Proceedings of Conference: ***Adapting to Change: New Thinking on Comfort*** Cumberland Lodge, Windsor, UK, 9-11 April 2010. London: Network for Comfort and Energy Use in Buildings, http://nceub.org.uk

Studying the Adaptive Comfort Model a Case Study in a Hot Dry Climate, Cairo, Egypt

Amgad Farghal and Andreas Wagner
Division of Building Physics and Technical Building Services
Karlsruhe Institute of Technology, Englerstrasse 7, D – 76131 Karlsruhe, Germany
Mail: amgad_77@yahoo.com

ABSTRACT

This study focused on naturally ventilated buildings that are the base of the Adaptive Comfort Model, implemented in ASHRAE Standard 55-2004 section 5.3, as one of the methods for determining acceptable thermal conditions in naturally ventilated spaces. The studied buildings thermal environments were experimentally tested against the requirements of the Adaptive Comfort Standard. The data points representing the indoor temperatures for votes on thermal sensation rating (-1, 0, 1) on the ASHRAE Scale were correlated with their corresponding mean outdoor temperature, and then plotted against the ASHRAE adaptive comfort model. An ANOVA Test for different buildings' neutralities across different climatic zones resulted in a significant difference between these thermal neutralities which can be explained by the different climates.

KEYWORDS

Field study, hot arid climate, Adaptive Comfort Model

INTRODUCTION

Experiments in climate chambers depending on heat balance models were the base of thermal comfort standards till recently. Although they were originated to support HVAC controlled buildings, they were used across both naturally ventilated and mechanically controlled buildings (Brager & de Dear, 1998). The standards were then further developed to include an introduction of the concept of adaptation with a separate method for naturally ventilated buildings. In the new ASHRAE standard 55-2004, dealing with thermal comfort in indoor environments for a range of metabolic rates from 1.0 to 1.3 met (58.15 to 75.6 W/m^2), acceptable operative temperatures (18˚C to 31˚C) are related to the mean monthly outdoor temperature. This relation is often used to predict the comfortable environments in hot climates, but to the limits of the model (Olesen & Brager, 2004). More field experiments are required to extend the limits of this model.

OBJECTIVES OF THE FIELD STUDY

The standard is based mainly on 36 naturally ventilated buildings, where most of these buildings represent moderate climates with only two buildings representing a desert climate. The refore the standards is limited to the mean outdoor temperatures ranging from 10 °C to 33 °C, while the mean outdoor temperatures in hot arid climates in the summer reaches a higher limit than in the standard. The range of mean outdoor temperatures and accepted indoor temperatures in hot arid climates may be much larger than the range incorporated in the existing standard.

Another issue is that the adaptive comfort model is generalized over different climatic zones. The classification of the standard into different climate zones, and setting a specific temperature range to each climate may expand the range of acceptable temperatures and gives the opportunity for more energy conservation.

The design of the field experiment and the methodology followed were fully discussed in (Farghal & Wagner, 2008), attached in the appendix is the questionnaire in the local language, the focus here will be on the data analysis and the interpretation of the findings.

FREQUENCY OF VOTES AND THEIR DISTRIBUTION

The days included in the study and the frequency of votes on each day across the four seasons of the study is shown in Figure 1. The study included a total number of 38 surveyed days, 24 of them had more than 50 votes and the rest, 14 days, had less than 50 votes each. The buildings Cairo and Ain Shams included in the study were two naturally ventilated buildings.

The months included in the study were February, March, April, May, July, November and December. The votes in July came from employees of the buildings; in the other months, both employees and students participated in the study. Figure 2 shows the distribution of votes according to different spaces for all days of the study across the four seasons included in the study.

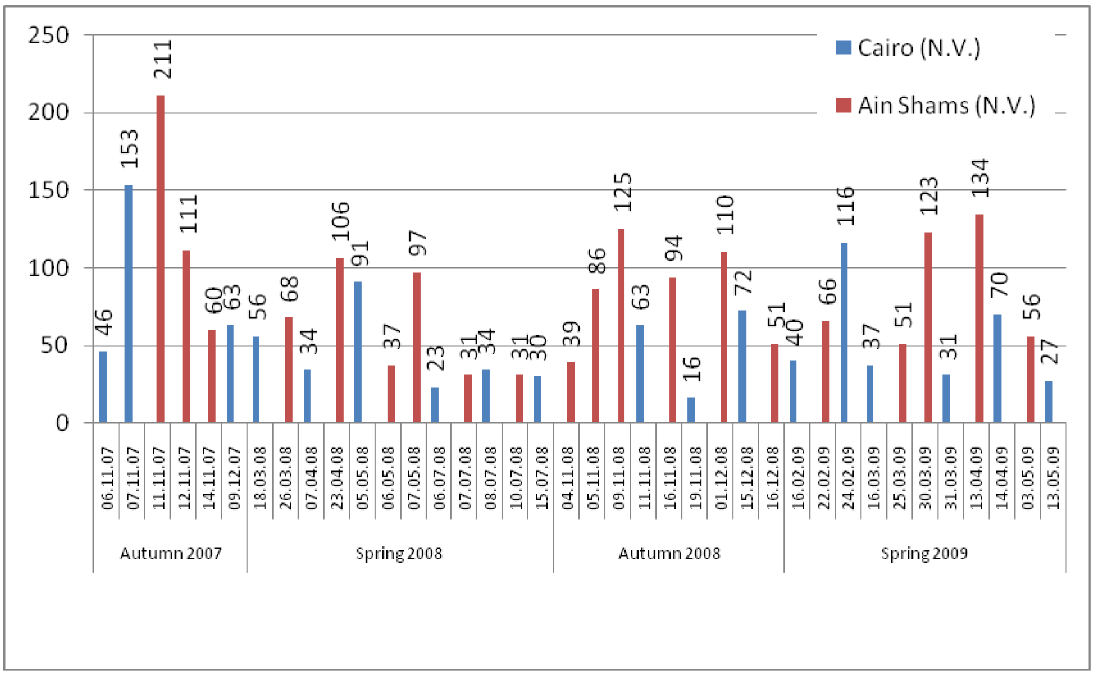

Figure 1: The days included in the study and the frequency of votes on each day across the four seasons of the study

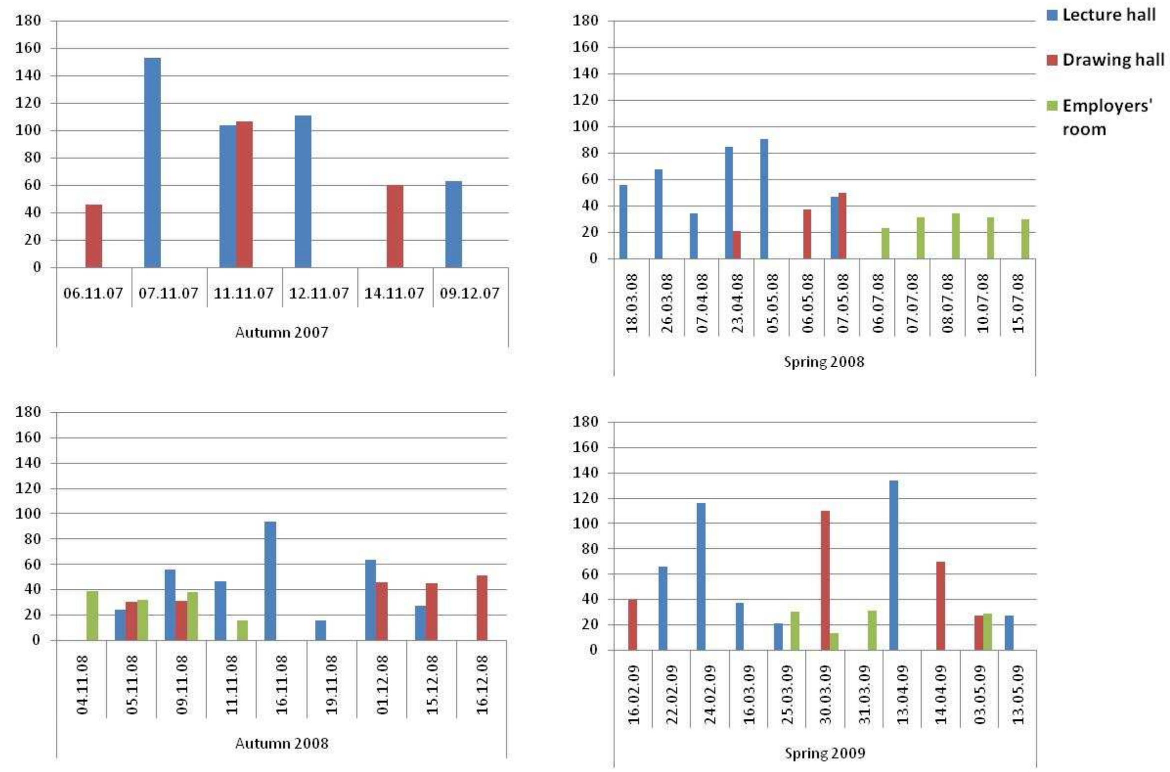

Figure 2: The distribution of votes according to different spaces on all days of the study across the four seasons of the study

The study conducted in autumn 2007 focused on students only while in spring 2008, the study included both employees and students who participated on separate days. Studies conducted during the two following seasons allowed students and employees to participate on the same days, making it possible to compare different types of users.

