between AC usage or Average temperature with heat related mortality would support the hypothesis of this thesis. If possible, further regression analysis can then be completed to assess trends in variance;

however, it is unlikely that regression will be possible or appropriate in the scope of this study.

Returning to the Survey data SPSS file, again the first tests to be run will be independent samples t-tests to assess significance of populational difference. However, further descriptives can also be run with the datasheet filtered by state to assess general differences in themes between states, given the Texas=1, Florida=2 coding. T-tests will also be run both sorted and not sorted by state to capture further differences in the data.

After analysis of the populational variance is completed correlations can then be run on the survey variables to assess any potential linkages; again both filtered and unfiltered by state to assess population variance. Most notably, if positive correlations are found between the heatRISK (degree of insulation) and HEATsic (degree of heat related illness) this would strongly support the hypothesis of this thesis (as insulation goes up, so does heat related illness). Additionally, if correlations are found in one state but not in another and their extreme heat days were found to be similar, more connotations of behavioral difference can be assessed. Finally, given the various themes gleaned from the interview process, qualitative factors in these correlations can also be compared.

Chapter 3 – Results

Part 1 – Governmental Data Analysis

The Air Conditioning Constant – RECS Data

While the RECS datasheets were attractive for contextual analysis, and actual metered reports on electrical consumption by Air Conditioning units, major inconsistencies became evident when coding was attempted. AC installation and average temperature settings were the only consistently reported variables.

Firstly, there is the variable of "homeUSE" coded to assess the millions of homes that had Air Conditioning Equipment installed. While this variable was consistently logged with each RECS (2001, 2005, 2009) the division of geographic region was inconsistent. The 2001 survey was broad in scope and only reported on regions; e.g. West South Central, or South Atlantic. The following 2005 survey then had separated data for only Texas and the rest of the Southern region. Finally, the 2009 survey had individual report tools for each individual state. Thus, longitudinal analysis of these data would be inconsistent and inaccurate. However, it can be very generally stated that each state in question has experienced a rise in households that use AC. Texas began with 11.5 million air conditioned homes in 2001 and ended with 12.4 million homes in the last publically available RECS in 2009. In turn, Florida began with 19.3 million homes using AC and ended with 21.2 million air conditioned homes as of 2009. In short, AC is still growing as an industry and studies such as this will be vital to understand such a prevalent behavior pattern.

The issues with the RECS data continue with the reporting of homes with ample tree shade. While this is certainly a viable variable to take into account, the RECS abandoned reporting on this particular variable after 2005 altogether. Thus, this variable also had to be discarded.

Finally, while the average temperature at which people set their air conditioner during the summer (acAVE) was a robust variable throughout the various RECS, another issue halts any real analysis: uniformity. For both Texas and Florida, for all RECS reports (2001, 2005, 2009), the mode average AC temp was 74-76 degrees Fahrenheit. The distribution of this variable was extremely modal with 2.7 million homes reporting this average. The second most common setting (70-72 degrees) only represents 1.6 million homes. While this variable offers no trends to be described and no variance in AC usage to attempt to correlate with rising heat, the uniformity is its own significance.

It is important to know that the average AC temperature and usage for both Texas and Florida was 24 hours a day at 74-76 degrees. This confirms on a very reliable scale that Air Conditioning use is indeed ubiquitous for the states in question. Apparently only a very small portion of Southern America is presently without AC in their home. In conclusion, aside from this uniformity of usage, all remaining results and analysis will only come from the CDC data and the actual field data of this thesis.

CDC Context: Comparing Texas and Florida Population and Ecology

The first procedure to be run on the CDC data was descriptive frequencies to provide a populational and ecological background on the two states. This procedure was run on the entire sample size first and then filtered by state to identify any significant differences between the states before analysis. The data covers the years of 2001 – 20012 allowing for 11 years of ecological context from each state.

Population

Descriptives were run on each state population immediately after they were coded by state to allow for the most general demographic picture to be drawn. In **Texas**, the mean population for the state for the timeframe of the study was 23,626,083 (S.E. = 465,905.60, S.D. = 1,613,944.31, min = 21,319,622, max = 26,094,422). This shows that the population of Texas has grown 4,774,800 in 11 years. **Floridian** mean population for the term of the study was 18,028,161 (S.E. = 281,016.52, S.D. = 973,469.80, min = 16,356,966, max = 19,355,257). Thus Florida’s own population has grown by 2,998,291 in 11 years. Please refer to the **Figure 1** below. Again, while the two samples are clearly different in size, Levene and t-tests can be used to assess degrees of variance to guide further analysis.

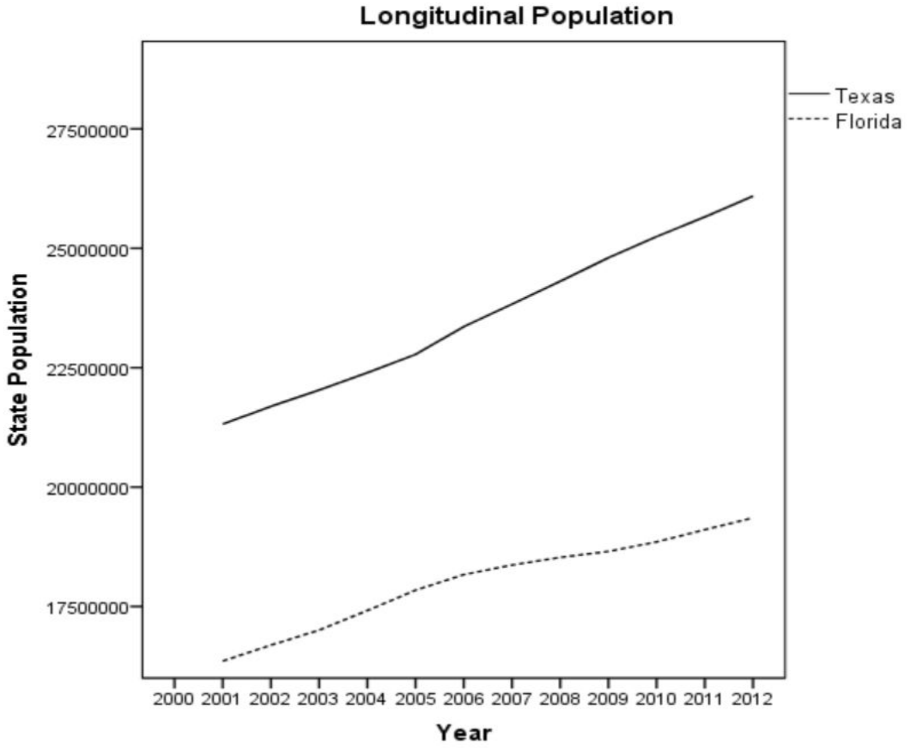

Figure 1

So, how do the two populations differ in regards to variance? Levene's tests were run to assess equality of variance, and independent sample t-tests to then compare means. Confidence interval percentage was 95%. Cases were sorted listwise to compensate for a single missing data point on 2012 extreme heat that was suppressed by the CDC datasheets (this will be the parameters for any other t-tests outlined in this section). Levene's test confirmed equality of variance between Texas and Florida (F = 3.53 , *p* = .075). However, Texas's mean population was higher (M = 23,401,689.18 , S.E. = 447,278.70), than that of Florida's (M = 17,907,516.18 , S.E. = 278,025.30). This difference, 5,494,173, was extremely significant *t*(20) = 10.43 , *p* = .000.

Luckily, the goals of this thesis were not to confirm differences in population "scores", which is how this test sees the data. These t-test results simply support that being scored as "Texas" greatly predicts higher population. This is simply true. What is more interesting about this variable is the Levene Test. Having "passed" the Levene test for equality of variance (F = 3.53 , *p* = .075), this supports that the two states populations are growing at statistically "normal" rates together. That the population of these two states show equal rates of growth is important contextual information given the following variables of heat mortality and percentage of poverty (each of these being populational or geographically bound).

Percentage of People in Poverty

Pressures of poverty should be briefly analyzed due to the economic nature of Air Conditioning as a service, in addition to the livelihood implications mentioned in the introduction. For the entire sample, the mean percentage for the timespan was 15.3 (S.E. =

.43, S.D. = 2.12, min = 11.90, max = 18.50). In **Texas** the mean percentage was 16.73 (S.E. = .31, S.D. = 1.10, min = 15, max = 18.50). In **Florida** the mean percentage was 13.9 (S.E. = .57, S.D. = 1.97, min = 11.90, max = 17.20). Please see **Figure 2** below.

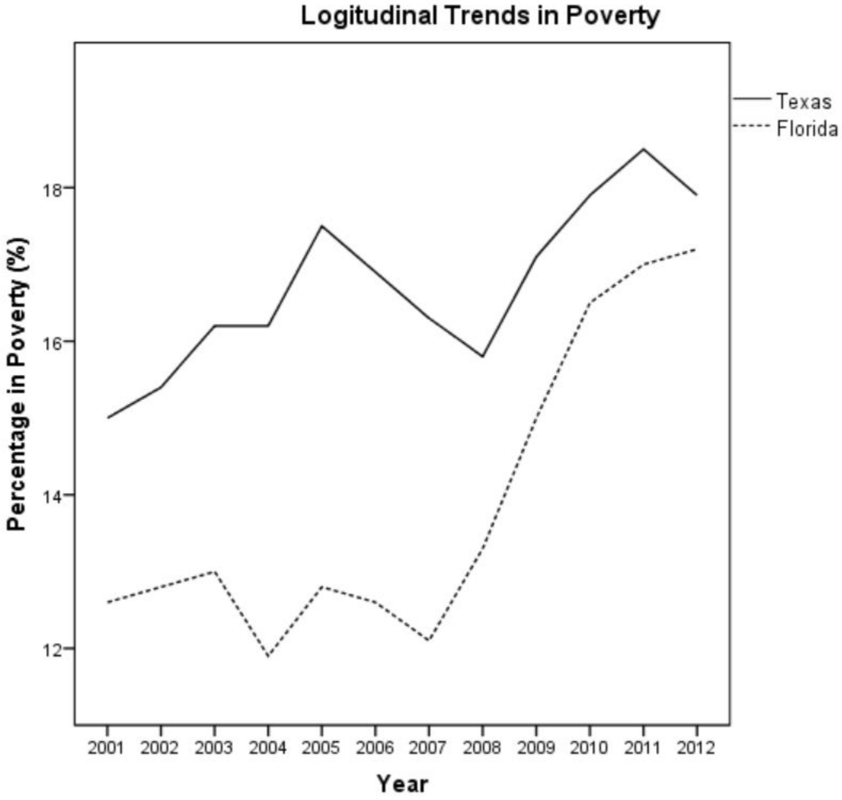

Figure 2

The variable passed the Levene test (F = 2.50 , *p* = .132); hence, equality of variance was assumed for the t-test. Texas' percent in poverty was higher (M = 16.62 , S.E. = .32), than that of Florida (M = 13.60 , S.E. = .53). This difference between means, 3.02, was found to be extremely significant *t*(20) = 4.87, *p* = .000.

While the other variables were directly numerical and could be skewed by the differing size of population, this variable is a percentage and as such removes such factors. Texas was shown to be generally a more poverty stricken state with 3.02% more people under the poverty line than the average Floridian. However, Florida's poverty rate is growing far faster and can be expected to pass Texas in coming years. The significance of this difference found by t-tests further supports that Texans are far more likely to be in poverty than Floridians. This is important for this study because air-conditioning is an economic factor. If you have it at home, somehow you are paying for it. Outlining this context of poverty will be vital to understanding discussions of how AC is an economic as well as health risk factor.

Extreme Heat Days

Extreme heat days were the chosen measure of ecological heat pressure so this variable should be analyzed next. First descriptives for the entire sample were run. The mean for the entire sample was 3668.80 (S.E. = 1020.80, S.D. = 4787.90, min = 36, max = 19704). Over the timeframe of the study the two states combined logged 80713 extreme heat days. It should be reminded that "days" in this case do not refer to a 24 hour cycle for the state, but for the county. So, the number of extreme heat days is determined by the sum total of extreme heat days for all counties. While this seems to separate Texas from Florida, following analysis will show how this is compensated for statistically. **Texas** extreme heat days had a mean of 5700 (S.E. = 1818.24, S.D. = 6030.43, min = 372, max = 19704). Over the timeframe of the study Texas logged 62700 extreme heat days (78% of the sample). **Florida** extreme heat days had a mean of 1637.55 (S.E. = 495.14, S.D. = 1642.20, min = 36, max = 5133). Between 2001 and 2012, Florida logged a total of 18013 extreme heat days (22% of the sample). See **Figure 3** below for a visual of the data.

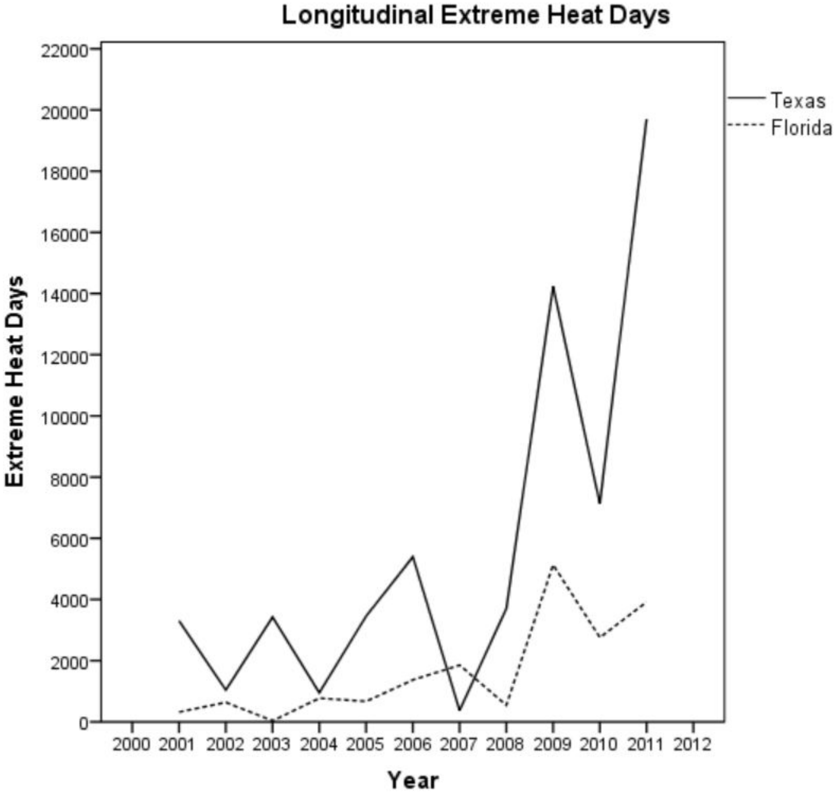

Figure 3

In regards to variance, Levene's test rejected the null hypothesis of equality of variance (F = 6.33, *p* = .021). Hence, results without equality of variance in the t-test were considered. Texas' average number of extreme heat days was higher (M = 5,700 , S.E. = 1,818.24), than those of Florida (M = 1,637.55 , S.E. = 495.13). However, the mean difference, 4,062.50, was not significant *t*(11.5) = 2.16, *p* = .53. While this is approaching significance, when compared to the 0.00 significance scores of the other variables, the score is more impactful. So in conclusion, both states show erratic profiles of heat (Texas dropping to a low of 372 only to rise to a high of 19,704 in 4 years), but with general trends of escalating heat indexes (Texas being the hotter state all years but 2007)[1].

When further analysis was run, it was shown that the two states do not have equality of variance (F = 6.33, p = .021), but did have statistically similar means of extreme heat days, $t(11.5) = 2.16$, p = .53. This is extremely important for coming discussion of the Field Survey data because it allows the two states of differing population size and ecological characteristics to be considered statistically similar “hot zones”.