The study covered four seasons, autumn 2007, spring 2008, autumn 2008 and spring 2009. The number of votes in autumn 2007 was 644. The number of votes in spring 2008 was 638. The number of votes in autumn 2008 was 656 and the number of votes in spring 2009 was 751. The resulting number of votes was 2689.

DISTRIBUTION OF VOTES BY AGE AND GENDER

The distribution of votes by age and gender is shown in Figure 3. The percentage of female votes was 60.7 %, while the percentage of male votes was 36.2 %; 3.1 % did not answer the question determining the gender type. 82.7 % of the votes were younger than 25; this age category represented students, while the other age categories represented employees and lecturers.

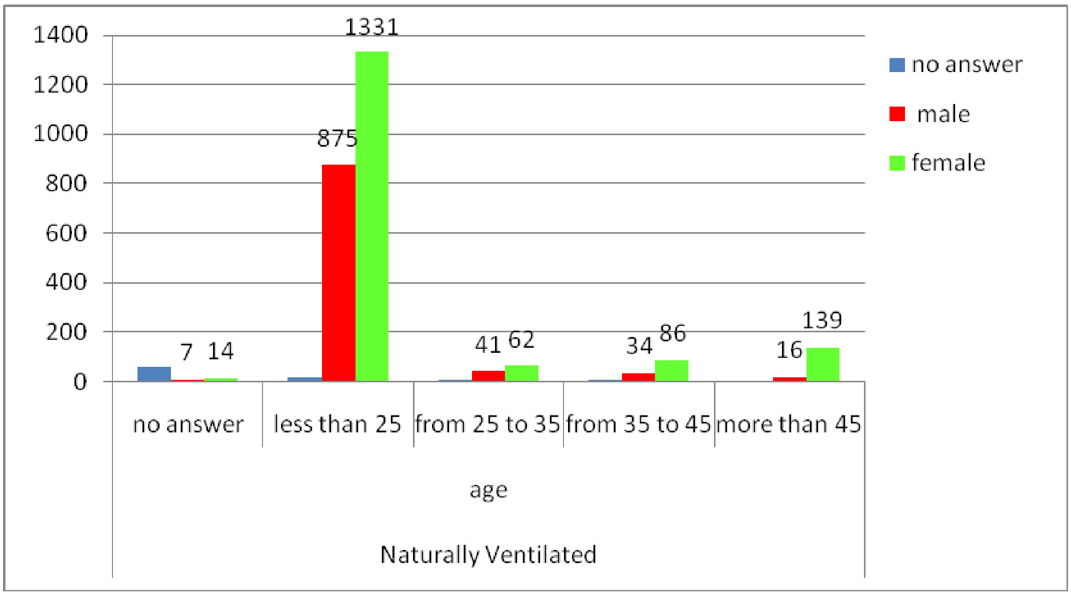

Figure 3: The distribution of votes in naturally ventilated buildings by age and gender

THERMAL ENVIRONMENT'S CHARACTERISTICS

This section deals with the thermal environment in the different four field studies. The parameters measured were indoor air temperature and the relative humidity. The value of each represents the mean value calculated from the average of readings of all devices that were placed in each space. The values obtained for each space and the mean values of each building during the different four seasons of the field studies are discussed. The outdoor air temperature were obtained from the Egyptian Meteorological Authority from the nearest metrological station, less than 50 km from any of the two buildings. The mean of the 6 a.m. and 3 p.m. readings represented the value of each point.

AIR TEMPERATURE

The indoor air temperature was measured in each space on each day of the field studies. The mean indoor air temperature and the mean outdoor air temperature for each day of the field studies over the four seasons are shown in Figure 4. It can be observed that the maximum mean indoor temperature recorded was 34.3°C, and the minimum mean indoor air temperature was 20.5°C, which means that the study covered a range of 14 K. The minimum mean outdoor air temperature was 16.1°C and the maximum mean outdoor temperature was 35°C, covering a range of outdoor temperatures of 19 K. The general trend in the autumn seasons was that the recorded indoor temperature started from a high temperature and decreased as the study continued, while the reverse occurred in the spring seasons. The mean outdoor air temperature was always lower than the mean indoor air temperature as the survey was conducted between the 10 a.m. and 4 p.m., while the mean outdoor air temperature was calculated as the average of the 6 a.m. and the 3p.m. readings.

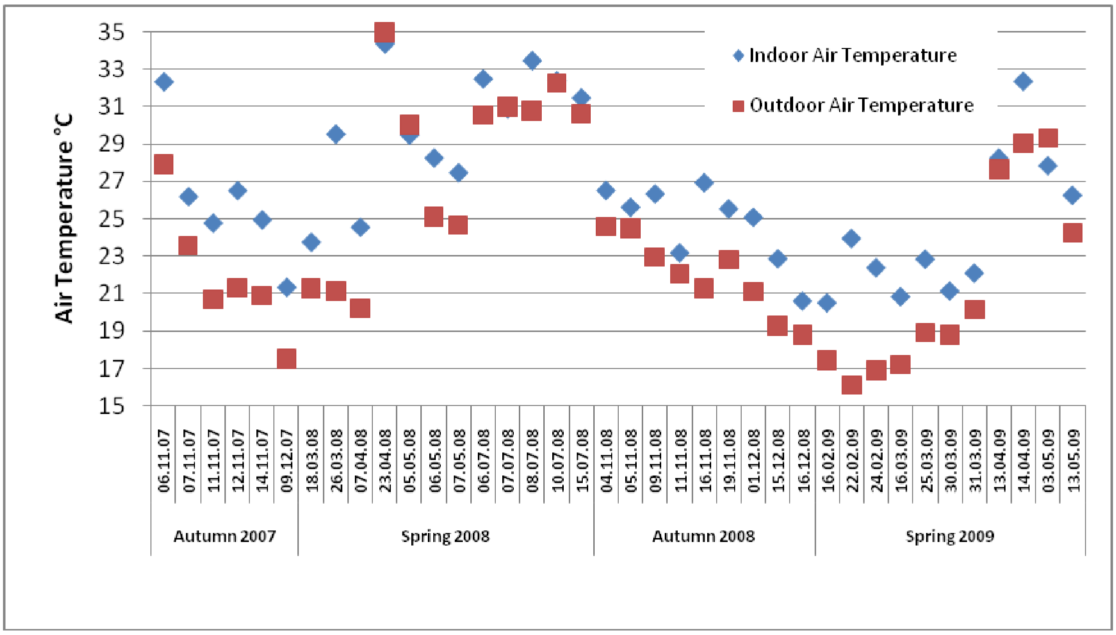

Figure 4: The mean indoor air temperature values (°C) recorded during the days of the study, and the mean outdoor air temperature values (°C) obtained from the Egyptian Meteorological Authority

The mean indoor air temperature, with the 95% confidence interval, across each season is shown in Figure 5. Spring 2008 had the higher mean, and it was higher than the average range covered by the other studies in the other three seasons. This led to the investigation of the thermal range covered across the four seasons.