Heat Mortality

The “heat mortality” variable is informative even in the **full sample size**. In the summer months (May-September) of 2001 and 2012, Texas and Florida suffered 1373 *known* deaths from heat related illness. The mean per year for the entire sample was 57.20 (S.E. = 9.90, S.D. = 48.40, min = 14, max = 203). **Texas** “heat mortality” showed different frequencies. Between the summers of 2001 and 2012, Texas alone suffered 1139 known deaths from heat related illness (83% of the sample). The mean per year in Texas was 94.92 (S.E. = 12.15 , S.D. = 42.10, min = 47 , max = 203). **Florida** “heat mortality” was more subdued. Between the summers of 2001 and 2012, Florida suffered 234 known deaths from heat related illness (only 17% of the sample). The mean per year in Florida was 19.5 (S.E. = 1.5 , S.D. = 5.20, min = 14, max = 30). See **Figure 4** below for a graph of heat related illness over time for the two states.

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[1] It was mentioned in the introduction that “extreme heat days” are calculated in part by county geography, so it should be stated: the land mass of Florida and Texas has not increased in the time of this study, so this general trend of increase is due to hotter temperatures and or higher humidity, not differing sizes of the states.

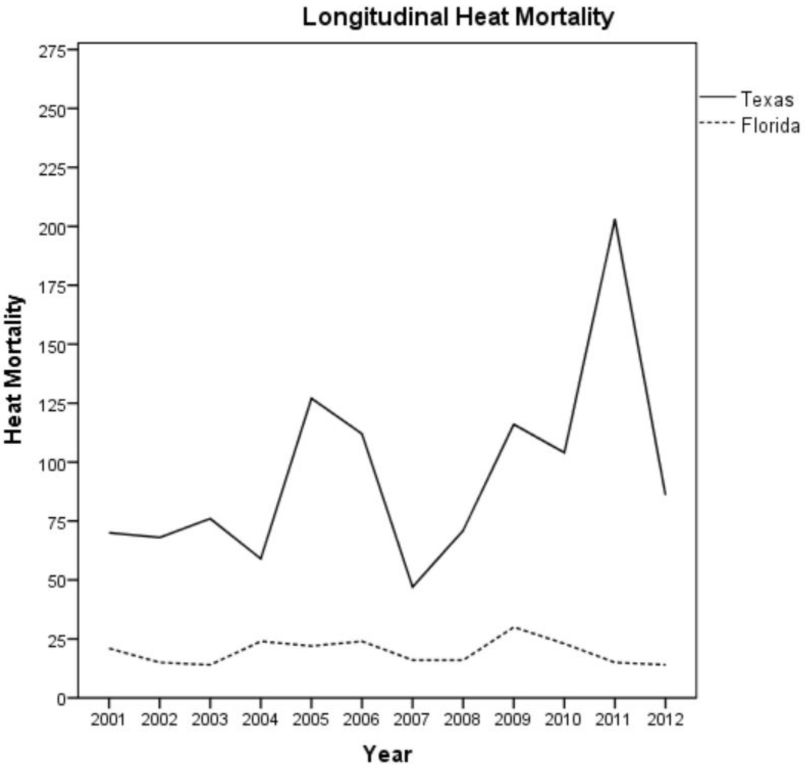


Figure 4

Already, some aspects are worth commenting on. Firstly, in the entire 11 year span of these data, only 1373 deaths for both states were recorded, most of these from Texas (representing 1139 – 83% - of all cases). This is interesting considering 2004 (the year of the deadly European Heat Wave) is included in the data and there is no irregularity in the data for this year. This is due, of course, to the event being bound to a European teleconnection (Poumadere et al., 2005; Trenberth & J.T., 2012). However, these states have higher heat averages than France. Understanding why there is no comparable level of heat illness the same year could hold further qualitative insight.

Levene's test again rejected the null hypothesis (F = 12.80 , *p* = .002). Hence, results without equality of variance in the t-test were considered. By returning to the plot for this variable (**Figure 4**) one can plainly see that Texas has a far more chaotic distribution, contributing to this result. Again, Texas' averages were higher (M = 95.73 , S.E. = 13.27), than those of Florida (M = 20 , S.E. = 1.55). Furthermore, the mean difference, 75.72, was extremely significant $t(10.27) = 5.66$, $p = .000$. Being a Texan means having a higher risk of heat related mortality given this simple measure. Recalling, the far less significant difference of heat indexes outlined above, such stark contrast in heat mortality points to one of two confounding variables: simple populational sample inflation, or something other than extreme heat affecting rates of heat related illness.

In regards to populational inflation, the mean difference each year between the population of Texas and Florida was shown to be 5.5 million people. Given the total populations of Florida and Texas each year, this shows that Texas has maintained 1.6 times the populations of Florida for the span of the study. However, the rates of heat related illness in Texas for every year other than 2004 more than triple those of Florida (203 versus 15 in 2011). If this discrepancy were due to differences in population, Texas should only expect 30 to 40 deaths per year (1.6 times more than the Floridian average of 15 per year). However, Texas' heat mortality often reaches the hundreds. Furthermore, given the major differences in the normality of these two states plots, Texas being far less monotonic, there is clearly still room for ecological and cultural factors being to blame for Texas' higher incidence aside from populational factors alone. Furthermore, the chosen correlations below can accommodate for this factor of difference to allow for robust comparison.

Heat, Poverty, and Illness: Two Correlations to Guide

While many correlations were run on all variables for this datasheet, many of these correlations are simply too directly linked to general secular trends to be informative. For example: poverty was shown to correlate with population (poverty already being a calculation within percent in poverty) and percent in poverty correlated with year (all variables will correlate with year because it is a uniform moving scale). However, two correlations of this data are worth illustration: Xheat:heatMORT, and heatMORT:poverty. The first because it captures the most directly questioned relationship in this thesis (higher heat results in higher risk), and the second because notions of poverty are vital to identifying vulnerable populations (Ebi, Lewis, & Corvalan, 2006; Kovats & Hajat, 2008). Furthermore, given descriptives of the data, the best correlation statistic for these data is Kendall's tau. Given the small sample size (N=22 when sorted listwise to be consistent with descriptives) and relative skewness of the data, Pearnson's r is not appropriate and given the non-monotonic plots Spearman's is also not appropriate. Luckily, there are many who support that Kendal's tau is a stronger estimate of correlations in a population (Field, 2013). One-tailed measures were chosen due to the longitudinal linearity of the data graphs.

The first Kendal's tau to assess any relationships between extreme heat days and heat mortality was run on the entire sample including both **Texan and Floridian** numbers. This resulted in a significant correlation between extreme heat days and heat mortality, $r = .566$, $p = .000$. But this is no new finding. The hotter it gets, the higher rates of heat mortality are and vice versa. In fact, this linear relationship was the introduction sentence to the key article on the France Heat Wave (Poumadere et al., 2005). What is helpful about this correlation is that it shows the established relationships of human biology and heat are further supported by this study as well at the most "birds eye" level.

When the sample was filtered to include only **Texas** (select cases: State = 1), an even stronger correlation between extreme heat and heat mortality was identified, $r = .782$, $p=$

.000. However, when **Florida** cases were selected (State = 2), no significant relationship between the two variables was found, *r* = .374, *p* = .058. This suggests that the Texan scores were responsible for the significance of the full sample (certainly possible when 83% of illness comes from Texas). However, recall that the extreme heat days for the two states were not found to be statistically significant, while differences in heat mortality were. Florida having no significant correlation between extreme heat days and heat mortality in spite of these statistically comparable climates is further evidence of confounding cultural factors between the two states. What could be keeping Floridian rates of illness so low with heat indexes comparable to those of Texas? Evidence is certainly pointing to the cultural realm and coming qualitative analysis will do much to sort out potential confounding variables.

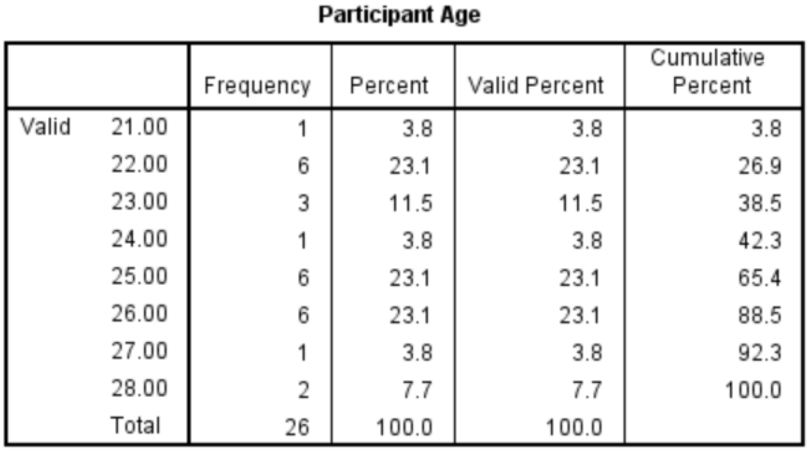
The following Kendal's tau, assessing any potential relationships between poverty and heat related mortality, was also run on the entire sample first. This test identified a significant correlation between the two variables, *r* = .431, *p* = .002. Strangely enough, the exact same pattern as the previous paragraph occurs when filtered by state. **Texas** data produced an even stronger correlation between heat related mortality and poverty (*r* = .523, *p* = .010), while **Florida** data showed no significant relationship (*r* = -.286, *p* = .105). This discrepancy could have a number of interpretations, but given the extremely broad context, the most appropriate statement to be made is that there appears to be a relationship between heat related illnesses in Texas, but not so in Florida. The following Field Data can now offer true insight when viewed in the context outlined in this section.

Part 2 – Field Survey Data

As stated in the “Statistical Procedures” section of this paper, a total of 39 variables were identified during the course of the interview process. Only variables that were significant or relevant to the thesis are discussed. However, the full table of correlations run is included in **Appendix IV**.

Demographics

The final sample size for this study was N=26 (13 from each state). Of these 26 participants, the age range was 21-28 with a mean age of 24.4 (S.D. = 2.02, S.E. = .39). Hence, this variable is fairly homogeneous. For a detailed breakdown of participant age, see **Figure 5** below.



Participant Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	21.00	1	3.8	3.8	3.8
	22.00	6	23.1	23.1	26.9
	23.00	3	11.5	11.5	38.5
	24.00	1	3.8	3.8	42.3
	25.00	6	23.1	23.1	65.4
	26.00	6	23.1	23.1	88.5
	27.00	1	3.8	3.8	92.3
	28.00	2	7.7	7.7	100.0
	Total	26	100.0	100.0	

Figure 5

The first Kendal’s tau was run to assess how “Age” may correlate with any of the variables of risk. While the two states were shown to have inequality of variance (F = 6.06, *p* = .021), there was no significant difference between their mean age; thus, a single correlation can be run for the whole sample. A significant correlation was found between age and how much AC strains their bills (BILLimpact) (*r* = .343, *p* = .032). This suggests that as one gets older the more severe the economic impact of AC. Other correlations were with nominal variables and therefore not applicable. This single correlation of age and economic strain from AC makes perfect sense in this age demographic (21-28); in that, the older one is, the less likely their parents or dormitory were paying their electricity bills. While interesting, this is not the primary research question of this paper[2].

In regards to racial identity, the majority self-reported identity was "white" (65.4%) followed by "Hispanic" (19.2%). The remaining 15.4% were made up of: "Black" (11.5%), "Asian" (7.7%), Vietnamese (3.8%), and Syrian (3.8%). When filtered by state, Florida represented a slightly more diverse sample with approximately 15% more "Black" and "Hispanic" responses. T-tests showed no significant difference of race between the two states and Racial ID had no identified correlations for any variables. The constructed nature of race is a major anthropological trope and to have this variable correlate with nothing is just further support that notions of race do not impact adaptation to heat, cultural or biological.

As you can see, I was extremely lucky to end up with a very well defined research group in spite of the random and anonymous nature of my recruiting process. There is a perfect 50/50 split between States of residence, the age range present can be considered a single cohort, and racial demographics (while majority white) are representatively diverse. T-tests found no significant differences between the populations in any demographics.

This population offers a unique insight into heat related illness. For one, 20-30 year olds represent the age range least at risk for heat related illness (Alana Hansen, December 2011; González-Alonso, 2012; Kenney et al., 2004). Hence, any findings of heightened sensitivity can spell exponentially increased threat later in life. Both males and

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[2] See "Variables of AC Use" for a full breakdown of BILLimpact descriptives along with some qualitative notes on AC bills.

females are included in the sample; however, no data was collected on sex because there is no known sexual dimorphism in heat regulation (Hanna & Brown, 1983). There is also no known racial (genetic) variation in heat regulation aside from sweat which was not a variable in this study (Molnar, 2006). Finally, as a "happy accident" of the listervs I used to recruit, all Texas cases come from around the city of Houston and all Florida cases came from around the city of Orlando (only 1.3° difference in latitude). In conclusion, the following results come from populations with fairly well controlled biological confounding factors. The only major factor in heat adaptation not accounted for was BMI. This will be discussed in the limitations.

How are people Staying Cool?

The very first qualitative question of the survey was "What are your main ways of keeping cool during the summer?". When asked this, the participant was allowed to free list whatever came to mind for as long as they liked, talking about any way they like to stay cool during the summer. Identifying how important AC usage was to them early in the study is important to guide further questions and analysis as opposed to assuming AC usage. No correlations will be discussed for this section due to all the variables being nominal.

How to Stay Cool (COOL123)

This resulted in a plethora of responses, so for the sake of analysis, only the first 3 people mentioned were recorded into SPSS. These were the COOL1,2,3 variables. Additionally, these were ranked based on the order the participant reported them. For example: first mentioned method is COOL1, second mentioned method is COOL2, third mentioned is COOL3. Hence, these variables can be considered hierarchical.

The majority response for COOL1 for the entire sample was “AC” (46.2%) followed immediately by “stay inactive/indoors” (42.3%). The remaining 11.5% was split between “clothing change” and “pools/beach”. When filtered by state, Texas represented more diversity in adaptive strategies with 4 major themes being present, compared to Florida only offering 2 themes. Both shared AC as the majority response.

The majority response for COOL2 was again “AC” (42.3%) this time followed by “cold drinks” (23.1%). The remaining 34.6% was taken up by a more heterogeneous response base than COOL1, including: stay inactive, fans, clothing, and pools. When sorted by state, this time Florida shows more diversity adding the themes of “the beach” and “clothing change” to otherwise shared responses with Texas. AC is still the majority response for both states even as a secondary response (still “flipping” with “stay inactive” as the first two coupled responses).

As described in the above, the majority response for both COOL1 and 2 alternated between “stay indoors/inactive” and “AC”. This was the same for both states. These two responses were invariably linked because often the first response to this question was “Oh, I don’t know, stay inside, blast the AC” or “Turn up the AC and avoid going outside.” Qualitatively speaking it is clear that for these participants indoor spaces, inactivity, and air conditioning are part and parcel. In fact, given the homogeneity of this being the very first response shows that this is the “default” behavior for the entire sample. Notions of inactivity linked with AC and summer heat will permeate this section. This becomes even clearer when COOL3 is examined.

COOL3 represents a tipping point where responses become far more heterogonous. While there is still a clear mode response of “cold drinks” (23.1%), the remaining 76.1% is taken up by responses such as: breeze, ice, fans, pools, and stay inactive. This variable shows the most interesting shift when sorted by state. For Texans, even at the tertiary level, AC is still present as a response (15.4%) while it has dropped out from Florida. This is especially interesting when Floridian’s mean tertiary strategy “pools/beach” (46.2%) is compared to Texan’s mean tertiary strategy “stay inactive” (23.5%). While Texas’ COOL3 variable is more diverse, the responses suggest less physical activity. These three variables already suggest ecological and health repercussions.

COOL3 seems to represent when people begin to show their idiosyncrasies. Geographically speaking, this is when you can see that Florida’s population is clearly aware of their more coastal ecology than Texans. The coded response “pools/beach” was for any person who described using either of these bodies of water as a regular reliable way to cool down. This response is present at all 3 cool levels for Floridians, just like “AC” is for Texans. This development actually bears a subtext of health impacts. Given that pools and beaches bring a certain level of physical activity with them, while AC clearly clustered with “inactivity”, this could be considered a secondary effect of AC in addition to being a barrier to adaptation.

As an interesting anecdote, while both states share the opinion that “cold drinks” are a great way to stay cool, Floridians made a special point to point out the unique nature of Texan soft drink consumption. One participant said “You Texans always have those 64oz giant cups from gas stations full of ice and Dr. Pepper. I mean we do that here too, but it seems more needed or something in Texas.”

Finally, there were many interesting responses that were coded as “other” simply because only one person said them. A particular favorite was from person who absolutely loathed the heat, saying “Oh, I shave my head. I don’t wear underwear. I wear very breathable clothes and put talcum powder anywhere I might get sweaty. I just cannot deal with any kind of heat.” Other people described putting up flypaper so they could open the windows but not heat up from running around after the bugs that got in.

In short, staying inside with AC is clearly the primary way to stay cool for the entire sample. However, once AC was exhausted from their strategies, ways of staying cool became a lot more creative and diverse. This will be even more evident in the atlCOOL variables.

When AC is Not an Option

The following variables had to do with hypothetical situations arising from the question: “what if AC did not exist?”. This was followed with asking if the person would even live in Texas or Florida if AC was not an option, and then if they did stay, how would they adapt? These variables were a kind of research “probe” so that prediction of how humans might deal with heat, should AC fail, as an adaptive strategy in addition to getting an early gauge of how the loss of AC might upset the person’s adaptive ability. Again, no correlations will be discussed due to the variables being nominal.

Staying Cool with No AC (atlCOOL123)

Like their AC present counterparts above, the “altCOOL” variables, altCOOL1 – altCOOL2 – altCOOL3 (methods of staying cool in the summer without AC), were qualitative data coded for quantitative analysis. As such, descriptives of means, or modes is not included. Additionally, these were ranked based on the order the participant reported them. For example: first mentioned method = altCOOL1, second mentioned method is altCOOL2, third mentioned is altCOOL3. Hence, these variables can be considered hierarchical.

The altCOOL1 variable majority response for the full sample was fans (26.9%). This variable is already more diverse than its mirror (COOL1) in that aside from fans there is a tri-modal split between “ice”, “building change”, and “other”. The following atlCOOl variables follow this trend showing no real mode of responses aside from both sharing “breeze” as a mean response (altCOOL2 = 19.2%, atlCOOL3 = 15.4%). When filtered by state, the vast majority of Floridians would use fans (53.8%) while Texas’ responses were a 3 way tie between “ice”, “building change”, and “other” (30.8%). Fans did not even make the Texas list.

For some context, participants were told that they could “dream big” even redesign the city if they had to. With this in mind, the only prominent strategies people gave were: fans (both hand powered and otherwise), breezes, and water/mister parks. For just about any question dealing with times AC was not available at some point the person would mention fans, it probably didn’t come out at a mode because of how the order in which they said it was not uniform. As for breezes, these usually came with some notion of architecture change: higher ceilings, larger windows, less concrete, etc. Finally, many mentioned that they would add public misters to help people stay cool “the way they do in Vegas”. In the next variable you will see that many people cited Arizona, New Mexico, or Nevada as a potential place to relocate if they had no AC, equally common was this reference to “misters like they have in Vegas”. People like those misters. However, as we will see soon, many of these same people are humidity sensitive so this love of misters shows some cognitive dissonance in their own understanding of heat.

Besides these three major themes above people were very unpredictable. Some wanted to have igloos. Others took cold showers daily. A personal favorite was a pilot who would fly his helicopter over water to cool off while stationed on a boat in the Gulf of Qatar. Each of these interesting examples fell under “other” because they only came up once, but this higher percentage of “other” in altCOOL as opposed to COOL represents a solid finding. When AC is not an option, people come up with a much more diverse set of ideas to adapt. Strangely enough, only in notions of “AC culture” did anyone mention “just getting used to it” as an alternative.

Relocation (goACstay)

In the extreme case of alternative cooling strategies to AC, the vast majority of the sample (65.4%) would relocate if AC was no longer an option regardless of other strategies. This is a significant finding given the already existing literature regarding air conditioning’s effect on the development of the Southern United States (Cooper, 1987; O’Neill, Zanobetti, & Schwartz, 2005; Quandt et al., 2013; Seybold, 2011). My favorite quote for this question came from a Houstonian. When asked if he would live in Houston without AC he said “Hell No! You might as well go to Hell drenched in gasoline!”. Interestingly, this same individual is currently living with a broken AC and depends on it in public spaces to cool off.

A good handful of people often began a discussion of “prior knowledge” in this question as well. Apparently, if they had never known about AC it would not be an issue. Alternatively, if AC was something they had grown accustomed too and it was removed, then they would leave without a question. This prominent theme of “choice” when dealing with the heat will resurface in the “DEAL” variable.

In summary, the populations represented in this sample show a clear majority preference for AC as a way to stay cool. In fact, they tend to get a bit unrealistic (igloos) when AC is removed as an option. These findings now lead into just how much AC they use and how this could affect their lives.

Variables of AC Usage

Installation and Style

Moving on, 100% of the sample was found to have not just some form of Air Conditioning in their home, but 100% Central Air in their home (“AC” variable). This supports the RECS datasheets however unhelpful they might have been in other respects. While this seems to undermine the original research question; for, to assess how presence of air conditioning might affect heat related illness, there would have to be variation in either this or the usage variable. This finding actually raises a very important point on present opinions of the strategic uses of AC in heat adaptability: why was there so much heat related illness in a population with 100% CENTRAL AC? Recall that the lack of AC was cited as a major contributing factor in all of the major Heat Waves death tolls (Agarwal, 2015b; Nauman, 2015; Poumadere et al., 2005; Trenberth & J.T., 2012). It would seem according to these opinions, that Air Conditioning is a viable adaptation to future heat waves. However, the results of this thesis suggest that the question is far more complex.

Qualitatively, responses to this question showed a general confusion among 21-28 year olds regarding AC terminology. When asked if the AC in their home was central, a common response was “Maybe? It has a dial thing I set to auto otherwise I don’t know.” Here they are mentioning a thermostat (part of a central air system). People would also describe “Well its not in my house, its some box that whirrs outside, I know some people have dual unit systems but mine is just one”. Here they are describing the actual AC unit that pumps central air throughout their house. Usually, once I asked if the air came through vents or from window unit, this cleared up confusion. In general, people were surprisingly confused regarding the AC units of their homes.

The only common theme of conversation for this variable was the issue of automatic thermostats. Many would say “well I just leave it set to auto and it turns on and off on its own.” This constituted an “all day” response; for, the thermostats function is to keep the temperature within a given range and turn off for economy. Hence, an auto thermostat, while “off” still is considered “climate control”. Furthermore, while this devise is automatic, many reported a constant policing of the thermostat by themselves, roommates, or parents. This was captured in the later “ACpols” variable.

Rising Prevalence of AC (moreACu, moreACthem)

Demographic usage variables (“moreACu”, “moreACthem”) were the product of the question “do you use more AC than previous years? How about those around you?”. This question was included to find if, in general, people were becoming more dependent on AC. Also to see if they knew of places where AC previously was not used but now was. The very first subject interviewed for this project turned out to be a half-French American who has visited France each summer her entire life. As such, she had direct experience of the 2004 French Heat Wave. She explained how no one in France had AC before the deadly heat wave. Now, nearly everyone she knows has some form of AC. This was the exact scenario that was supposed to be brought up by “moreACthem”.

Demographically, 50% of the full sample was also shown to use more AC now than in previous years (“moreACu” variable). However, 42.3% also claim to not use any more than usual, often due to them already “using it all the time for as long as I can remember” furthering the finding of AC saturation. Filtering by state did little to change the data aside from showing that the only 2 “no control” responses came from Florida.

The above was mirrored in that the full sample also mostly cited a rise in AC use in their surroundings (42.3%)(“moreACthem” variable). However, the actual majority response in this case was “complications” either due to moving often or a sense of destabilization. When filtered by state, it was shown that “complications” was in fact the majority for this population (53.8%). “Complications” responses were usually due to the participant moving around a lot so notions of regional climate muddied their AC use. This also brought up that some did not pay for their AC so they had no real gauge to know if they were using “more”. This ties directly into the correlation of “Age” and “BILLimpact”; for, the younger they are the more likely they are to have AC paid for by another party. In conclusion, this variable shed light on the fact that many young adults feel that temperature is not a stable pressure due to migration, hot climate control in northern states, or climate change having more to do with “erratic weather” than steadily hotter weather.

AC Bill Strain (BILLimpact)

The level of factor in the persons bills (BILLimpact) was included to capture economic strain due to AC (vital with the considered correlations of poverty and heat related illness found in the previous section). For the full sample, the majority response was "adjust for economy" (26.9%) followed closely by "don't pay" (23.1%). Only 15.4 percent of the sample was shown to turn the AC totally off due to cost (N = 4). For the 20 year olds in this study, there is a fairly good distribution of impact that AC has on their monthly bills; however, very few would fall into the "AC poverty" category (cant afford to run the AC). This variable is likely to change later in their life as suggested by the correlation of Age and BILLimpact. Nearly a fourth of the sample does not pay for their AC at all (usually due to some kind of school or job housing). Regardless, not having control over one's bills always predicted more AC use, while controlling one's bills could tell you more about the person's economic strain depending on usage.

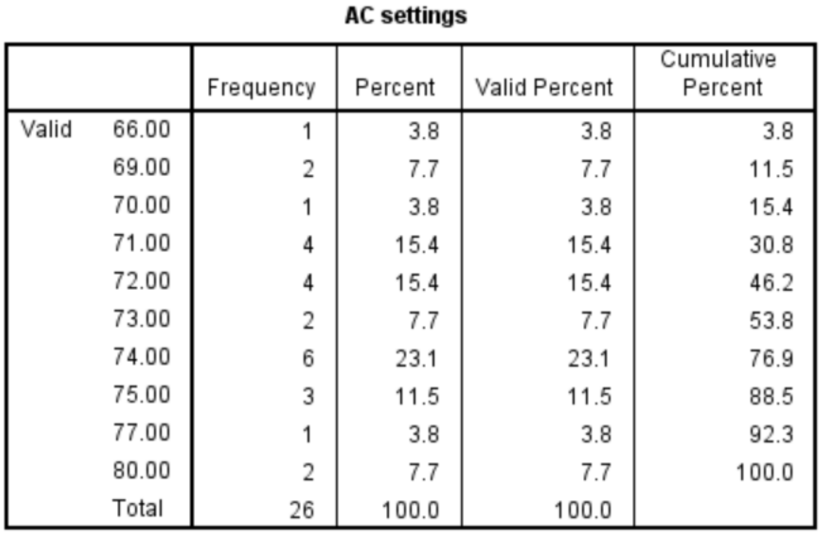
Hours of Use (usage)

The usage variable (how often they use the AC in summer months) had some variation; however, the majority response when the entire sample was analyzed was "all day" (73.1%). The second most common response was "more than 8 hours" (15.4%). Usage was, in fact, separated out in terms of variance by Levene test: (F = 13.19, p = .001). Filtering by state produces an interesting qualitative shift. All Texan responses fall on "more than 8 hours a day" or "all day" while these two responses only represent 76.9% of the Floridian population. While this difference in usage did not produce a significant t-test result (t(15.13) = 7.77, p = .097), the only cases (N=3) of people using very little to no AC at home identified by this thesis were from Florida. Texas is already appearing to be just a bit more AC heavy than Florida. This variable was shown to correlate with heat avoiding behavior change ("effectLIFE" variable") (r = .386, p = .028), and heat related illness ("heatSIC" variable) (r

= .375, *p* = .033). For both states, however, usage only correlated with effectLIFE; hence, the more AC either state used, the more extreme measures they would take to avoid heat. These correlations will also come up in the "heatSIC" section.

Average AC Temperature (avTEMP)

AC settings also have some helpful variation. For the full sample, the mean AC temperature in Fahrenheit was 73^{o} (S.D. = 3.11, S.E. = .61). The majority response was 74^{o} (23.1%). The only other two modes were tied at 15.4% (71 and 72 degrees). See **Figure 6**



AC settings

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	66.00	1	3.8	3.8	3.8
	69.00	2	7.7	7.7	11.5
	70.00	1	3.8	3.8	15.4
	71.00	4	15.4	15.4	30.8
	72.00	4	15.4	15.4	46.2
	73.00	2	7.7	7.7	53.8
	74.00	6	23.1	23.1	76.9
	75.00	3	11.5	11.5	88.5
	77.00	1	3.8	3.8	92.3
	80.00	2	7.7	7.7	100.0
	Total	26	100.0	100.0	

Figure 6

To fully round out the context of AC use by the sample population, these averages of AC temperature were also very in keeping with the RECS averages (M = 73^{o}F) with a full range from 66-80^{o}F. Couple this with the majority "all day" AC usage and 100% presence of AC technology above, and it can be fairly claimed that this population spends the vast majority of their summer time in a "climate" of 66-80 degrees. Given that the average summer temperatures (May – September) over the last 10 years for both Florida and Texas usually fall between 82 and 100 degrees, this represents a potentially 40^{o}F delta between indoor and outdoor temperatures to pull from both extremes. In conclusion, while no applicable variables correlated with average AC temperature, the potential adaptive risk of over dependency can be well illustrated by this population should any variation of illness and risk be found.

Side Note on “COLDsleep”

Before moving on from variables of usage, whether or not they lowered the AC temperature at night (coldSLEEP) developed as a common trope of usage even though it was a nominal variable. While this question was not directly asked, it was the result of discussions regarding the average temperature of their home. There was a fairly even split in responses for the whole sample (yes = 53.8%, no = 46.2%). Furthermore, when filtered by state, the descriptive statistics are identical: 46.2% no, 53.8% yes. Even those few who did not use AC all the time would use it at night when they do.

I don’t have much to say about how this could impact adaptive risk aside from that this behavior may have its roots deep in human adaptation. You see, even dry desert dwelling people such as the K!ung who are physiologically acclimatized to heat, also show metabolic responses of cold adaptation when they sleep (Molnar, 2006). This is due to how the dessert, while extremely hot and arid in the day, does not hold on to heat. As such, it often reaches subzero temperatures at the coldest of the night (Moran, 2008). As a response, humans who are acclimatized to such an environment will actually experience “non-shivering thermogenesis” and heat up as they sleep. This showed up in the sample as “I just heat up when I sleep I don’t know why. So I always need to crank up the AC when I sleep.” This finding is significant when the urban environments of the participants are considered. Cities hold on to a lot of heat in concrete and radiate this heat out at night. Thus, even in climates that would mirror the dessert effect described above no longer have this “heat dump” opportunity at night. As a final result, AC’s get turned up in a time where human adaptive physiology is expecting a major cool down.

In closing, these 20 year olds are using a lot of AC just as government data suggested. However, it is clear that this usage is so prevalent, that analysis by variation of usage degree (t-tests, correlations, and the like) cannot be done in the scope of this study. However, more qualitative measures of heat risk and insulation from the heat by lifestyle are just as important as average usage. For example: a participant may leave their AC on automatic 65^{o}F all day, but only actually be in the house for half of the day and working outside the rest of the day. The following section will accommodate for such aspects of lifestyle.