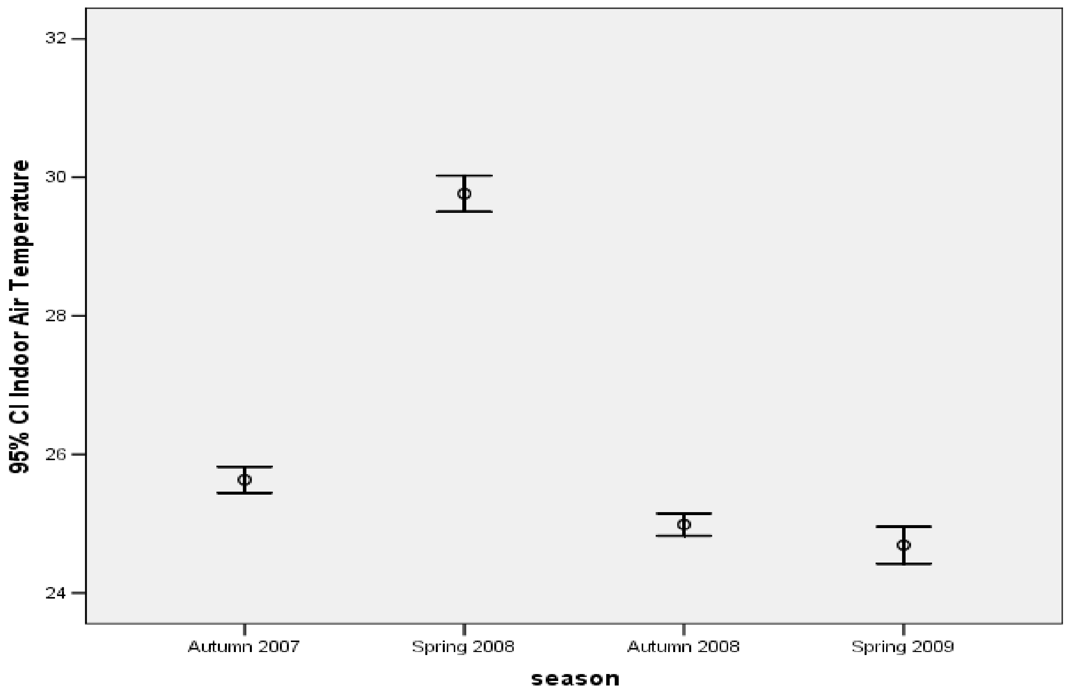

Figure 5: The mean indoor air temperature across the four seasons of the study

The days in spring 2008 had indoor air temperatures of more than 25° C, which led to a higher mean of the indoor air temperature than the other seasons investigated in the study. The range of indoor air temperatures between 21°C and 25°C was clearly represented in the season of spring 2009; this had an impact on the neutral temperature calculated for each season later on.

RELATIVE HUMIDITY

The mean indoor relative humidity of each day and corresponding mean outdoor relative humidity are shown in Figure 6 . The minimum indoor relative humidity was 21% and the maximum indoor relative humidity was 60 %, covering a range of 40%. The minimum outdoor relative humidity was 22% and the maximum outdoor relative humidity was 66%, covering a range of 44%. In most cases, the indoor relative humidity percentage is within acceptable ranges, the mean indoor relative humidity lay between the 40% and the 60% as recommended by (CIBSE, 1997)for office work.

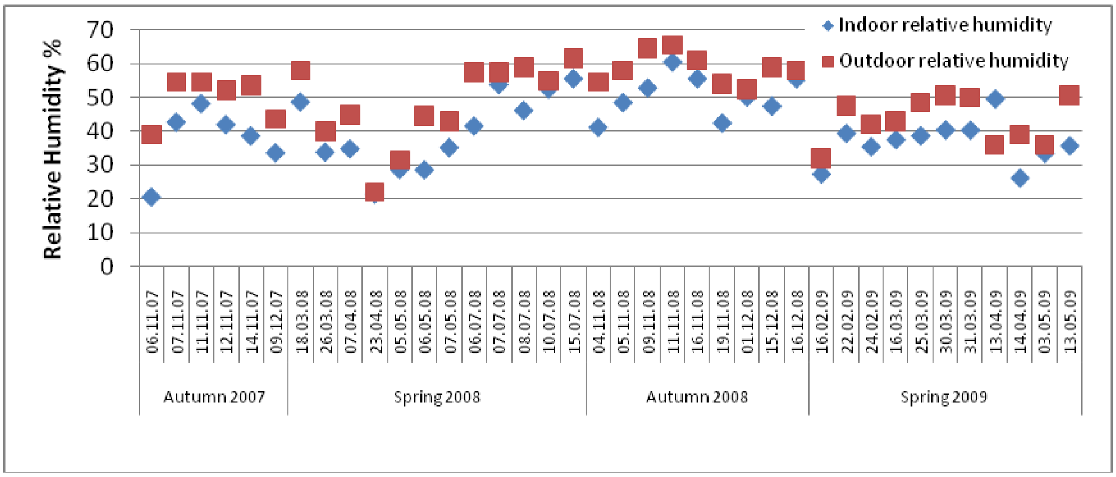

Figure 6: The mean indoor relative humidity (%) for the days of the study together with the corresponding outdoor relative humidity

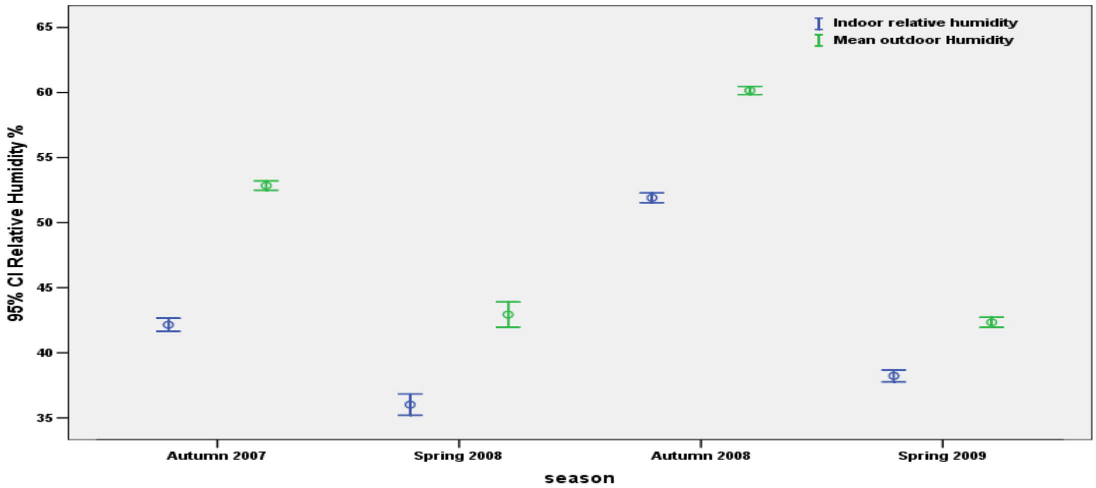

Figure 7: The mean indoor relative humidity and the mean outdoor relative humidity for the seasons included in the study

The mean indoor relative humidity and the corresponding mean outdoor relative humidity are shown in Figure 7 . The mean outdoor relative humidity was in general higher than the mean indoor relative humidity.

COMFORT VOTES

This section presents the results of the votes obtained in the four seasons' questionnaires on the various comfort parameters. It included thermal comfort parameters such as thermal sensation, thermal preference and thermal acceptance; it also included humidity comfort parameters such as humidity sensation, humidity preference and humidity acceptance. The last parameter discussed was the overall satisfaction with climatic conditions.

THERMAL SENSATION VOTES

The distributions of thermal sensation votes in the four seasons of the study are shown in Figure 8, Figure 9, Figure 10 and Figure 11. In the autumn seasons, the percentage of votes for the central category of the scale (-1, 0, 1) is 88% in autumn 2007 and 84% in autumn 2008. The case differed for the spring seasons. Spring 2008 was considered the hottest conditions of the whole study. The percentage of votes for the central category of the ASHRAE scale (-1, 0, 1) was 54%. In spring 2009, the percentage of votes for the central category of the ASHRAE scale (-1, 0, 1) was 78 %.