Contextual Heat Risk Variables

Understanding and individual’s history with heat is vital to ascertaining present risk. The variables of hydration, average summer outdoor time, occupational exposure, previous acclimatization, and previous illness, were the chosen variables for this analysis. Each of these contributed to the final “heatRISK” variable that will be the crux of analysis of the research question.

Hydration

The “hydrated” variable is the first of the health related measures. Qualitatively speaking, the primary mode of hydration for the sample was water bottles. When asked “How much water do you drink a day on average”, more often than not people would reply

"Im not exactly sure but I can tell you how many bottles of water I drink." This resulted in a fairly handy research tool. Participants either drank from regular 16oz disposable water bottles and could offer a reasonable number of bottles per day, or drank from a personal water canteen that measured fluid ounces or milliliters. As such, while the scale for the variable was ordinal, these estimates are based off very measurable reports of water consumption[3]. Anecdotally, one known dehydrated cases reported "only drinking water when they give it out for free". In other words, he only recalled drinking water when it is placed in front of him at a restaurant.

For the full sample, the majority of the participants were "average" levels of hydration (50%). The sample indicated 30.8% were well hydrated and 19.2% of the sample was dehydrated. The two states separately showed similar levels of hydration. This is important to the data because dehydration is a leading cause of heat related illness (Yeargin, 2006). Hydration produced correlations when filtered by state. Only Texas showed significant correlations of hydration with outdoor time (r = .497, p = .038), heatBUGS (r = -.519, p = .035), previous acclimatization (r = .703, p = .010), and heatRISK (r = -.608, p = .017). In short it seems that for Texans, good hydration can possibly lead to more time outdoors (positive correlation), less irritability due to heat (negative correlation), and less heat risk (negative). This is totally in keeping with current science on how hydration is key to healthy living in the heat. In conclusion, however, this cohort can rule out hydration as a confounding variable for findings of heat risk.

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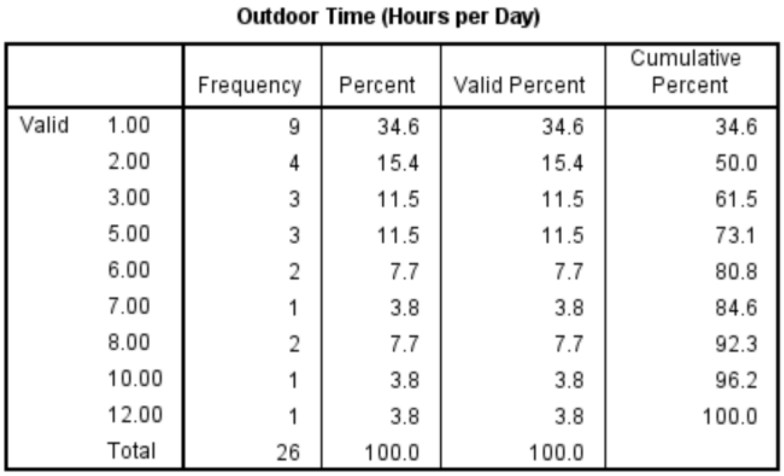
[3] Asking about number of bottles a day can be a helpful research tool in the future.

Summer Outdoor Hours (outHOURS)

Outdoor time is another vital health risk measure and produced variation. However, the majority response for the total sample was 1 hour per day (34.6%). Given the dispersion of other responses, **Figure 7** is included below.



Outdoor Time (Hours per Day)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1.00	9	34.6	34.6	34.6
	2.00	4	15.4	15.4	50.0
	3.00	3	11.5	11.5	61.5
	5.00	3	11.5	11.5	73.1
	6.00	2	7.7	7.7	80.8
	7.00	1	3.8	3.8	84.6
	8.00	2	7.7	7.7	92.3
	10.00	1	3.8	3.8	96.2
	12.00	1	3.8	3.8	100.0
	Total	26	100.0	100.0	

Figure 7

Qualitatively speaking, the most common response to this question was "as little as possible". Any responses of over 5 hours a day were due to some kind of outdoor job. Jobs included: open air warehouses, theme park attendants, and open air pilots. The only 12 and 10 hour responses came from students working at an archaeological field school over the summer which had them outside at all times aside from sleeping. In short, the general consensus of this group was that summer was a time for staying inside unless otherwise demanded. This is nothing new, what has changed is the nature of the indoors this time is being spent in.

When filtered by state, Texas' mean jumps to "2 hours a day" (23.1%) while Florida's remains "1 hour per day" (53.8%). These results are a bit more worrisome distributions than the hydration variable. While the majority of the sample was at least normally hydrated, the vast majority of the sample spent very little time outside unless made to by some job. Now, spending as little time in the heat as possible in the summer is natural; however, when one considers that a response of 1 hour outside implies 23 hours in heavy AC (as shown in the variables below), the beginning of barriers to adaptation can be seen.

This claim was supported in that, time outside correlated with HEATsic (r = -.335, p = .040), HEATbugs (r = -.317, p = .047), level of factor in bills (r = .317, p = .046), heatRISK (r = -.461, p = .004). In other words, spending time outside exposes you to more heat which makes you less likely to be sick or irritated by the heat. In turn this seems to make the impact on your bills go down as well as your heat risk. Already the hypothesis of this thesis is supported (time outside on a day to day basis actually reduces heat risk).

Occupational Exposures (heatEXPO, coldEXPO)

Heat Exposure was a simple yes or no question regarding occupational exposure. For the entire sample, 46.2% claimed to have higher than normal occupational exposure to heat, usually in the form of a warehouse job. The remaining 53.8 percent reported no abnormal exposure to heat. When filtered by state, Texas is shown to have the majority of responses as “occupationally heat exposed” (61.5%) while Florida shows to have mostly normal occupational heat levels (69.2%).

Cold Exposure is the same as above but for occupational cold exposure. For the entire sample, only 3 participants (11.5%) reported working in cold conditions. This was usually in the form of an extremely air-conditioned full time job.

In retrospect, these two variables could have been cut; for, more detailed information of the same nature (how often is the person very hot or very cold) is captured in the above “time outdoors” question. What ended up being valuable from these questions was getting to discuss occupational training and situations that otherwise would not have come up; such as the notion of constantly having to wear a jacket to work in the summer. Alternatively, many of the Floridians were theme park workers and this question got them talking about how their employers trained them to deal with heat related illness. In fact, 65.4% of the sample was “heat trained”. This means that regardless of profession, the individual has been trained on how to stay hydrated, how to spot heat related illness, and how to treat it. While it is good to see so many people being trained to mitigate heat risk, it is worrisome when the incidence of illness is so high in the same sample as will be shown.

Past Acclimatization

Past Acclimatization was originally included in the question list to elicit experiential accounts of how it “felt” to acclimatize to heat, also to spot any increased risk if the person mentions never being able to acclimatize. Both of these goals were accomplished. While the descriptives for the variable seem minimal (just 73% having said to have acclimatized) the qualitative responses from this question were extremely valuable. The entire “DEAL” variable came from this question. More often than not, people would say something like “Well if I know I will be in the heat for a while, somehow its easier to deal with. If its me being stuck in the heat, it much worse.” A full discussion of these quotes will be in the DEAL variable section. Alternatively, people would also say things like “Oh, god no. I will always and forever be uncomfortable in the heat.” These responses led to further questioning regarding potential heat risk. These will be more fully discussed in the effectLIFE variable. In short, this variable/question proved to be a very big talking point for participants.

Heat Related Illness Incidence (heatSIC)

Heat Related Illness is perhaps one of the most vital variables in this study (heatSIC). For the entire sample, 34.6% had no heat related illness, 11.5% had mild cases, 19.2% experienced heat exhaustion, and 34.6% had an extreme event with lasting sensitivity. This is a very strange distribution with a bi-modal split between no illness at all, and severe illness with lasting sensitivity. This in no way matches any current model for heat related illness, and is especially worrisome when the age of participants is “supposed” to be the least susceptible age.

Levene and t-tests did not separate the states in terms of variance, so any correlations could identify potential contributing factors to heat related illness, the exact goals of this thesis. Heat related illness was shown to correlate with outdoor time already (*r* = -.335, *p* = .040), but it also correlates with effectLIFE (*r* = .331, *p* = .050), and heatRISK (*r* = .469, *p* = .005). These correlations, linked with each other in particular, are the exact findings this thesis hypothesized. Recall that heatRISK was coded ordinally with 1 being the least risk and 5 being the most risk. HeatSIC was also coded so that 1 was no sickness and 5 was bad illness with lasting sensitivity. Thus, given this correlation, the more insulated from the heat a person is, the more likely they are to have a more serious heat related illness (AC is acting as a barrier to adaptation). However, the question can be asked: “given that AC is shown to reduce risk for heat related illness, shouldn’t staying in more AC keep you safe?” Even the results of this thesis say “yes”, but for one very important qualitative caveat: all heat related illnesses represented by this study occurred *outside* (not protected by a bubble of AC). The fact that effectLIFE is also included in this relationship shows a psychological component as well and will be analyzed in the following section.

Lifestyle Heat Risk Variables

The question "Do you ever feel sick of the heat, even if you are not physically ill" was asked to capture psychological stress that heat places on people (heatBUGS). This turned out to be one of the most important questions I asked along with its follow up "how does this feeling effect your life" (effectLIFE). While there was no significant variation in home climate control, there was variation in how people reacted to heat in aviodance behavior, how much time they spent outdoors, and if they experienced a major heat related illness at a younger age. This led to the heatRISK variable being sorted into 5 levels. The first "exposed" was for those who either worked outdoors, used their AC for less than 8 hours a day, and/or spent at least 5 hours a day outside during the summer. These people would be the least at risk, and are expected to be acclimatized (if heat related illness existed they could not be in this category. The next level "seasoned" was for those who have experience with living exposed to the heat but still have reliable AC use. These folks usually worked and played outside but ran the AC heavily at home. The mid-level result was "commuter" and this was for all the "in and out" types of people. People who scored at this level of risk usually were exposed to the heat when commuting between air conditioned spaces. In short, 50% in 50% out. "Insulated" was for those people who live work and play in AC space. These are considered adapted to the AC environment and of higher risk. Finally, "illness" present was for those who *had* to be in cold space due to a chronic sensitivity to the heat. Given their already developed inability to adapt, these individuals represented the highest risk. No significant differences between the states in heat risk were found, however, the results showed variation that will allow for the primary correlation of this thesis to be run: heatRISK, and heatSIC.

Heat Related Irritability (heatBUGS)

Irritability due to heat (heatBUGS) proved to be another vital health related variable. For the entire sample, the majority of participants reported mild irritability due to heat (30.8%). The following two modes are tied at 15.4% (no irritability, and full blown irritation). Three individuals (11.5%) were shown to absolutely loathe the heat. When filtered by state, Floridians were shown to be mostly "mild" levels of irritation (46.2%) while Texans mostly saw it as a human norm (30.8%). Heat related irritability was shown to have a strong correlation with effectLIFE ($r = .583$, $p = .000$). When filtered by state, Florida produced no significant correlations. Texas however correlated heatBUGS with effectLIFE ($r = .748$, $p = .002$), BILLimpact ($r = -.565$, $p = .017$), and heatRISK ($r = .485$, $p = .045$).

While this 30.8% (the mode) showing mild irritability due to the heat is the quantitative majority, the qualitative reality was more of a divide between those that saw discomfort as "just part of being hot" and those that saw it as something to be avoided (again this is the theme of "just dealing with the heat"). When sorted by state is seems that more Texans see heat discomfort as natural while Floridians find it more psychologically draining. However, both states had people who "saw red" when they had to be left outside. The same "no underwear and talcum powder" guy from COOL even said that "Nothing makes me angrier than being stuck in the heat. If it's because I am waiting on someone, they done fu*ked up!”. Before offering further analysis, the effectLIFE and heatRISK variables must also briefly be discussed.

Heat Driven Behavior Change (effectLIFE)

Behavioral change (effectLIFE) is tied to the above variable as it was a follow up question. For the full sample, the majority response was to “plan around the heat” (38.5%). All other responses (no effect, cancel outdoor plans, and extreme response) were all tied at 19.2%. There is little difference when filtered by state, aside that the most extreme case came from Texas (a single participant who absolutely loathed the heat). Behavior change correlations have been introduced before, but it was also shown to correlate with BILLimpact ($r = .387$, $p = .018$), and heatRISK ($r = .427$, $p = .010$). When filtered by state, Florida had no significant correlations yet again. Texas responses to behavior change correlated with BILLimpact ($r = -.523$, $p = .027$), and heatRISK ($r = .603$, $p = .013$).

Qualitatively, most explained what I started calling “cool zone planning”. A participant would describe a scenario where they had to be in the heat for a few hours. They would then mention how they made sure to stop at a mall, food place, or any other air conditioned space to “get a break from the heat”. This behavior was constant across types of heatBUGS and can be considered the primary adaptive strategy for people to avoid heat when not at home. On the more extreme side, some people only went out at night due to heat irritability, and one family even went so far as to rent a hotel for over a week just because their AC was broken. Clearly this variable has many interesting insights into behavior as a result of extreme heat

Level of Insulation from Heat (heatRISK)

As described in the previous section, how insulated from the heat they are (heatRISK) is the primary diagnostic variable for the purposes of this research question and correlations with this variable have already been introduced. For the full sample, 34.6% of participants had some history with or a present case of heat related illness that keeps them indoors. In the same sample, 15.4% of participants scored as “exposed”, 11.5% of participants scored as “seasoned”, 30.8% scored as “commuters”, and 7.7% were “insulated with no illness”.

The psychological component mentioned at the beginning of this section is validated by heatBUGS positively correlating with effectLIFE as shown above (the more irritated by the heat you are the more drastically you will avoid it). While only Texas went further to also correlate this with the Meta variable heatRISK, the sample wide correlation of the two variables continues to suggest that behavior change due to irritability from heat is a significant factor. Indeed, effectLIFE was immediately correlated with BILLimpact and heatRISK. It is in the correlations between these two variables that the inclusion of “poverty” from the CDC data becomes most meaningful. In short, the more drastically one tries to avoid heat, the more they worry about the cost of the AC they are using. Furthermore, it is not ACusage that is significantly correlated with heat risk, but behavior change. Thus, it is when one begins to actively and knowingly avoid the heat due to irritation that their risk for heat related illness goes up. This is a very significant finding when heat risk was shown to correlate with heat related illness, bringing the final picture to: irritability leads to behavior change, which raises their heat insulation level (risk), which in turn predicts higher morbidity of heat related illness.

Part 3 Culture of Hot Weather

This final section was included to complete preliminary cultural theme analysis between Texas and Florida; for, no anthropological analysis is complete without seeing how people pattern themselves and share information with one another. I am glad to have done this because questions relating to this motive produced some very interesting perceptions of Air Conditioning and the future of human development.

Everyday Experience of Climate Change

Seasons and Temperature

Participants were asked if they felt if summers were getting hotter for longer (e.g. longer on either end of May-September). This resulted in the “longerSUM” variable. For the full sample, 92.3% of participants confirmed a noticed longer summer. However, when filtered for state, 100% of Texans reported seasonal shift while only 84.6% of Floridians noticed the same.

“Warming?” was geared to assess if they felt summers were getting hotter for longer periods of time. For the full sample size, 76.9% confirmed this with a “yes”, while 15.4% cited temperature destabilization over warmer. When filtered by state, it was revealed that all “no” responses came from Florida, though both states cites some kind of unstable climate making this question had to answer.

As you can see, both variables show the vast majority of both states confirmed that the summers are getting hotter for longer. However, it should be explained that given the “southern” geography of these states, many felt that their state “Only had two months of winter, or maybe four to six weeks scattered across November to March.” In other words, many felt that the summer wasn't necessarily longer, but that summer for them was already much longer for them than most. They did agree however that the summers were hotter.

While this thesis is not meant to validate any notions of "global warming", this variable was chosen for analysis for a very particular reason. The CDC environmental health tracker, from which the epidemiology of heat related illness was pulled, is presently only collecting date for what they define as "summer months" (May – September). This is the case for both ecological heat data and human morbidity/mortality. Given the findings of this thesis, for at least the states of Texas and Florida, data collection on "climate change vulnerability" should be expanded to the months of March through November! As will be shown throughout this section, people in southern states are using AC year round and struggling with heat throughout the "winter". In fact, the interviews for this paper were quite timely; for, many interviewees mentioned how unseasonably hot it was in December. Hence, any data presently in the CDC reports can be considered a major underestimation of risk for states in the "southern region" of the United States.

Heat Related Illness in the Community

In regards to heat illness in the surrounding population (sicFAM), the majority report only a mild incidence (42.3%), followed by "none" (38.5%). Two individuals reported general populational trends of illness and three were the only one they knew to suffer heat related illness. While t-tests showed no significant difference between the states in levels of populational trends of illness incidence ($t(24) = -.923$, $p = .365$), it was shown that Florida had the only reported cases of reported populational trends in illness incidence. Otherwise the two sets of descriptive statistics were fairly similar. This is due to the confounding nature of the heavily theme park focused employment of the sample. These individuals reported these because they had witnessed constant episodes of heat related illness and saw it as “part of the job”. One former employee said “People come here from all over expecting perfect Florida weather. People from England do not have any idea how to handle heat here. But they love our Air Conditioning.” The otherwise majority of “mild trends” can be attributed to the high incidence rate of the sample. This offers deeper understanding on concepts of “normality” of heat related illness. No subject felt that their illness, or that of others was “unnatural”. The general feeling was that any illness was due to lack of attention on their part or an expected product of their environment.

Parents, Politics, and Themes of their Own

This section it titled “Themes of Their Own” because each variable (a theme) mentioned here came about as bi-products of other questions. These themes must be included in the cultural discussion because they represent talking points that people will gravitate to when asked about AC conversationally, regardless of question. Given their commonality in the random sample, each of these themes could offer minimally biased cultural insight.

Parents

Many participants when talking about the “moreACu” or “moreACthem” questions mentioned how their parents used AC. Recalling that the age group for this sample was 21-28 the use of parents as a comparison seems logical. The resulting “parent” variable was coded to examine if this population of 20 year olds, after leaving the house, carried over their parents patterns of AC use. For the full sample, 57.7% of participants carried on the same patterns of AC use their parents had (Texas having the only case where the use escalated). However, a few offered very interesting anecdotes about why they did not carry their parent's habits.

One young woman (who was very heat sensitive) explained how her parents would never allow her to adjust the thermostat growing up. Instead they ran the AC below 69°F constantly, forcing her to don a jacket and blanket to stay warm throughout her childhood. When she left the house and had control of her own activities and thermostat she quickly found that she could not be outside long without overheating. So, she decided to keep the AC no lower than 75°F to attempt to get used to heat. On the opposite, another young woman grew up in a home where she was not allowed to use the AC under threat of punishment. When she moved, especially because she moved to an "all bills paid" apartment, she began running the AC "full blast" all she wanted to make up for all the times living without it.

Further research into how this can constitute "cultural inheritance of climate" could prove very interesting. However, a far more anthropological variable came from discussing how things changed when they left their parent's home; for, with a roommate or not, personal control of the thermostat was a political process.

AC Politics

Some form of "AC politics" with parents, roommates, customers, and generally anyone they had to share a space with was described by 73% of the sample. The parental scenarios explained above show where this "campaign" begins, but the effects continue into independent life.

One interviewee who loved the heat explained how her roommates would not hang out with her because she left sunny windows open with no AC on. When the same interviewee had to live with new roommates at a new dorm, she was “out voted” on her AC preference and was miserable her entire stay, having to “bundle up” to prevent from being “frozen out”. In this example alone, one can see how AC politics can contribute to temperature destabilization. Constant voting and policing of the thermostat is based on *preference* not the temperature outside that would supposedly be objective. This is especially interesting when considering that the constant bickering between household members was often over no more than a 5^{o} degree change (the above example as an extreme for clarity). In short, even beyond personal AC preference and usage, politics of thermal comfort often circumvent this preference and leave at least one member of each household in uncomfortable temperatures. It would seem that the use of Air Conditioning cultivates cultures of temperature sensitivity as a notion of agency.

Humidity, Cognitive Dissonance, and “Dealing with it”

The variable of humidity sensitivity was mentioned in the “altCOOL” section above regarding how many people loved misters as a way to stay cool. However, 92.3% were shown to be humidity sensitive (100% of Floridians). The variable simply had to be included because, without fail, people would usually end up talking about how “heat is ok, humidity is just awful.” This tied into their decision of where they would move if AC stopped working, how much heat irritated them, and notions of “beating the heat in other places”. Participants in this study simply did not enjoy the humidity and felt it was the number one contributor to discomfort in the heat. This introduces the notion of cognitive dissonance for the sample.

Many would say things like “its winter it is supposed to be cold” or “I hate humidity but those misters are great”. About a third of people (34.6%) based opinions and expectations of when heat was to occur on a calendar more than understanding of their states ecology (Florida is never cool like other states in December). The best quote to illustrate this was a Floridian who said “We just love looking at snow through our computer screens while its 100 degrees outside.” Another example was of a person’s boss turning off the ac and opening the windows “just because it was December, but it’s still 85 degrees and 70% humidity out there.” In short, this variable shows that for at least 34.6% of people, unrealistic understanding of local ecology is a source of strife. This brings us to the “DEAL” variable.

Whether they were being asked about how heat affects their plans, if they feel summer is hotter, or just about any question, more often than not (80.8% of the sample) the participant would say something along the lines of the following: “Well, if I know I am going to be hot for a while like going camping its easier to deal with”, “Somehow if I am not allowed to complain about it I can deal with it longer”, or “once you just give into being hot and sweaty its no big deal”. This variable, though spontaneous, simply had to be included in the discussion because it captured a unique aspect of human heat tolerance: constant temperature is more tolerable than changes. Mirrored quotes to this phenomenon were “its going in and out of cold to hot that makes me feel sick”. Now reconsider the variable of ACpols and how many fights were about a 5^{o}F change along with the “effectLIFE” variable and how many “plan around the heat” going in and out of cold spaces. These together illustrate a human population with *no* constant temperature. When they are out, they are going from 75^{o} AC to 100^{o} weather. At home they fight with their roommates or parents about hotter or colder and usually end up in some compromise state. Luckily with the average AC temperature known to be between 68 and 88 (and the usage rate to be 100%) it can now be shown that for this population the only possible constant temperature exposure range is 68-80^{o}F. Beyond this, even constant heat is considered more tolerable than the constant "in and out" of modern climate controlled life.

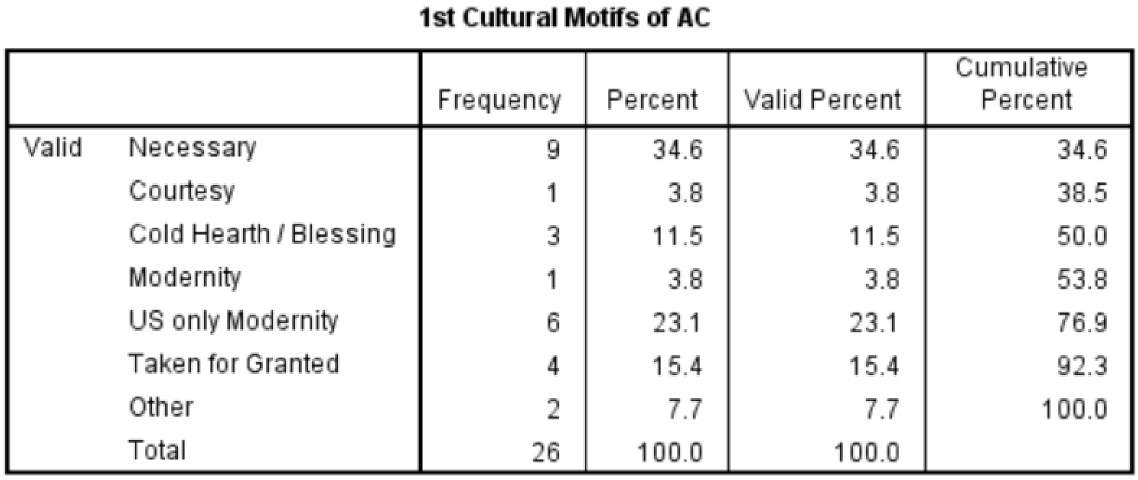
How People View AC Internally and Cross Culturally

Texas and Florida Comparison

Firstly, let us begin with how the states portrayed each other in terms of beating the heat. Texan observations of Others was a variable designed just for Texas cases to assess how they saw others keeping cool. Floridian Observation of Others is the same but for Floridian cases. The mean difference for both Texan and Floridian people was the differences between dry heat and wet heat and how this affects AC usage (M = 23.1%). What is most interesting is that residents of each state felt that the other was more humid. Beyond this, the kind of drinks the others used to stay cool was a major topic of interest. Apparently Floridians see Texans as drinking far more soft drinks while they and others drink more beer. Texans on the other hand commented often on all the "water sports" in Florida. In general they felt Florida was "more fit for the heat" describing more shade, more open windows to allow for breeze, and more pools and beach trips. It was only a single Floridian that mentioned any aspect of acclimatization saying: "There is this place I know where people are really proud to live in these old houses you can't install AC in. It just as hot there, but I don't know they seem to just be ok with it, like their bodies are just used to it." Otherwise, just as above the majority of responses about how others deal with heat focused around cultural adaptations. Cultural tropes fully developed in the next question, however, including these first sweeping generalizations was very helpful in guiding further questions.

Pan-US Air Conditioning Culture Comparison

Where the cultural commentary really gets interesting is when people were asked generally about “cultural aspects of AC at home and abroad”. The variable of cultural motifs of AC (ACculture1) was coded to allow for simple descriptive statistics of qualitative themes. As such, they are best viewed in **Figure 8** below. However, when filtered by state an interesting distinction is easily evident that was not present in the state vs. state comparison above. The majority theme for Floridians was of AC being an aspect of a “modern life, but only in America” (30.8%). Texans on the other hand mostly viewed it as a necessity (46.2%). In the secondary response, however, the states flip (30.8% of Floridians seeing it as “necessary courtesy”, 30.8% of Texans seeing it as “US only modernity”.



1st Cultural Motifs of AC

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Necessary	9	34.6	34.6	34.6
	Courtesy	1	3.8	3.8	38.5
	Cold Hearth / Blessing	3	11.5	11.5	50.0
	Modernity	1	3.8	3.8	53.8
	US only Modernity	6	23.1	23.1	76.9
	Taken for Granted	4	15.4	15.4	92.3
	Other	2	7.7	7.7	100.0
	Total	26	100.0	100.0	

Figure 8

Somehow I ended up with people commenting on Spain, Amsterdam, Mexico, Caribbean Islands, Peru, England, South Africa, and Japan. Stranger still, at least 5 people had all been to Spain recently and spent most of their time talking about their use of handheld fans, face misters, and parasols. Each country brought with it a few unique stories of beating the heat; however, one theme in particular stuck out from all the rest: US only Modernity.

Whether the person was talking about Mexico, England, or Japan they all mentioned how strange it was that if they went somewhere, and there was no AC, they would hardly notice. However, back in America, if there is no AC “something is wrong. People get upset and ask for a manager.” This even tied into aspect of everyday life. One participant even said “Sometimes when I am really tired of the heat, I just think, if this was Mexico, would I care?”. This showed up time and again. “In Japan they don’t separate indoor and outdoor space the way we do. If AC is there it is just for one room. I think it’s a cultural thing too, they just don’t expect it. Its summer, its hot.” In short, anyone who had been out of the country became immediately and lastingly aware that nowhere else is AC as ubiquitous as in the USA. Themes of modernity were also present (i.e. the arrival of AC allows for more modern buildings, or is some cultural status symbol of modern living), however, those international travelers felt that “Only the US is still building big boxes in the desert to pump full of AC. Everywhere else its open windows beer and siesta.” This brings up the next most common cultural theme: necessary and or necessary courtesy.

Among Texans and Floridians (both traveled and not) it was felt that Air Conditioning in the Southern United States was absolutely necessary. Support for this can be seen in how many people are irritated by heat, how much they use it, and how many would move if it did not exist. While a few actually did bring up the economic role Air Conditioning played in the reconstruction of the South, most simply supported this with horror stories of when the AC did not work either at home or at their business. “It’s like, if your AC breaks you can't do business" said one participant. Another who worked a t a movie theater explained "I get more complaints to adjust the AC up or down than any other complaint combined!" When grilled further about how these all seem to be "courtesy acts" that is when the theme of "necessary courtesy" developed. So while this response did not have the percentage that "necessary" did this was usually due to the building conversation. In short, AC culture is inherently Modern Southern United States American culture of Necessary Courtesy. When one considers that the major predictor for heat related illness began with irritability due to heat, and that the major theme of AC stories above is catering to irritated guests, the beginning of the chain in the Ecological model can be identified as this Southern Culture of Air Conditioning. One participant put this very subtlety saying "The South has won." By this he meant that the Southern Economic model of the United States of America is what is being "sold" as "modernity" and that this is linked to Air Conditioning use rising all over the world. Looks like he may not have been far off.

As a final cultural side note, though this response was rare, it had a certain anthropological beauty to its phrasing: "Air Conditioning is the Cold Hearth". A classic image of early man is a band of people gathered around a fire. This theme of the hearth is prolific in human history and to attempt to cite any one analysis of how important the "hearth" is to human life would simply be exhausting. However, regardless of literature review the parallels are self-evident. While before people were gathered by an offering of warmth and food, now the same is a cold space: ducking into an Air Conditioned fast food place to cool off and get some food. People would describe growing up with a window unit and how the whole house would congregate around the vent and play cards. Now, at the end of the analysis, just as in the beginning, the discussion returns to "shelter". Air Conditioning is shelter, it is comfort, it is necessary courtesy. It is modernity. However as the morbidity data shows, once a person becomes culturally, or psychologically dependent on AC, physiological dependency is soon to follow.

Chapter 4 – Discussion and Conclusions

The introduction to this paper began with a basic analysis of shelter and its relationship with the human experience. It keeps us warm when the weather is cold, cool when the weather is hot, and dry when the weather is wet. Truly there is no place like home. Through the course of this research, however, it has become increasingly clear that shelter no longer just means home. What's more the home shelter is now entirely based on preference as opposed to ecological mitigation. As was shown in how often people used "cool zone planning", or the act of planning the day around air conditioned space, true full shelter from the heat is accessible to even those with no AC at home. Gone are the days of finding a shady tree during a commute; for, looking for shade was never mentioned by this cohort. Its closest parallel was to "stay indoors", usually followed by "stay inactive". The theme of AC politics showed how, for some, even the home environment is not shelter for them when another has control over the thermostat. For the majority of others, stories of stress and squabbles over five to ten degree changes illustrate how temperature is now more about comfort and control as opposed to staying safe. It also seems that Texans who can afford AC are healthier than those that cannot. But for some reason this is not the case in Florida. Again "correlation without causation" is always possible, but all of this together showed how people today either are choosing their average temperature, or having it chosen for them by whoever it is in control of the thermostat, and this has lasting impacts on how they tolerate heat, both biologically and culturally.