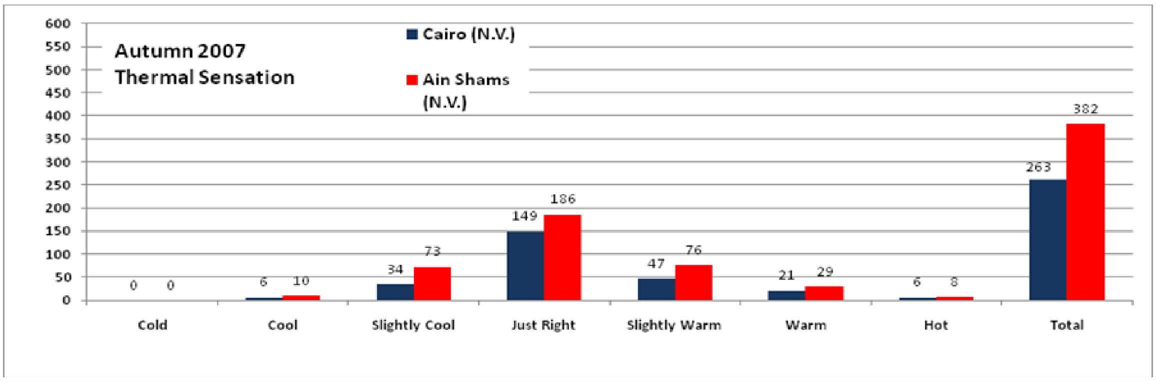

Figure 8: The distribution of thermal sensation votes in autumn 2007

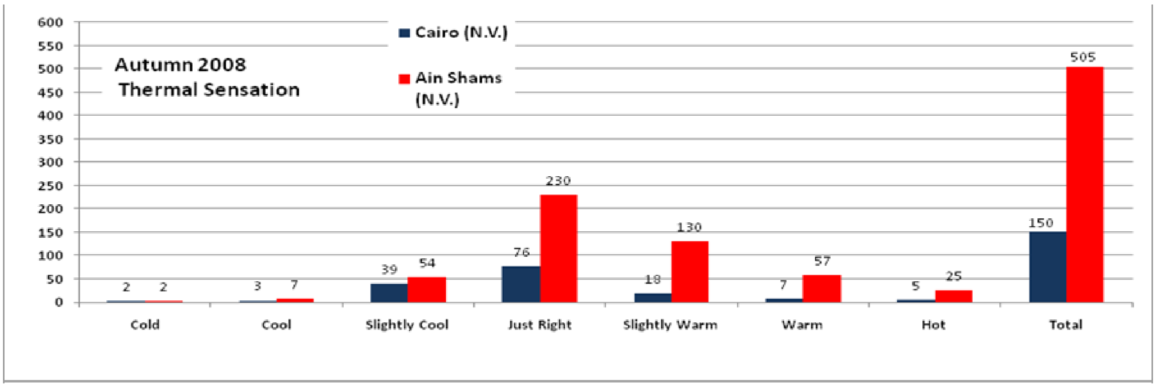

Figure 9: The distribution of thermal sensation votes in autumn 2008

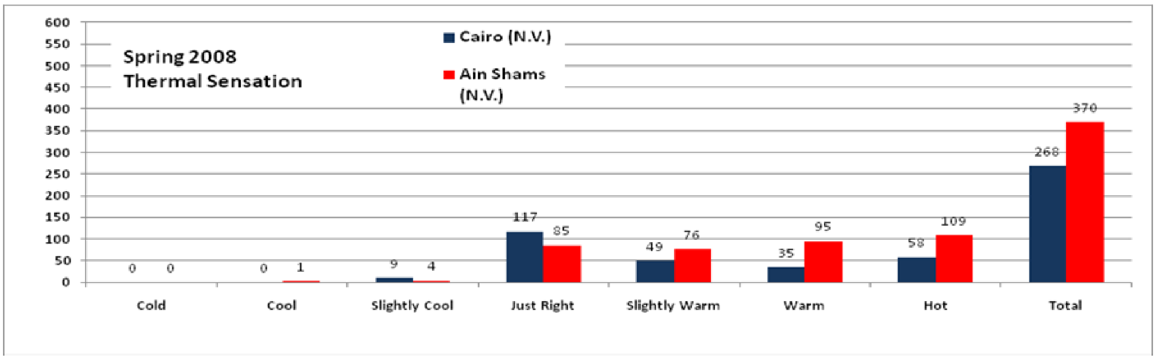

Figure 10: The distribution of thermal sensation votes in spring 2008

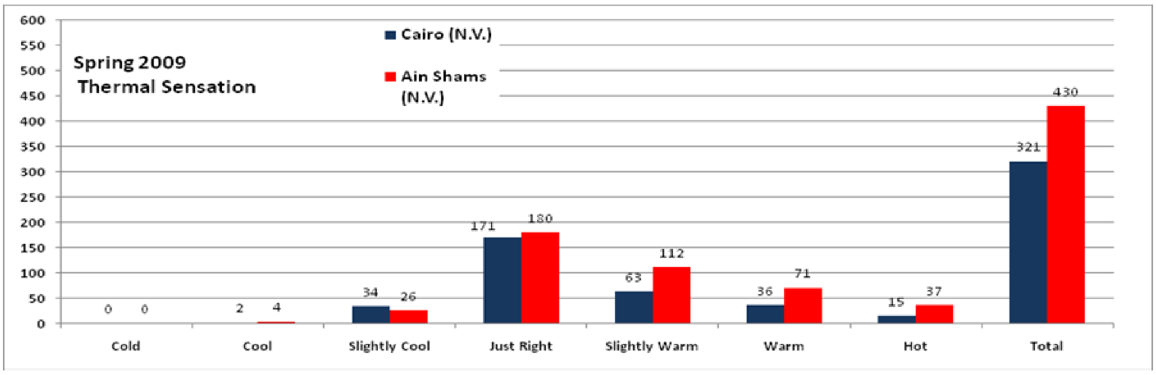

Figure 11: The distribution of thermal sensation votes in spring 2009

Figure 12 shows the mean of the thermal sensation vote for the four seasons of the study. The higher means were in the hottest season spring 2008.The study took place in a hot dry climate, so the votes corresponding to the cold category of the ASHRAE scale was almost not found. The votes were generally inclined towards the warm zone of the scale.

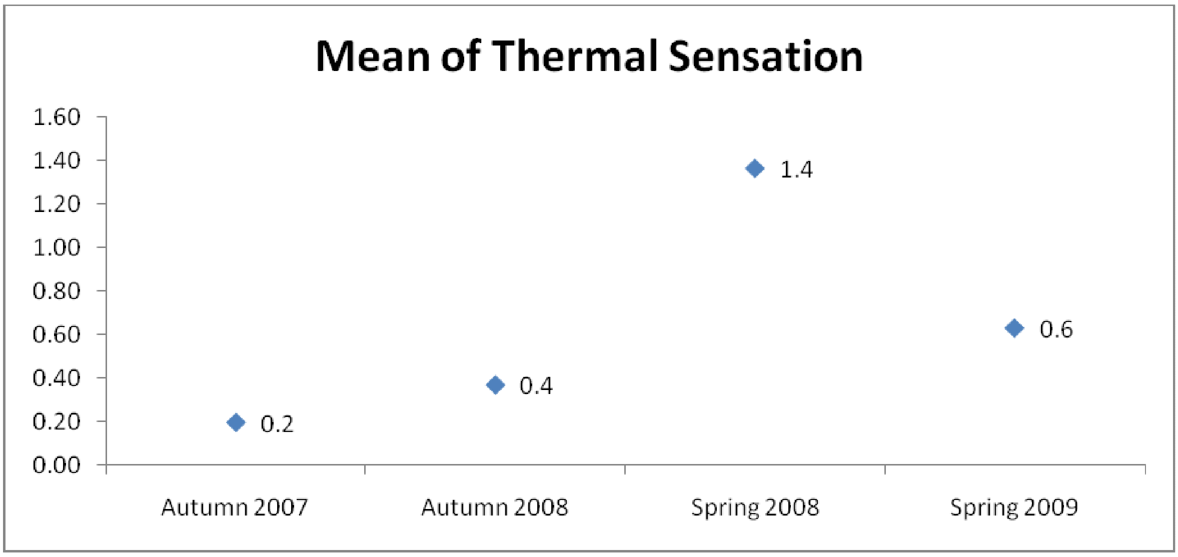

Figure 12: The mean thermal sensation for the four seasons of the study

RELATION BETWEEN THERMAL SENSATION AND THERMAL PREFERENCE

The distributions of thermal preference votes across thermal sensation votes are shown in Figure 13. In the "just right" category of the thermal sensation scale, 62.1 % of the votes preferred the thermal conditions to be the same, 28.7% preferred cooler conditions while only 9.1% preferred warmer conditions. The distribution of preference votes across thermal sensation votes followed the logical concept in the case where subjects feel "slightly cool or cool or cold" they preferred warmer conditions, and on the contrary when they felt "slightly warm or warm or hot" they preferred cooler conditions.