Texas and Florida

Texas and Florida turned out to be fairly comparable states in terms of population and heat index. However, Texas clearly showed a “better fit” for the particular research hypothesis; i.e. is air conditioning use resulting in maladaptive biological and cultural norms. Texan participants mentioned AC use far more often and culturally view it as far more necessary than Floridians. Many significant correlations for the full sample lost significance when Texas was removed, and any correlations for Texas alone were more strongly linked to use of AC than any of those in Florida. This is greatly due to Florida being such a “beach and sun” culture state and residents very much took advantage of these amenities. For example, one Floridian who also spent much time in France even stated that “Both places have ‘cultures of the sun’. We just like to be out enjoying it and doing things that get us out in it. I think that’s why we go with less AC than others.” The other participants of this thesis would agree with her, pools and beach being far more prominent AC alternatives for Floridians than Texans. This contrast of the two states cultural adaptations also exposes previously unexpected health risks for over dependence on AC.

AC Dependency and Inactivity

Recall that the primary quote regarding AC usage usually came in the form of “I just avoid activity/outdoors and run the AC”. Even when AC was not an option, Texans often turned to fans and cold drinks but stuck to their avoidance of activity and the outdoors. Floridians cited pools or water sports whether AC was an option or not. While the participants would often leave the conversation topic here, it is important to consider the smaller acts contained in the larger act of “going to the beach”. To do this, a person must 1.

Go outside and become exposed to the heat in transit; 2. Burn calories in one way or another (sunbathing or swimming); and 3. Gain life experience in mitigating heat risk (sun block after their first bad burn, etc.). Each of these activities is an act of heat risk reduction in the schema of this thesis and can be backed up as adaptive by the literature review of human history of heat behavior. When the same sub-textual analysis is carried out on the Texan profile a fairly stark opposition can be found.

Certainly Texans mentioned pools and beach as options, but they were far more rare, and usually only when AC was removed from their choice pool. Furthermore, Texans often cited cold soda or beer (not water) as a way to stay cool. Finally, inactivity was directly linked textually to AC use. This suggest that in the face of hot weather, young adult Texans become inactive, but consume more calories in the form of soda, and avoid activities that could actually help their bodies acclimatize. In conclusion, this link of inactivity and calorie excess could tie the results of this study to the literature of obesity. It is highly possible that air conditioning dependency could be a previously unaccounted for variable in such studies.

Moving forward, Houston, Texas in particular would seem the best place to understand potential maladaptive use of AC both culturally and biologically. Floridians' awareness of their proximity to good beaches and resulting "sun culture" has them better adapted to "natural heat" than their Texan counterparts, anthropologically speaking. However, returning to the literature review, the findings of this thesis coming from Houston and Orlando geographically point out another trend impactful to future understanding of the cultural ecology of climate change.

Hot Humid Port Cities and Natural Disaster

Ecologically speaking, when the cities of Houston and Orlando are compared to the examples of extreme heat case studies of France, India, and Pakistan, more consistencies of risk can be seen. All of these regions are major economics hubs, either port cities or coastal ones, and all have now confirmed strangely high heat related illness morbidity. The only thing separating Houston from Karachi is a more resilient grid to provide AC. However, Houston's hurricane risk and resulting power outages show just how likely it is for a similar extreme heat event as the Karachi case study to occur here.

Consider Hurricane Ike in 2008. While Houston was blessed with "forgivable" temperatures in the mid to upper 80s in late September, the four major electricity providers for Houston documented 72% of all serviced Houstonians without power for up to two weeks (Clanton & Cook, 2008). Sure enough, city relief efforts focused around the establishing of "cool zones". These were buildings with functioning air conditioning that were posted as "refuge spots" for people to use to cool off. This came up in the thesis as "cool zone planning" as individual behavior. The city wide devotion to air conditioned space as *the* primary adaptive strategy further validate the themes of over use in this thesis along with assertions of Houstonians' cultural addiction to air conditioning as the "best option" to help keep people healthy. However, this is highly costly. A single restaurant running refrigerators for their food and employees consumed over $2000 per day in petroleum fuel for their generators (Clanton & Cook, 2008). Furthermore, these zones were often not available to those most at risk.

Again, the elderly raised a cry regarding their risk for heat related illness. Documented mortality from the lack of power was primarily due to inability to receive dialysis care; however, enough elderly people understood their heat risk to petition the local government to do what they could to prevent looming illness. Elderly people wrote the Houston Chronicle with stories of friends stuck in bead sweating and a general sense of dread in their community. They knew that they were only a few more hot days from succumbing. Again, it was said the only thing that kept them alive was the “merciful but still hot” upper 80^{o}F weather and a few visits from a generous ice cream man (Schiller & Staff, 2008). This author posits that if Ike were to have happened in July (as the Karachi case) heat related illness, especially of the elderly, would have been disastrous given all of the factors outlined above.

Turning to the exhaustive report on Ike published by FEMA, it is concerning to note that Air Conditioning is not mentioned *at all* (FEMA, 2008). An entire chapter is devoted to impacts on “built environments” but this only documented loss of housing space and infrastructural collapse in terms of bridges and the like. A total of 2.5 million power outages, often lasting until October, were confirmed but there is no discussion on how this affected community health (FEMA, 2008). Such analysis is saved for its own section, but again, heat related illness is overlooked and only reports of disaster related death (trapping, drowning, and isolation from needed care) are reported. Clearly both Texas and FEMA do not see heat related illness as linked to natural disaster at this point in impact assessment.

Understanding these emerging trends of risk is vital to bolster climate change resiliency for coastal, high population density, urban ecology. This profile seems to be the utmost at risk for heat related illness in the developed world. Given that the great majority of the sample cited climate change as a real, experienced event in their lives, further studies on air conditioning’s relationship to heat risk in Urban Costal Environments is called for.

The Temperate Temperature Constant

Another major finding from this work is that the only constant temperature range the entire sample experiences in their lives (aside from episodes of exposure like field schools) is 68-80^{o}F *regardless of season*. AC installation, use, and average temperature were all strikingly uniform. If you recall, the original motives for this thesis were to identify potential physiological acclimatization hampering as a result of living in air conditioned space. Many issues prevented me from carrying out a full heat stress study at this time: no heat stress test facility, unstable weather preventing natural expected acclimatization, etc. What is most important as a "result" of this failed method, was not the lacking facilities and fickle weather, these issues have been present since the beginning of adaptability research. What was of note was the near impossibility to find a population of people living in natural exposure to the heat. Certainly these populations exist, but they are increasingly rare in the United States.

My first thought was to seek out two comparing prison populations when it was found that some Texas prisons still do not have AC. However, as any researcher knows, working with prisoners is next to impossible aside from very specific research. I then turned to homeless or other people who could in no way afford AC. Again, homeless populations are extremely challenging to research so they were not seriously considered. Once I started asking everyone I know if they had "less well off" people they knew who did not live with AC, everyone asked replied with "Not around here, maybe in the country or across the border, but here everyone has it." People explained how even the most tight of financial situations they knew at least had a window unit. This led me to think, "Maybe the window is closed". Perhaps, in Houston at least, people have already begun to use so uniformly that the "migratory" population has vanished and the research cannot be done. This led to all of the “big data” included above to attempt to identify any form of contrast at all possible to compare two groups of differing AC use. As was shown above, even when the “lens” is turned from Houston to Florida, the ubiquity of AC use remains constant.

This uniformity of AC installation, use, and average temperature suggests modern populations like this sample can only be considered biological “natives” to the equivalent of a temperate climate and “commuters” in and out of any colder or hotter climate. In short, it is mostly likely that when a full heat stress test is run for future research of this question, those persons that live with AC all the time will be most similar in heat regulation to traditional human adaptability studies of temperate physiological acclimatization. The “hot weather native” has all but vanished in the populations studied by this thesis. This confirms one of the postulations that began this work.

Looming Issues of Heat Illness: Young Cases and Incidence Reporting

Along with confirming the expected ubiquity of constant AC usage, this thesis also found a strikingly high incidence of not just heat related illness (65.4% had some illness even mild) but extreme cases of illness (34.6%). Normally, the age cohort included in this thesis represents the least at risk for heat related illness, so finding such a high incidence is concerning. This increased incidence and severity was tied to a number of cultural and behavioral contributors, however, before discussing these, equally concerning are qualitative issues of epidemiological reporting.

When asked about their experience with heat illness, all the “war stories” come up. One person detailed a gold mining expedition in Alaska where the rationing of water led him to panic when he knew he was having heat exhaustion. With no water to cool off, he had to find a stream to dunk his head in to prevent loss of consciousness. Another person details working with a co-worker on an airplane engine when the co-worker passed out due to heat and fell from the air-plane to the ground below totally unconscious. More general accounts tended to be due to "not paying attention" and finding themselves overheated when normally having no issues when being in the heat either at work (open air) or outside for some event.

When asked about their *treatment* at the time of illness a shocking trend emerged: none of these illness cases were reported. One girl who had a heat stroke in central Florida explained "After playing outside I felt overheated and went inside early to cool off. I don't remember anything after that but waking up shaking in a pool of sweat with no memory of how I got inside. I never told anyone about it" This represents a clear case of heat stroke (tremors, loss of consciousness, delirium) (Mehta & Jaswal, 2003), however, this occurrence never made it to governmental demographic of heat related illness. Given that only one of the 26 interviewed reported going to a clinic, this suggests a potential mass under-reporting of maladies by the CDC.

Moving on, most of note is that 100% of all heat related illness in this case occurred *outdoors*. While this seems to detach the Air-Conditioning factor, it is this detachment that is exactly the culprit. Each of these people grew up with some kind of air conditioning and live with it presently. If they were having heat exhaustion in their home, this would show that the same illness event as France would be occurring: people being boxed in "oven like" rooms and succumbing to heat exhaustion. This would support that AC can be used to adapt to rising heat. These people are perfectly safe at home with their AC, yes. But what these cases of heat related illness represent, truly, are illness of exposure an environment in which they cannot cope for one reason or another.

Before moving on, a final note on epidemiological reporting. The CDC database did not report anything short of heat related mortality in Texas or Florida until 2011 (the highest year rates of heat related mortality for both states). This is an important finding given the lack of reporting mentioned above, and the key article on the French heat wave provided in the background section. The authors mention that individual hospitals, let alone countries, have very different reporting requirements for mortality. As such, any discrepancies in these demographics are likely due to these differing levels of reporting. (Poumadere et al., 2005) The sudden onset of hospitalizations and ER visits being monitored in 2011 are indicative of such a change in reporting policy. Coupled with the Field data showing a major lack in patient reporting as well, there is good reason to conclude that there is far more heat related morbidity than presently understood.

Heat Driven Behavior, Choice, and Illness

While no direct causal relationship between air conditioning and heat related illness can be powerfully asserted by the findings of this thesis, clear correlations and trends of dependency have been well documented. Hours of AC use was shown to correlate with how irritated one was when in the heat, and how hard they will try to avoid heat was correlated with how badly they had been sick before. This is a vicious cycle, suggesting that continual avoidance of the heat due to what begins as mild discomfort builds to an increasingly dependent relationship with AC; culminating in an episode of long term exposure to the heat bringing the onset of illness. Two particular stories from participants illustrate this exactly.

One Houstonian girl grew up Barrel Riding in Rodeo’s with her mother. She was exposed to high heat and little shade on rodeo grounds and always felt fine with it as a child.

However, after living with college roommates who ran the AC cold (AC politics again), she now finds the heat to be less bearable. She even suffered heat exhaustion her last rodeo. Now working in the garden, she has to keep mindful of her time outdoors, though she does note that being out of the AC is making the heat easier again.

Another Houstonian grew up in a house with the AC at 70 at all times. He carried this behavior over to his personal life until he had to go up to Alaska for summer work. Once in Alaska he suffered heat exhaustion on a particularly long hike with little shade. After finding water he was able to cool down. He brought back a major sensitivity to heat. While he always disliked the heat, he now avoids it even more to prevent another exhaustion event.

Each of these stories suggests a person’s ability to regulate heat being changed by the use of air conditioning, and illness occurring when it is removed. However, the same stories along with those of others also show a more subtle theme that sheds light into the crux of this research: the human body likes constants, but human opinion now controls the temperature, and that opinion changes too fast for the body to cope in any measurable way. In fact, the “vicious cycle” above is driven by a desire for consistency. Once a person becomes “fed up” with going in and out of the heat, they give up on being in the heat entirely. This causes them to search for a way to keep their experienced temperature constant by means of “cool zone seeking”. The result is an unknowing acclimation to the air conditioned environment that will only make their experience of heat that much more uncomfortable; thus, further validating their behavior to avoid the heat and use more AC.

In the end, the most powerful variable identified by this thesis was choice. Whether it was the “DEAL” variable detailing how people feel the heat is much more livable if they have no choice but to deal with it, or in the primary correlation pathway identified by statistics: irritability in the heat correlates with higher AC usage, which also correlates with how much they avoid the heat, which when all added to assess their heat risk correlated with a higher incidence of heat related illness. This confirms the hypothesis of this paper. In a “natural state” a person cannot choose their climate without long and arduous migration, which would acclimatize them in the process of transit. Now natives of Portland can fly to Florida and never acclimatize if they choose the “cool zone plan”. On the same token the same individual can “deal” with the heat and acclimatize, only to find Air Conditioning everywhere, so they choose to bring a jacket everywhere they go. Regardless of statistical correlations, nearly every variable above carries with it the message “you get to choose your temperature”. Now, with potential strong links to heat related illness this same claim echoes: “in doing so you choose your adaptation”.

Limitations

In all frankness and honesty, this entire process began with limitations; i.e. the lack of direct biological measures. While the data above are certainly reliable to assess the context of the problem, both sources have a certain secondary nature to their data. The government data in its sweeping generalization, and the Field Work data in its anecdotal nature. To truly understand the desired feedback mechanism between air conditioning use and risk for heat related illness, measures such as heart rate, BMI, and core temperature, all should be assessed. Luckily, the findings offered in the previous section paint a very favorable picture to encourage further research into this topic. The heat illnesses logged were primary accounts. The method used to assess psychological strain was comparable with any qualitative assessment of perceived stress. It is only in the assessment of heat risk that a biological assessment could greatly assist the reliability of the data. Thus in terms of future research, this study could be greatly furthered by the original study design outlined in the Method section. With the rigor and controls of a well sorted population being administered repeatable heat stress tests, the trends above suggest a strong likelihood that an adaptive relationship between use of climate control and ability to acclimatize to heat will be found.

Appendix I – IRB Cover Letter

UNIVERSITY OF HOUSTON
CONSENT TO PARTICIPATE IN RESEARCH

PROJECT TITLE: Controlled Climates and Human Variation: The Relationship between Air Conditioning and Lowering Heat Thresholds in a Hotter World

You are being invited to participate in a research project conducted by Gabriel Durham from the Department of Comparative Cultural Studies at the University of Houston. This project is part of the data collection for a Master's Thesis under the supervision of Dr. Janice Hutchinson.

NON-PARTICIPATION STATEMENT

Your participation is voluntary and you may refuse to participate or withdraw at any time without penalty or loss of benefits to which you are otherwise entitled. You may also refuse to answer any question. *[If you are a student, a decision to participate or not or to withdraw your participation will have no effect on your standing.]*

PURPOSE OF THE STUDY

The purpose of this study is to see how dependent people in the Southern United States of America are on air-conditioning. Also, with average temperatures in the South rising, this study will also help us see how this dependency will grow in the future.

PROCEDURES

A total of 30 subjects from 3 Southern States will be asked to participate in this project. You will be one of approximately 10 subjects asked to participate from this State.

While most of the data for this study will come from big government databases, it is always better to find out what real, living people are doing. To do this, we simply need to ask you a few questions regarding your day-to-day life and history of how you stay cool during the summer. This will be a one hour phone interview that will be recorded for later research.

CONFIDENTIALITY

Your participation in this project is anonymous. Please do not write your name in any email you may send me or say your name in any phone conversations. You will be given a code number (or fake name if you prefer) to record your answers. Your phone number will also not be saved by the phone I will use to talk with you.
Your interview will be recorded for transcription purposes. However, after a transcript of the interview is made, the recording of the interview will be destroyed so that your voice will not be recognized.

RISKS/DISCOMFORTS

There are no foreseeable risks/discomforts in this study.

BENEFITS

While you will not directly benefit from the study, your participation may help investigators better understand the relationships between many issues. These include the relationship between climate control and the human body, psychological pressures caused by heat, and may other important human issues in the face of climate change.

ALTERNATIVES

Participation in this project is voluntary and the only alternative to this project is non-participation.

PUBLICATION STATEMENT

The results of this study may be published in professional and/or scientific journals. It may also be used for educational purposes or for professional presentations. However, no individual subject will be identified.

If you have any questions, you may contact Gabriel Durham at 713-724-1824. You may also contact Dr. Janice Hutchinson, faculty sponsor, at 713-743-3987.

ANY QUESTIONS REGARDING YOUR RIGHTS AS A RESEARCH SUBJECT MAY BE ADDRESSED TO THE UNIVERSITY OF HOUSTON COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (713-743-9204).

Principal Investigator's Name: Gabriel Durham

Signature of Principal Investigator: __Gabriel Durham_______________

Appendix II – Recruitment Script

Did you have a HOT summer?

Sure you did! That is part of what makes it summer!

However…

Have you noticed summers are getting **hotter**, longer?

Do you have to crank up the **AC** (and your bills) everyday just to keep sane?

Then you may be able to help!

My name is Gabriel Durham and I am collecting data for my Master's Thesis.

If you want to voice your opinion on such topics as: **climate change, climate control, heat exhaustion/stroke, and outdoor sports**, then I need to hear from you!

Any information given will be totally **anonymous**. If you are interested, please reach out to me at either of the below contacts!

Phone: (713) 724-1824 Email: gbdurham@central.uh.edu

This project has been reviewed by the University of Houston Committee for the Protection of Human Subjects (713) 743-9204

Appendix III – Question Sheet

Heat History Questions

1. How old are you?
    i.
2. What is your racial identity?
    i.
3. What are your main ways to “keep cool” during the summer?
    i.
4. Do you drink a lot of water?
    i.
5. Does your home have some form of Air-Conditioning?
    i.
6. How often do you use it during “summer months” (in hours)?
    i.
7. Have these months changed? (longer AC use each year or shorter)
    i.
8. What is the average temperature you keep your AC at? Has this changed?
    i.
9. How often are you outside, or exposed to temperatures over 90^{o}F during the summer (in hours)?
    i.
10. Does any aspect if your life expose you to more heat than others you know? Avid camper, work in a hot factory, bakery, etc.
    i.
11. Does any aspect of your life expose you to unusual cold during the summer months? Work in cold storage, keep your home cooler than 60^{o}F all the time, trips to the southern hemisphere?
    i.
12. Have you ever been sick due to heat? Heat stroke, heat exhaustion, etc. (if yes please explain each occurrence).
    i.

13. Has anyone you know been sick due to heat?
    i.
14. Do you ever feel “sick of” the heat though you are not physically ill?
    i.
15. If so, how has this feeling effected your life? Cancel plans, stay inside unusually long, become irritable?
    i.
16. Would you live where you live now without AC?
    i.
17. If you did not have AC what do you think would be the best way to stay cool?
    i.
18. Do you notice that after you have been hot for a while that you can deal with heat better?
    i.
19. Do you use more AC than previous years? How about those around you?
    i.
20. If you have moved any time in the last 10 years: What are some differences you notice in “beating the heat” between the places you have lived?
    i.
21. How much does AC factor into your monthly bills?
    i.
22. What are some “cultural” aspects of AC? How do people talk about it? Is it loved, resented, or just necessary?
    i.
23. Anything you want to share that I did not ask about?

Appendix IV: T-test and Correlation Tables

CDC Group Statistics

	State	N	Mean	Std. Deviation	Std. Error Mean
Heat Mortality	Texas	11	95.7273	44.02747	13.27478
	Florida	11	20.0000	5.13809	1.54919
extreme heat days	Texas	11	5700.0000	6030.42894	1818.24274
	Florida	11	1637.5455	1642.19081	495.13916
population count	Texas	11	23401689.18	1483455.528	447278.6709
	Florida	11	17907516.18	922105.5856	278025.2950
percentage in poverty	Texas	11	16.6182	1.07221	.32328
	Florida	11	13.6000	1.75499	.52915

CDC Independent Samples t-test

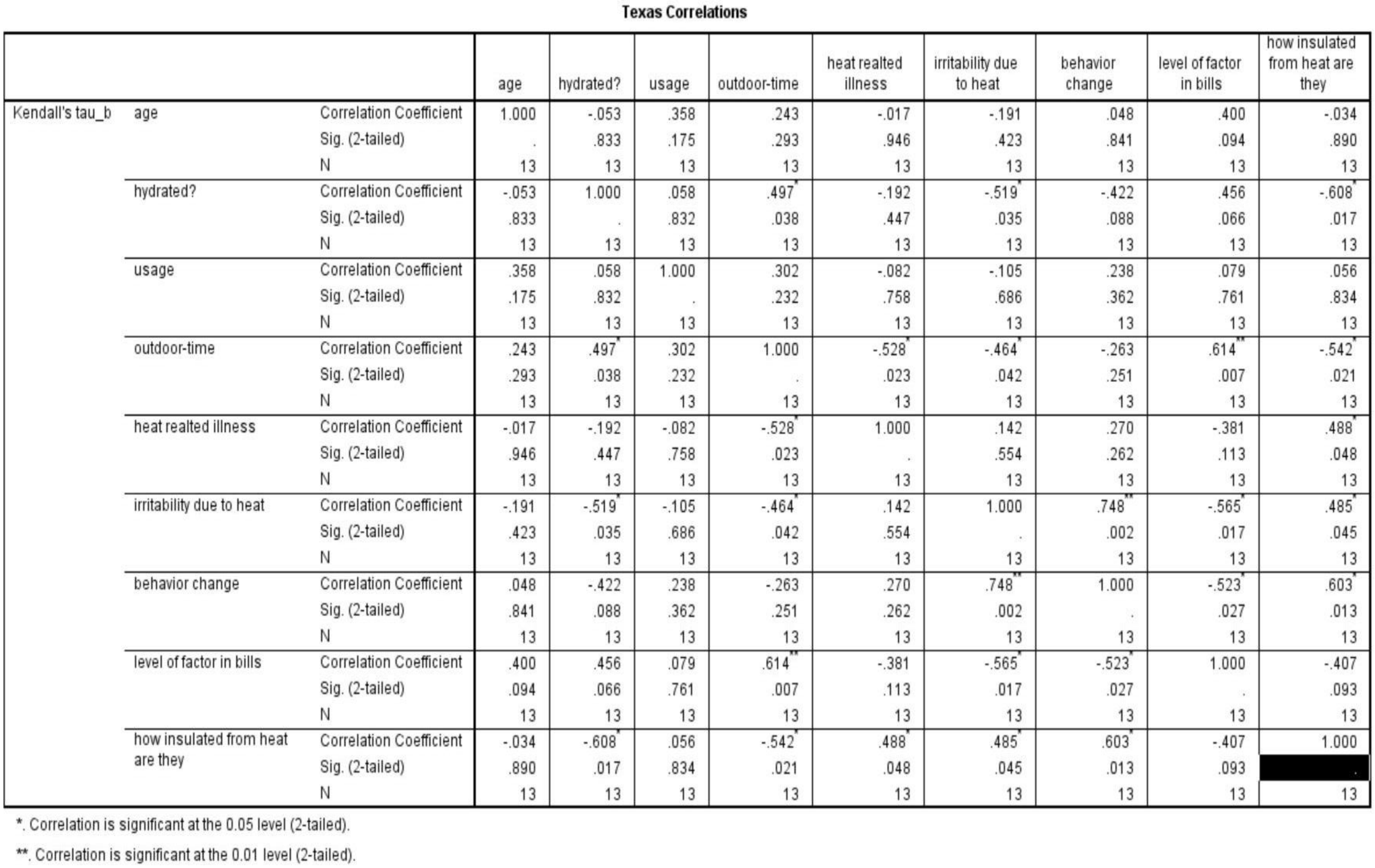
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Heat Mortality	Equal variances assumed	12.804	.002	5.666	20	.000	75.72727	13.36487	47.84864	103.60591
	Equal variances not assumed			5.666	10.272	.000	75.72727	13.36487	46.05515	105.39940
extreme heat days	Equal variances assumed	6.326	.021	2.156	20	.043	4062.45455	1884.45468	131.55096	7993.35813
	Equal variances not assumed			2.156	11.475	.053	4062.45455	1884.45468	-64.34993	8189.25902
population count	Equal variances assumed	3.531	.075	10.432	20	.000	5494173.000	526646.2514	4395608.170	6592737.830
	Equal variances not assumed			10.432	16.724	.000	5494173.000	526646.2514	4381646.895	6606699.105
percentage in poverty	Equal variances assumed	2.465	.132	4.867	20	.000	3.01818	.62009	1.72470	4.31167
	Equal variances not assumed			4.867	16.552	.000	3.01818	.62009	1.70720	4.32916

Full Sample Correlations

			age	hydrated?	usage	outdoor-time	heat realted illness	irritability due to heat	behavior change	level of factor in bills	how insulated from heat are they
Kendall's tau_b	age	Correlation Coefficient	1.000	.225	.055	.200	.167	-.138	.034	.343*	.156
		Sig. (2-tailed)	.	.183	.749	.203	.308	.390	.832	.032	.335
		N	26	26	26	26	26	26	26	26	26
	hydrated?	Correlation Coefficient	.225	1.000	.006	.313	-.098	-.167	-.122	.317	-.288
		Sig. (2-tailed)	.183	.	.975	.063	.576	.331	.480	.063	.096
		N	26	26	26	26	26	26	26	26	26
	usage	Correlation Coefficient	.055	.006	1.000	.035	-.016	.036	.386*	-.303	.375*
		Sig. (2-tailed)	.749	.975	.	.838	.929	.837	.028	.080	.033
		N	26	26	26	26	26	26	26	26	26
	outdoor-time	Correlation Coefficient	.200	.313	.035	1.000	-.335*	-.317*	-.076	.317*	-.461**
		Sig. (2-tailed)	.203	.063	.838	.	.040	.047	.636	.046	.004
		N	26	26	26	26	26	26	26	26	26
	heat realted illness	Correlation Coefficient	.167	-.098	-.016	-.335*	1.000	.096	.331*	-.111	.469**
		Sig. (2-tailed)	.308	.576	.929	.040	.	.566	.050	.505	.005
		N	26	26	26	26	26	26	26	26	26
	irritability due to heat	Correlation Coefficient	-.138	-.167	.036	-.317*	.096	1.000	.583**	-.265	.250
		Sig. (2-tailed)	.390	.331	.837	.047	.566	.	.000	.102	.129
		N	26	26	26	26	26	26	26	26	26
	behavior change	Correlation Coefficient	.034	-.122	.386*	-.076	.331*	.583**	1.000	-.387*	.427*
		Sig. (2-tailed)	.832	.480	.028	.636	.050	.000	.	.018	.010
		N	26	26	26	26	26	26	26	26	26
	level of factor in bills	Correlation Coefficient	.343*	.317	-.303	.317*	-.111	-.265	-.387*	1.000	-.251
		Sig. (2-tailed)	.032	.063	.080	.046	.505	.102	.018	.	.125
		N	26	26	26	26	26	26	26	26	26
	how insulated from heat are they	Correlation Coefficient	.156	-.288	.375*	-.461**	.469**	.250	.427*	-.251	1.000
		Sig. (2-tailed)	.335	.096	.033	.004	.005	.129	.010	.125	.
		N	26	26	26	26	26	26	26	26	26

*. Correlation is significant at the 0.05 level (2-tailed).

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



Texas Correlations

			age	hydrated?	usage	outdoor-time	heat realted illness	irritability due to heat	behavior change	level of factor in bills	how insulated from heat are they
Kendall's tau_b	age	Correlation Coefficient	1.000	-.053	.358	.243	-.017	-.191	.048	.400	-.034
		Sig. (2-tailed)	.	.833	.175	.293	.946	.423	.841	.094	.890
		N	13	13	13	13	13	13	13	13	13
	hydrated?	Correlation Coefficient	-.053	1.000	.058	.497*	-.192	-.519*	-.422	.456	-.608*
		Sig. (2-tailed)	.833	.	.832	.038	.447	.035	.088	.066	.017
		N	13	13	13	13	13	13	13	13	13
	usage	Correlation Coefficient	.358	.058	1.000	.302	-.082	-.105	.238	.079	.056
		Sig. (2-tailed)	.175	.832	.	.232	.758	.686	.362	.761	.834
		N	13	13	13	13	13	13	13	13	13
	outdoor-time	Correlation Coefficient	.243	.497*	.302	1.000	-.528*	-.464*	-.263	.614**	-.542*
		Sig. (2-tailed)	.293	.038	.232	.	.023	.042	.251	.007	.021
		N	13	13	13	13	13	13	13	13	13
	heat realted illness	Correlation Coefficient	-.017	-.192	-.082	-.528*	1.000	.142	.270	-.381	.488*
		Sig. (2-tailed)	.946	.447	.758	.023	.	.554	.262	.113	.048
		N	13	13	13	13	13	13	13	13	13
	irritability due to heat	Correlation Coefficient	-.191	-.519*	-.105	-.464*	.142	1.000	.748**	-.565*	.485*
		Sig. (2-tailed)	.423	.035	.686	.042	.554	.	.002	.017	.045
		N	13	13	13	13	13	13	13	13	13
	behavior change	Correlation Coefficient	.048	-.422	.238	-.263	.270	.748**	1.000	-.523*	.603*
		Sig. (2-tailed)	.841	.088	.362	.251	.262	.002	.	.027	.013
		N	13	13	13	13	13	13	13	13	13
	level of factor in bills	Correlation Coefficient	.400	.456	.079	.614**	-.381	-.565*	-.523*	1.000	-.407
		Sig. (2-tailed)	.094	.066	.761	.007	.113	.017	.027	.	.093
		N	13	13	13	13	13	13	13	13	13
	how insulated from heat are they	Correlation Coefficient	-.034	-.608*	.056	-.542*	.488*	.485*	.603*	-.407	1.000
		Sig. (2-tailed)	.890	.017	.834	.021	.048	.045	.013	.093	.
		N	13	13	13	13	13	13	13	13	13

*. Correlation is significant at the 0.05 level (2-tailed).

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

Florida Correlations

			age	hydrated?	usage	outdoor-time	heat realted illness	irritability due to heat	behavior change	level of factor in bills	how insulated from heat are they
Kendall's tau_b	age	Correlation Coefficient	1.000	.534*	-.075	.190	.313	-.034	.103	.334	.242
		Sig. (2-tailed)	.	.036	.765	.435	.208	.890	.677	.162	.314
		N	13	13	13	13	13	13	13	13	13
	hydrated?	Correlation Coefficient	.534*	1.000	.020	.244	-.019	.239	.241	.190	-.018
		Sig. (2-tailed)	.036	.	.938	.334	.942	.346	.345	.443	.944
		N	13	13	13	13	13	13	13	13	13
	usage	Correlation Coefficient	-.075	.020	1.000	-.249	-.039	.225	.455	-.476	.501*
		Sig. (2-tailed)	.765	.938	.	.318	.880	.369	.072	.052	.042
		N	13	13	13	13	13	13	13	13	13
	outdoor-time	Correlation Coefficient	.190	.244	-.249	1.000	-.230	-.190	-.035	.227	-.526*
		Sig. (2-tailed)	.435	.334	.318	.	.351	.435	.887	.339	.028
		N	13	13	13	13	13	13	13	13	13
	heat realted illness	Correlation Coefficient	.313	-.019	-.039	-.230	1.000	.087	.386	.147	.448
		Sig. (2-tailed)	.208	.942	.880	.351	.	.726	.123	.545	.067
		N	13	13	13	13	13	13	13	13	13
	irritability due to heat	Correlation Coefficient	-.034	.239	.225	-.190	.087	1.000	.462	.000	.129
		Sig. (2-tailed)	.890	.346	.369	.435	.726	.	.061	1.000	.591
		N	13	13	13	13	13	13	13	13	13
	behavior change	Correlation Coefficient	.103	.241	.455	-.035	.386	.462	1.000	-.257	.228
		Sig. (2-tailed)	.677	.345	.072	.887	.123	.061	.	.286	.347
		N	13	13	13	13	13	13	13	13	13
	level of factor in bills	Correlation Coefficient	.334	.190	-.476	.227	.147	.000	-.257	1.000	-.167
		Sig. (2-tailed)	.162	.443	.052	.339	.545	1.000	.286	.	.478
		N	13	13	13	13	13	13	13	13	13
	how insulated from heat are they	Correlation Coefficient	.242	-.018	.501*	-.526*	.448	.129	.228	-.167	1.000
		Sig. (2-tailed)	.314	.944	.042	.028	.067	.591	.347	.478	.
		N	13	13	13	13	13	13	13	13	13

*. Correlation is significant at the 0.05 level (2-tailed).