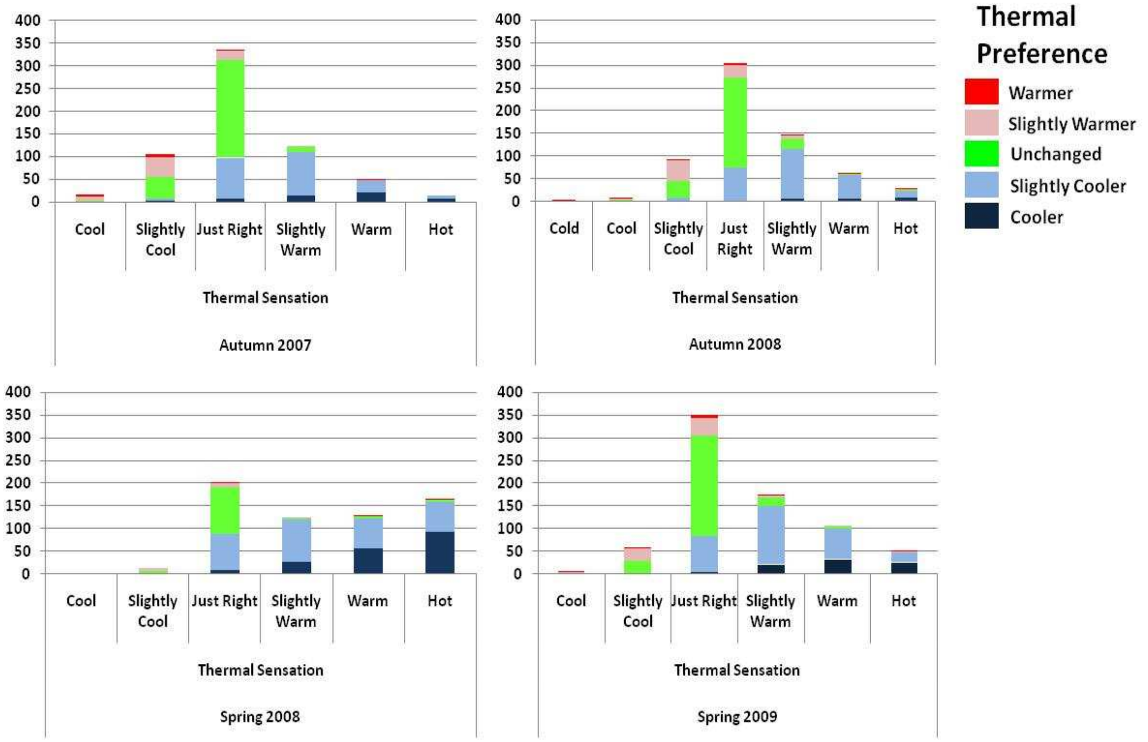

Figure 13: The distribution of thermal preference votes across the thermal sensation votes for naturally ventilated buildings

It seems that there were a percentage of subjects who misunderstood the meaning of the thermal preference question. This category was divided in two groups, the first group was those subjects who preferred cooler conditions while voting for an existing cold condition in the space (thermal sensation votes "slightly cool or cool or cold"). The second group consisted of those subjects who preferred a warmer condition on the preference scale, while voting for "slightly warm or warm or hot" on the thermal sensation scale. This could be investigated by adding the thermal preference to the thermal sensation vote for each subject; the logical outcome should present a "just right" condition. The addition of both scales will be named here as the adjusted preferred condition; this is shown in Figure 14. The "just right" category was represented by 52.8%, the central category "slightly cool, just right and slightly warm", which is considered the comfort zone in the existing ASHRAE standard -55 2004, was 91.7%. This indicates that the probability of misunderstanding the meaning of the two questions asking about the thermal sensation and thermal preference was lower than 10% and also indicated that people may prefer to feel slightly cool or slightly warm in some cases.

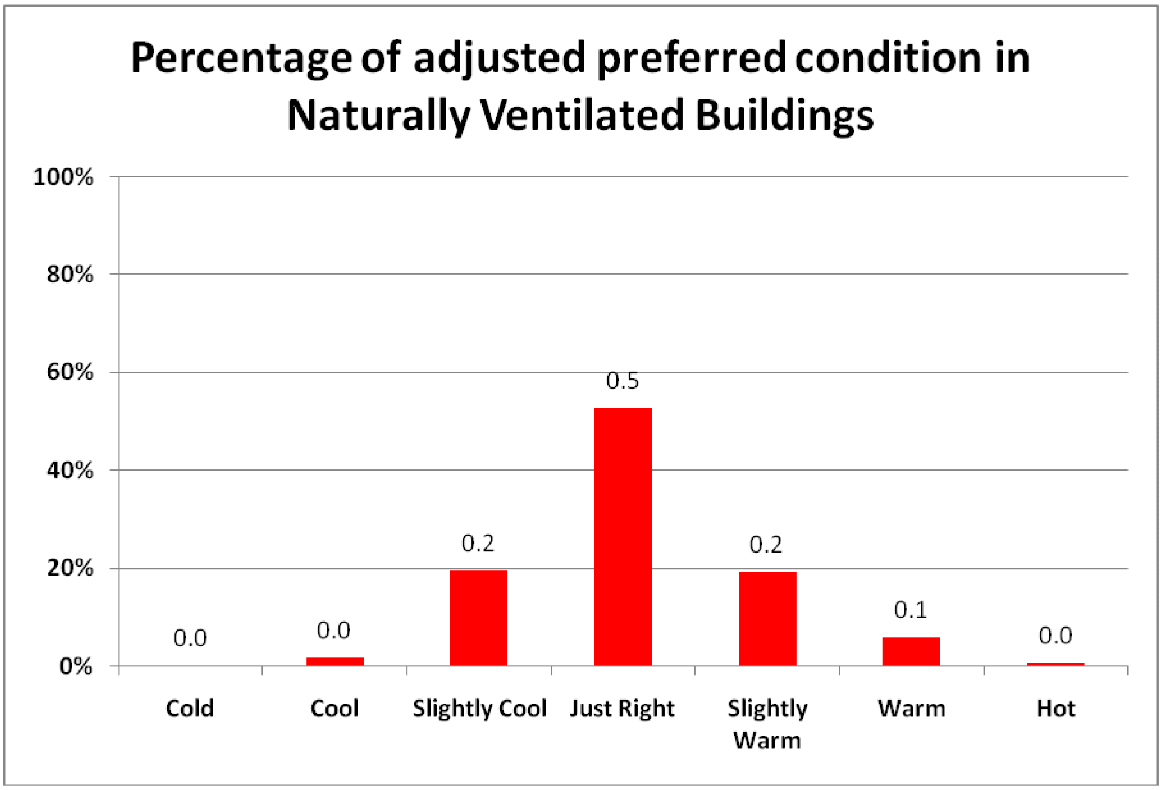

Figure 14: The percentage of adjusted preferred condition in naturally ventilated buildings

ACCEPTANCE VOTES

The percentage of accepted indoor thermal conditions is shown in **Error! Reference source not found.**. The percentage of acceptability was 75 % or more in most cases except for the hottest season of spring 2008 when it went down to 50%. **Error! Reference source not found.** shows the actual acceptance percentage for the indoor thermal conditions corresponding to the votes of the central category of the ASHRAE scale (-1, 0, 1). It was 85% or more in all the cases. This differed from the assumption of the Adaptive Comfort Standard that the percentage of acceptance for this category is 80%.

THE DISTRIBUTION OF THERMAL SENSATION VOTES FOR INDOOR AIR TEMPERATURES

The indoor air temperatures were grouped in intervals and the thermal sensation votes were distributed among these intervals. The indoor air temperature covered a range of 16 K starting from 21°C up to 36°C, as shown in

Figure 15. The percentage of the central thermal sensation category “just right” was over 50% for the range of indoor air temperatures from 21°C up to 26°C, the central category “slightly cool, just right, slightly warm” formed more than 80% of the votes up to the indoor temperature 26°C. This percentage began to decrease starting from the indoor air temperature 27°C.

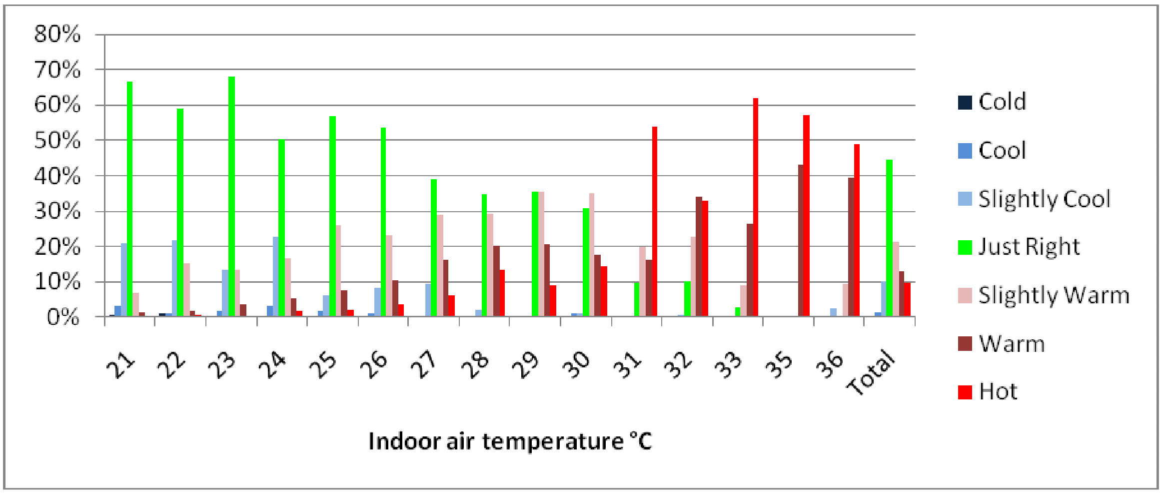

Figure 15: The percentage of thermal sensation votes subject to the indoor air temperatures

RELATION BETWEEN THERMAL SENSATION VOTES AND THE GENERAL SATISFACTION WITH INDOOR CLIMATIC CONDITIONS

The relation between the thermal sensation categories and the general satisfaction with the indoor climatic conditions is shown in Figure 16. People whose thermal sensation votes lay in the central category of “slightly cool, just right and slightly warm” were much more satisfied with the general indoor climatic conditions than people voting for the outer categories (Cold, cool, warm and hot) of the thermal sensation scale. The Pearson correlation between the two parameters was r = + 0.426, n=2689, $p < 0.001$ (2- tailed), a significant good correlation.

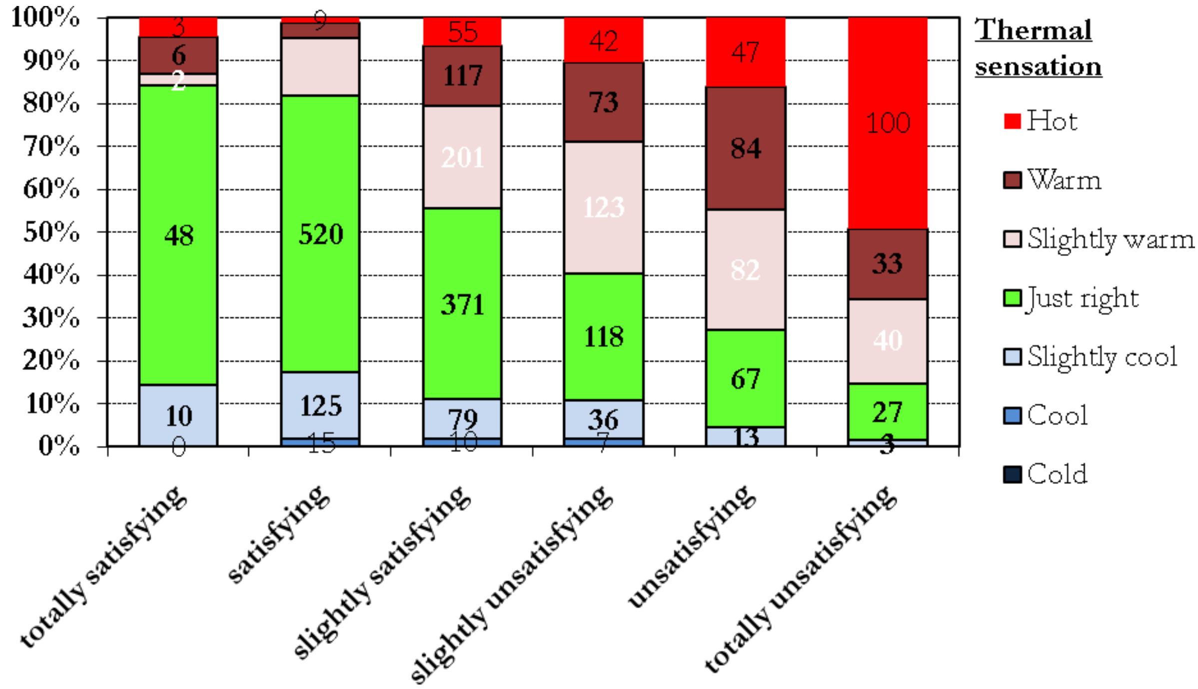

Figure 16: The relation between thermal sensation votes and the general satisfaction with the indoor

climatic conditions

CORRELATIONS BETWEEN THERMAL SENSATIONS AND INDOOR THERMAL ENVIRONMENT AND OUTDOOR THERMAL ENVIRONMENT

A set of correlations were analyzed to reveal the relation between thermal sensation and the measured indoor and outdoor environmental parameters within the study which resulted in the findings in Table 1.

Table 1: The Pearson correlation between thermal sensation and environmental parameters

Correlation	Thermal sensation : Indoor Air Temperature	Thermal sensation :Outdoor Air Temperature	Thermal sensation : Indoor Relative Humidity	Thermal sensation : Outdoor Relative Humidity
r	0.593	0.536	-0.165	-0.256
n	2689	2689	2689	2689
p	<0.01	<0.01	<0.01	<0.01
Type of correlation	Strong	Strong	Weak	Moderate

In general the correlation between thermal sensation and indoor air temperature was stronger than the correlation between thermal sensation and indoor relative humidity. The correlation between thermal sensation and the indoor parameters was stronger than the correlation between thermal sensation and outdoor parameters.

CORRELATION BETWEEN THERMAL SENSATION AND ADAPTIVE OPPORTUNITIES

One question in the questionnaire used in the study asked about various adaptive opportunities in the space. The correlations found between these opportunities and thermal sensation votes are shown in Table 2 ranged from the stronger correlations to weaker ones.

Table 2: The Pearson correlation between thermal sensation and adaptive opportunities

Correlation	Thermal sensation : opening and closing of ceiling fans	Thermal sensation :drinking cold things during the last hour	Thermal sensation : closing and opening doors	Thermal sensation :closing and opening windows	Thermal sensation :putting off and wearing extra cloths	Thermal sensation :eating something cold during the last hour	Thermal sensation :eating something hot during the last hour
r	0.283	0.261	0.181	0.128	0.126	-0.048	-0.046
n	2689	2689	2689	2689	2689	2689	2689
p	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05
Type of correlation	Moderate	Moderate	Weak	Weak	Weak	Weak	Weak

THE CALCULATION OF NEUTRAL TEMPERATURES

The neutral "comfort" temperature was calculated by using regression analysis. This method was used to predict the value of the dependent variable "thermal sensation vote" for a particular value of the independent variable "indoor air temperature". The method assumes a linear relationship between "thermal sensation votes" and "indoor air temperature". The regression of the thermal sensation vote on the indoor air temperature for the whole study and for different seasons is shown in Table 3.

Table 3: Regression coefficients for thermal sensation vote on indoor air temperature for the whole study, different seasons and adaptive comfort, together with the calculated neutral temperature

Time of year	Regression Coefficient	Constant	Neutral temperature	r^2
For the whole study	0.192	-4.388	22.85°C	0.351
autumn 2007	0.17	-4.167	24.51°C.	0.187
spring 2008	0.237	-5.674	23.94°C	0.406
autumn 2008	0.204	-4.733	23.20°C	0.161
spring 2009	0.173	-3.63	20.98°C	0.363
Adaptive Model of ASHRAE Standard 55-2004	0.27	-6.65	24.6°C	0.46

The temperature that the subjects found comfortable could be deduced by replacing "thermal sensation vote" in the above equations with the value 0 which corresponds to a vote of "just right" and calculating the "comfort temperature". Comparing to the ASHRAE standard 55-2004, the neutral temperature was lower in the spring 2009 season because the range of indoor air temperatures experienced by the subjects in that season was lower than the other seasons. The neutral temperature of the other seasons was nearer to that calculated from the ASHRAE standard 55-2004. The method of linear regression which was used here to calculate the comfort temperatures was the same as in ASHRAE standard 55-2004.

THE ANALYSIS OF THE ADAPTIVE COMFORT MODEL

The outcome of the study was compared to the Adaptive Comfort Model. The blue line in Figure 17 shows the regression of the indoor air temperature on the mean outdoor air temperature. These data resulted from the votes of thermal sensation "slightly cool, just right and slightly warm", that represent the comfort range in naturally ventilated buildings.

$T_{in} = 10.591 + 0.665\ T_{out}$, ($r^2 = 0.69$)

Where T_{in} is the Indoor air temperature and T_{out} is the mean monthly outdoor air temperature.

The red line represents the equation of the adaptive comfort model implemented in ASHRAE 55-2004, the equation was:

$T_{in} = 17.8 + 0.31\ T_{out}$

Where T_{in} is the Indoor air temperature and T_{out} is the mean monthly outdoor air temperature

It is obvious from the outcome that subjects in the study could bear higher indoor temperatures compared to the temperatures set in the standard, this could be explained after analyzing the adaptive comfort standard itself.