Works Cited

Agarwal, V. (2015a, 05/31/
2015 May 31). India Heat Wave Death Toll Tops 2,000; Officials don't see relief from the sweltering conditions for four or five days. *Wall Street Journal (Online)*. Retrieved from http://search.proquest.com.ezproxy.lib.uh.edu/docview/1684269595?accountid=7107 Retrieved from http://sfxna11.hosted.exlibrisgroup.com/01uho?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&genre=unknown&sid=ProQ:ProQ:abiglobal&atitle=India+Heat+Wave+Death+Toll+Tops+2,000

Agarwal, V. (2015b, 06/01/
2015 Jun 01). World News: Death Toll Tops 2,000 Amid India's Heat Wave. *Wall Street Journal*. Retrieved from http://search.proquest.com.ezproxy.lib.uh.edu/docview/1684358149?accountid=7107 Retrieved from http://sfxna11.hosted.exlibrisgroup.com/01uho?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&genre=unknown&sid=ProQ:ProQ:abiglobal&atitle=World+News:+Death+Toll+Tops+2,000+Amid+India's+Heat+Wave&title=Wall+Street+Journal&issn=00999660&date=2015-06-01&volume=&issue=&spage=A.7&au=Agarwal,+Vibhuti&isbn=&jtitle=Wall+Street+Journal&btitle=&rft_id=info:eric/&rft_id=info:doi/

Alana Hansen, P. B., Monika Nitschke, Dino Pisaniello, Jonathan Newbury and Alison Kitson. (December 2011). Perceptions of Heat-Susceptibility in Older Persons: Barriers to Adaptation (Vol. 8, pp. 4714-4728): *International Journal of Environmental Research and Public Health*.

Armstrong, L. E., Becker, S. M., Blowers, J. A., Brown, C. M., Casa, D. J., Ganio, M. S., . . . Yeargin, S. W. (2007). Validity of devices that assess body temperature during outdoor exercise in the heat. *Journal of Athletic Training, 42*, 333+.

Armstrong, L. E., Burton, L. J., Casa, D. J., Maresh, C. M., Mazerolle, S. M., McDermott, B. P., & Scruggs, I. C. (2010). Current knowledge, attitudes, and practices of certified athletic trainers regarding recognition and treatment of exertional heat stroke. *Journal of Athletic Training, 45*, 170+.

Armstrong, L. E., Casa, D. J., Ganio, M. S., Johnson, E. C., Lee, E. C., Lopez, R. M., . . . McDermott, B. P. (2010). Perceptual responses while wearing an American football uniform in the heat. *Journal of Athletic Training, 45*, 107+.

Auliciems, A., & Dedear, R. (1986). Air conditioning in a tropical climate: Impacts upon European residents in Darwin, Australia. *International Journal of Biometeorology, 30*(3), 259-282. doi:10.1007/BF02189471

Austin, D. M., & Lansing, M. W. (1986). Body Size and Heat Tolerance: A Computer Simulation. *Human Biology, 58*(2), 153-169. doi:10.2307/41463738

Baker, P., & Weiner, J. S. (1967). The Biology of Human Adaptability. doi:10.1002/ajpa.1330270124

Baker, P. T., Buskirk, E. R., Kollias, J., & Mazess, R. B. (1967). TEMPERATURE REGULATION AT HIGH ALTITUDE: QUECHUA INDIANS AND U. S. WHITES DURING TOTAL BODY COLD EXPOSURE. *Human Biology, 39*(2), 155-169. doi:10.2307/41448836

Barnes, E. (2005). Diseases and Human Evolution. USA: University of New Mexico Press.

Benestad, R. E., & Schmidt, G. A. (2009). Solar trends and global warming. *Journal of Geophysical Research: Atmospheres, 114*(D14), D14101. doi:10.1029/2008JD011639

Briggs, C., & Bauman, R. (1999). The foundation of all future researches: Franz Boas, George Hunt, native american texts, and the construction of modernity. *American Quarterly, 51*(3), 479.

CDC. (2016). Health Effects Heat Stress - CDC Tracking Network. Retrieved from http://www.cdc.gov/nceh/tracking/about.htm

Clanton, B., & Cook, L. (2008). HURRICANE RECOVERY: A STATUS REPORT - Tempers rising as outages drag on - People without power demand more information. *Houston Chronicle,* p. 1.

Control, C. f. D. (2016). Health Effects Heat Stress - CDC Tracking Network.

Cooper, G. A. (1987). *"MANUFACTURED WEATHER": A HISTORY OF AIR CONDITIONING IN THE UNITED STATES, 1902-1955*. (8803275 Ph.D.), University of California, Santa Barbara, Ann Arbor. Retrieved from http://search.proquest.com.ezproxy.lib.uh.edu/docview/303459461?accountid=7107Retrieved from http://ev7su4gn4p.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rfr_id=info:sid/ProQuest+Dissertations+&+Theses+Full+Text&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&rft.genre=dissertations+&+theses&rft.jtitle=&rft.atitle=&rft.au=Cooper,+Gail+Ann&rft.aulast=Cooper&rft.aufirst=Gail&rft.date=1987-01-01&rft.volume=&rft.issue=&rft.spage=&rft.isbn=&rft.btitle=&rft.title="MANUFACTURED+WEATHER":+A+HISTORY+OF+AIR+CONDITIONING+IN+THE+UNITED+STATES,+1902-1955&rft.issn= ProQuest Dissertations & Theses Full Text database.

Ebi, K. L., Lewis, N. D., & Corvalan, C. (2006). Climate Variability and Change and Their Potential Health Effects in Small Island States: Information for Adaptation Planning in the Health Sector. *Environmental Health Perspectives, 114*(12), 1957-1963. doi:10.2307/4119613

Erickson, P. (2010). Readings For A History Of Anthropological Theory. In L. Murphy (Ed.), (Third Edition ed.). Canada: University of Toronto Press.

Farbotko, C., & Waitt, G. (2011). Residential air-conditioning and climate change: voices of the vulnerable. *Health Promotion Journal of Australia, 22*(4), S13-S16.

FEMA. (2008). Hurricane Ike Preliminary Impact Report: Federal Emergency Management Agency.

Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics* (4th ed.). California: Sage.

González-Alonso, J. (2012). Human thermoregulation and the cardiovascular system. *Experimental Physiology, 97*(3), 340-346. doi:10.1113/expphysiol.2011.058701

Graudenz, G. S., Oliveira, C. H., Tribess, A., Mendes, C., Latorre, M. R. D. O., & Kalil, J. (2005). Association of air-conditioning with respiratory symptoms in office workers in tropical climate. *Indoor Air, 15*(1), 62-66. doi:10.1111/j.1600-0668.2004.00324.x

Hacker, J. N., & Holmes, M. J. (2007). Thermal Comfort: Climate Change and the Environmental Design of Buildings in the United Kingdom. *Built Environment (1978-), 33*(1), 97-114. doi:10.2307/23289475

Hanna, J. M., & Baker, P. T. (1974). Comparative Heat Tolerance of Shipibo Indians and Peruvian Mestizos. *Human Biology, 46*(1), 69-80. doi:10.2307/41459929

Hanna, J. M., & Brown, D. E. (1983). Human Heat Tolerance: An Anthropological Perspective. *Annual Review of Anthropology, 12*, 259-284. doi:10.2307/2155648

Kenney, W. L., DeGroot, D. W., & Alexander Holowatz, L. (2004). Extremes of human heat tolerance: life at the precipice of thermoregulatory failure. *Journal of Thermal Biology, 29*(7–8), 479-485. doi:http://dx.doi.org/10.1016/j.jtherbio.2004.08.017

Kovats, R. S., & Hajat, S. (2008). Heat Stress and Public Health: A Critical Review. *Annual Review of Public Health, 29*(1), 41-55. doi:10.1146/annurev.publhealth.29.020907.090843

Layton, R. (1997). An Introduction to Theory in Anthropology. Cambridge: Cambridge University Press.

Leslie, P. W., & Little, M. A. (2003). Human Biology and Ecology: Variation in Nature and the Nature of Variation. *American Anthropologist, 105*(1), 28-37. doi:10.2307/3567311

Levin, S. (2009). Princeton Guide to Ecology. In S. Carpenter (Ed.). Princeton, NJ, USA: Princeton University Press.

Little, M. A., Thomas, R. B., Mazess, R. B., & Baker, P. T. (1971). POPULATION DIFFERENCES AND DEVELOPMENTAL CHANGES IN EXTREMITY TEMPERATURE RESPONSES TO COLD AMONG ANDEAN INDIANS. *Human Biology, 43*(1), 70-91. doi:10.2307/41462274

McElroy, A. T., Patricia. (2009). *Medical Anthropology in Ecological Perspective* (Fifth ed.). Boulder, CO: Westview Press.

Mehta, S. R., & Jaswal, D. S. (2003). Heat Stroke. *Medical Journal Armed Forces India, 59*(2), 140-143. doi:http://dx.doi.org/10.1016/S0377-1237(03)80062-X

Moberg, M. (2013). *Engaging Anthropological Theory* (First ed.). USA: Routledge.

Molnar, S. (2006). Human Variation *Races, Types, and Ethnic Groups* (6th Edition ed.). Upper Saddle River, New Jersey: Pearson.

Moran, E. (2008). Human Adaptability *An Introduction to Ecological Anthropology* (Third Edition ed.). Bolder, CO: Westview Press.

Nationale, A. (2004). *Rapport de la commission d'enquête sur les conséquences sanitaires et sociales de la canicule.* Paper presented at the Assemblée Nationale.

Nauman, Q. (2015, 06/25/

2015 Jun 25). Pakistan Heat Wave Eases, but Death Toll Rises; Hundreds remain under treatment for heat-related symptoms in southern region. *Wall Street Journal (Online)*. Retrieved from http://search.proquest.com.ezproxy.lib.uh.edu/docview/1691078291?accountid=7107 Retrieved from http://sfxna11.hosted.exlibrisgroup.com/01uho?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&genre=unknown&sid=ProQ:ProQ:abiglobal&atitle=Pakistan+Heat+Wave+Eases,+but+Death+Toll+Rises

Nudds, R. L., & Oswald, S. A. (2007). An Interspecific Test of Allen's Rule: Evolutionary Implications for Endothermic Species. *Evolution, 61*(12), 2839-2848. doi:10.2307/4627095

O’Neill, M., Zanobetti, A., & Schwartz, J. (2005). Disparities by race in heat-related mortality in four US cities: The role of air conditioning prevalence. *Journal of Urban Health, 82*(2), 191-197. doi:10.1093/jurban/jti043

Patel, K. (2015). NASA Studying 2015 El Nino Event As Never Before. GSFC News: United Press International.

Patz, J. A., Campbell-Lendrum, D., Holloway, T., & Foley, J. A. (2005). Impact of regional climate change on human health. *Nature, 438*(7066), 310-317.

Posey, C. (1980). Heat wave. *Weatherwise, 33*, 112–116.

Poumadere, M., Mays, C., Le Mer, S., & Blong, R. (2005). The 2003 Heat Wave in France: Dangerous Climate Change Here and Now. (Vol. 25, pp. 1483-1494): Risk Analysis.

Press, A. (2003). France heat wave death toll set at 14,802. *USA Today*.

Quandt, S. A., Wiggins, M. F., Chen, H., Bischoff, W. E., & Arcury, T. A. (2013). Heat Index in Migrant Farmworker Housing: Implications for Rest and Recovery From Work-Related Heat Stress. *American Journal of Public Health, 103*(8), e24-e26. doi:10.2105/AJPH.2012.301135

Ramphal-Naley, L. (2012). Screening for heat stress in workers and athletes. *Proceedings (Baylor University. Medical Center), 25*(3), 224-228.

RECS. (2015). Residential Energy Consumption Survey.

Rector, R. (2011). Air Conditioning, Cable TV, and an X-Box. In R. Sheffield (Ed.), *What is Poverty in the United States Today?* : The Heritage Foundation.

Schiller, D., & Staff, G. (2008). Hurricane Ike - Life after Ike - A lack of electricity has many of Houston's elderly wondering how much more they will be able to stand the heat - A test of tolerance. *Houston Chronicle,* p. 1. Retrieved from http://infoweb.newsbank.com.ezproxy.lib.uh.edu/resources/doc/nb/news/123665B11093A318?p=NewsBank

Serrat, M. A., King, D., & Lovejoy, C. O. (2008). Temperature Regulates Limb Length in Homeotherms by Directly Modulating Cartilage Growth. *Proceedings of the National Academy of Sciences of the United States of America, 105*(49), 19348-19353. doi:10.2307/25465647

Seybold, P. (2011). LOSING OUR COOL -- UNCOMFORTABLE TRUTHS ABOUT OUR AIR-CONDITIONED WORLD (AND FINDING NEW WAYS TO GE THROUGH THE SUMMER). *Humanity & Society, 35*(1/2), 192-194.

Steward, J. (1968). Cultural Ecology *International Encyclopedia of the Social Sciences* (Vol. 4, pp. 337-344). New York: Macmillan.

Sutton, M. Q., & Anderson, E. N. (2010). *Introduction to Cultural Ecology* (Second ed.). United Kingdon: AltaMira.

Trenberth, K. E., & J.T., F. (2012). Climate extremes and climate change: The Russian heat wave and other climate extremes of 2010. *Journal of Geophysical Research, 117*(D17).

Vanos, J., Warland, J., Gillespie, T., & Kenny, N. (2012). Thermal comfort modelling of body temperature and psychological variations of a human exercising in an outdoor environment. *International Journal of Biometeorology, 56*(1), 21-32. doi:10.1007/s00484-010-0393-2

Vinnikov, K. Y., & Grody, N. C. (2003). Global Warming Trend of Mean Tropospheric Temperature Observed by Satellites. *Science, 302*(5643), 269-272. doi:10.2307/3835376

Wang, S. Y., Huang, W. R., Hsu, H. H., & Gillies, R. R. (2015). Role of the strengthened El Niño teleconnection in the May 2015 floods over the southern Great Plains, . *Geophysical Research Letters, 42*, 8140–8146.

Yeargin, S. (2006). Heat Acclimatization and Hydration Status of American Football Players During Initial Summer Workouts. In D. Casa (Ed.), (Vol. 20, pp. 463-470): Journal of Strength and Conditioning Research.

Zhou, J., & Tung, K.-K. (2013). Deducing Multidecadal Anthropogenic Global Warming Trends Using Multiple Regression Analysis. *Journal of the Atmospheric Sciences, 70*(1), 3-8. doi:10.1175/JAS-D-12-0208.1