The Adaptive Comfort Model is mainly an outcome of analyzing a global database of 21000 measurements accompanied with their subjective votes, where office buildings were the most common type of buildings surveyed. According to the method of heating and cooling used, the buildings were classified into three main prototypes: air conditioned, naturally ventilated and mixed mode. The focus here is on naturally ventilated buildings which are the base of the Adaptive Comfort Model, implemented in ASHRAE Standard 55 – 2004.

The standard is a relation between mean outdoor air temperature and the corresponding acceptable indoor air temperatures. The data concerning the naturally ventilated buildings in the global database were extracted separately, forming a subgroup depending only on naturally ventilated buildings. The statistical analysis underlying the model considered each building as the unit of analysis, and a weighted analysis followed, where the number of votes in each building represented the weight.

Only statistically significant at ($p < 0.05$) buildings (data points) were considered, forming the data on which the Adaptive Comfort Model was based upon. This criterion of selection forming the model resulted in 36 significant building out of 44 naturally ventilated buildings, with almost 8900 subjective votes. The buildings selected covered seven climatic zones, which are shown in
Table 4 with the number of buildings in each zone.

Based on the data analysis shown above a variable standard depending on different climatic zones is suggested here. To better explain this idea it is necessary to point out the limits of the ASHRAE Standard -55 -2004. The limits of the Adaptive Comfort Model are the boundaries shown in the graph implemented in the ASHRAE Standard-55, which is the range of mean outdoor temperature between 10 °C and 33 °C. The limits depend on the mean outdoor

temperatures originally coming with the buildings which were selected for deriving the adaptive model. The mean outdoor temperature limits may not be extrapolated to temperatures outside that range.

The slopes of different climatic zones for different buildings incorporated into the standard are shown in Figure 18. Each slope has its limits given by the respective range of mean outdoor temperatures. The ANOVA test of different buildings' neutralities across different climatic zones resulted in a significant difference between thermal neutralities depending on different climatic zones (ANOVA across different climates $\alpha = 0.05$, $F(1, 35) = 11.560$ and $p < 0.001$).

If the limits of the adaptive model are the range of mean outdoor temperatures actually measured a variable Adaptive Comfort Model should be introduced with a classification of the outdoor temperature and other climatic parameters depending on different climatic zones. In addition, different adaptive reactions and different methods of control which are related to different climates can be taken into account by this variable model as well.

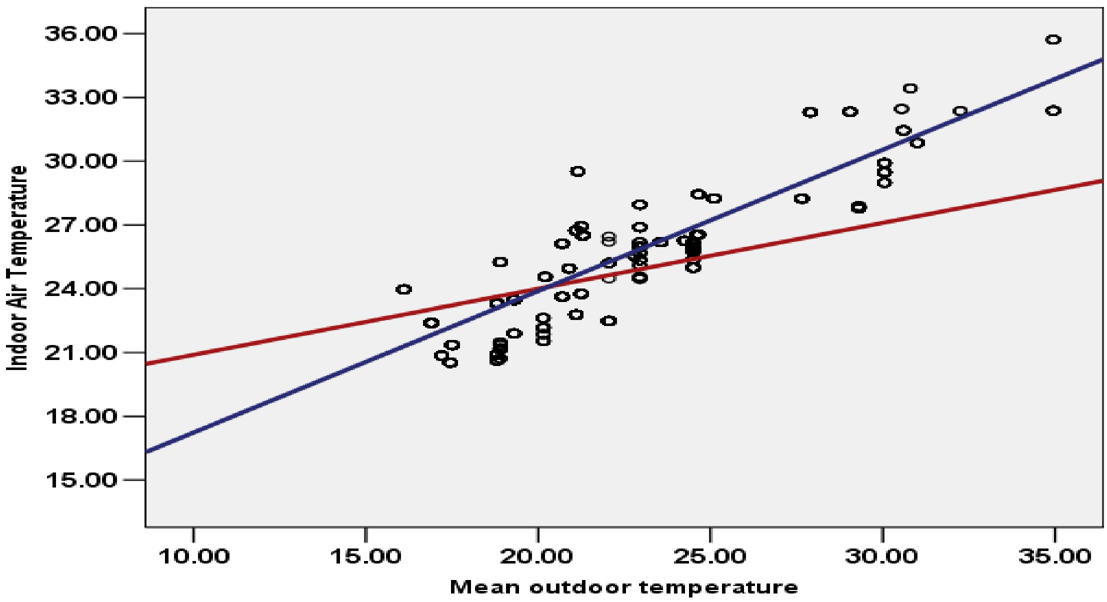

Figure 17: The blue line represent the outcome of the study, it is the regression of the indoor air temperature on the mean outdoor air temperature for the thermal sensation votes "slightly cool, just right and slightly warm" of the naturally ventilated buildings

Table 4: Climatic zones covered by the Adaptive Comfort Standard, and the number of buildings in each zone

Climate	Number of Buildings
Desert	2

Semi Desert	**6**
West coast marine	**8**
Mediterranean	**10**
Humid subtropical	**5**
Tropical savannah	**4**
Wet equatorial	**1**
Total	**36**

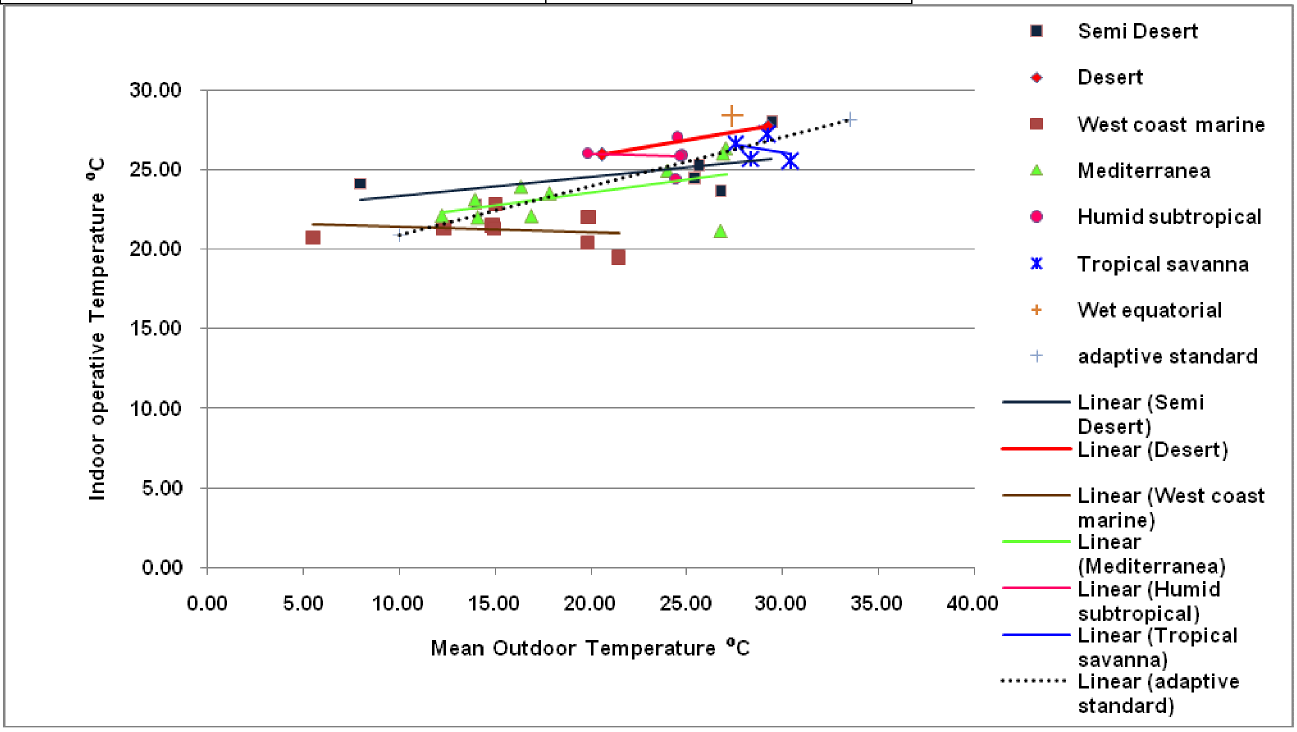

Figure 18: The detailed slopes of different climatic zones for different buildings incorporated into the Adaptive Comfort Standard of ASHRAE standard 55-2004

CONCLUSION

The study screened two educational buildings in the Greater Cairo Region, The study focused on the academic calendar and the months included in the study were February, March, April, May, July, November and December. Both students and employees shared in the study. Spaces included drawing halls, lecture spaces and employees' rooms.

The fact that the buildings' mean indoor air temperature was always higher than the mean outdoor air temperature shows that there was a great potential for using passive cooling techniques to lower the internal air temperatures.

The hottest season examined was spring 2008, and the coldest season was spring 2009, the mean indoor air temperatures examined were on average 25 °C except in spring 2008. The indoor relative humidity percentages were within the acceptable limits for office work in autumn seasons; in spring seasons it went below this range.

The study showed that the percentage of acceptance for the central categories (-1, 0, 1) on the ASHRAE scale represent more than 80%, which differ from the norms taken from the PMV-PPD model. This indicates that more field surveys should be studied with regard to acceptance ranges by incorporating a straightforward question about the acceptance of the indoor thermal conditions in the questionnaire templates.

The mean temperature for different thermal sensation categories varied from the autumn to spring seasons showing the capability of energy saving in moderate thermal conditions, which encourage the usage of naturally ventilated buildings and incorporating mixed mode strategies in hot arid climates, as far as they can meet expectations of thermal comfort.

The calculation of neutral temperatures showed the acclimatization of people to the prescriptive climatic conditions, and that the neutral temperature is related to the mean climatic conditions experienced by the population.

Only two buildings in the ASHRAE Standard 55-2004 represented the desert climate, while most of the buildings represented moderate climates. This explains why the comfort temperatures resulting from this study are higher than those implemented in the Standard. People in desert climates can bear higher temperatures than those in moderate climates.

The outcome of this study showed the capability of the studied population to adapt to hotter conditions than that set by the Adaptive Comfort Model implemented in the ASHRAE Standard 55-2004. At the same time the data analysis suggests to introduce a variable adaptive comfort model representing different climatic zones, particularly hot and arid zones.

APPENDIX

التاريخ _________	**رقم الغرفة** ______	**الوقت** _____:_______

إستخدامك اليوم كان لوسيلة مواصلات:	☐ عامة غير مكيفة	☐ عامة مكيفة
	☐ خاصة غير مكيفة	☐ خاصة مكيفة
	اخرى ______________________________	

كيف وجدت درجة الحرارة الخارجية اليوم؟

☐ أدفئ كثيرا مما كنت تتوقعها	☐ أدفئ مما كنت تتوقعها	☐ كما كنت تتوقعها	☐ أبرد مما كنت تتوقعها	☐ أبرد كثيرا مما كنت تتوقعها

عند دخولك هذا المكان اليوم، وجدت درجة الحرارة داخل المكان :

☐ أدفئ كثيرا مما كنت تتوقعها	☐ أدفئ مما كنت تتوقعها	☐ كما كنت تتوقعها	☐ أبرد مما كنت تتوقعها	☐ أبرد كثيرا مما كنت تتوقعها

كيف تجد درجة حرارة المكان الان؟

☐ حار جدا	☐ حار	☐ حار بعض الشئ	☐ معتدلة	☐ بارد بعض الشئ	☐ بارد	☐ بارد جدا

تفضل ان تكون درجة الحرارة داخل المكان:

☐	☐	☐	☐	☐
ادفئ	ادفئ بعض الشئ	كما هي	ابرد بعض الشئ	ابرد

درجة الحرارة داخل المكان الان تعد:

☐ مقبولة	☐ غير مقبولة

كيف تجد الرطوبة داخل المكان الان:

☐	☐	☐	☐	☐
رطب	بعض الشئ رطب	معتدل	بعض الشئ جاف	جاف

تفضل ان تكون الرطوبة داخل المكان:

☐	☐	☐	☐	☐
اكثر رطوبة	اكثر بعض الشئ	كما هي	اقل بعض الشئ	اقل رطوبة

بوجه عام، الرطوبة داخل المكان الان تعد:

☐ مقبولة	☐ غير مقبولة

بوجه عام، الهواء داخل الفراغ الان يعد

☐ خانق	☐ صافي
☐ رطب حار, مُغم	☐ جاف لطيف
☐ ترابي مغبر	☐ نَقِيّ
☐ رائحته كريهة	اخرى ________________

هل قمت بعمل اى من الاشياء التالية لتغيير المناخ الداخلي ؟

☐ غلق شباك	☐ فتح شباك
☐ غلق باب	☐ فتح باب
☐ غلق ستائر داخلية	☐ فتح ستائر داخلية

غلق مراوح سقف	☐	فتح مراوح سقف	☐
تغير درجة التكيف	☐	سؤال شخص اخر للقيام باى من الافعال السابقة	☐
خلع بعض الملابس	☐	لبس ملابس اضافية	☐
اخرى ________			

بوجه عام،تشعر ان الامكانيات المتاحة لك لتتحكم في المناخ الداخلي تعد

مرضية ☐	غيرمرضية ☐

انت ترتدى الان

غطاء راس نوعه		كاب ☐	طرحه ☐
اخرى			
ملابس الجزءالعلوي	تى شيرت بكم قصير	خفيف ☐	ثقيل ☐
	تى شيرت بكم طويل	خفيف ☐	ثقيل ☐
	بلوزة بكم قصير	خفيف ☐	ثقيل ☐
	بلوزة بكم طويل	خفيف ☐	ثقيل ☐
	قميص بكم قصير	خفيف ☐	ثقيل ☐
	قميص بكم طويل	خفيف ☐	ثقيل ☐
	بودي	بكم قصير ☐	بكم طويل ☐
	عباءة	خفيف ☐	ثقيل ☐
	بلوفر	خفيف ☐	ثقيل ☐
	جاكت	خفيف ☐	ثقيل ☐
	جاكت بدله	خفيف ☐	ثقيل ☐
ملابس الجزءالسفلي	جونله قصيره	خفيف ☐	ثقيل ☐
	جونله طويله	خفيف ☐	ثقيل ☐
	فستان طويل بكم طويل	خفيف ☐	ثقيل ☐
	فستان طويل بكم قصير	خفيف ☐	ثقيل ☐
	فستان قصير- بكم طويل	خفيف ☐	ثقيل ☐
	فستان قصير- بكم قصير	خفيف ☐	ثقيل ☐
	بنطلون جينز	☐	
	بنطلون قصير	خفيف ☐	ثقيل ☐
	بنطلون طويل	خفيف ☐	ثقيل ☐
اخرى ________			
شراب	شراب عادي قصير	خفيف ☐	ثقيل ☐
	شراب حتى الركبه	خفيف ☐	ثقيل ☐
	شراب طويل فوق الركبه	خفيف ☐	ثقيل ☐
حذاء	صندل	مفتوح ☐	مغلق ☐

حذاء	☐ نعل رفيع	☐ نعل سميك
	☐ حذاء رياضي	☐ شبشب

في خلال الساعة الاخيرة، هل قمت بعمل شئ مما يلي

☐ شرب مشروب ساخن
☐ شرب مشروب بارد
☐ اكل شئ ساخن
☐ اكل شئ بارد

خلال الساعة الماضية، ماذا كنت تفعل؟

	جالس مستكين	جالس (اعمل، اذاكر)	واقف	امشي داخل المبنى	امشي خارج المبنى	اخرى
آخر 30 دقيقة	☐	☐	☐	☐	☐	☐
من 30 حتى 60 دقيقة	☐	☐	☐	☐	☐	☐

بوجه عام، ما مدى رضائك عن الاحوال المناخية داخل المكان ، (درجة الحرارة، الرطوبة، سرعة الهواء.......)؟

☐ مرضية تماما	☐ مرضية	☐ غيرمرضية	☐ غيرمرضية تماما

الجنس:	☐ ذكر	☐انثى

العمر	☐	☐	☐	☐

اكثر من 46 عام	من 36 حتى 45 عام	من 25 حتى 35 عام	اقل من 25 عام	

REFERENCES

Brager, G., & de Dear, R. (1998). Thermal adaptation in the built environment: A literature review. Energy and Buildings , 27 (1), 83-96.

CIBSE. (1997). *Natural Ventilation in Non-domestic Buildings.* London: Chartered Institute of Building Services Engineers.

Farghal, A., & Wagner, A. (2008). Studying the adaptive comfort approach within a hot dry climate: A case study in educational buildings in the Egyptian climate. *Air Conditioning and the Low Carbon Cooling Challenge.* Cumberland Lodge, Windsor, UK: London: Network for Comfort and Energy Use in Buildings.

Olesen, B., & Brager, G. (2004). *A Better Way to Predict Comfort: The New ASHRAE Standard 55-2004.* Retrieved from UC Berkeley: Center for the Built Environment.: http://www.escholarship.org/uc/item/2m34683k