Thermal Adaptive Behavior of Occupants in Air-conditioned Office Buildings in Thailand

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Abstract. Thermal adaptive behaviors are the actions people take to adjust to the indoor environment. This study aims to clarify occupants’ perception of thermal environments and how they adapt themselves into those environments of air-conditioned offices in the tropical region. Six offices in Bangkok, Thailand, were investigated during April to September 2018. Indoor environment quality measuring devices were installed inside the offices to evaluate factors such as indoor temperature, humidity, and air velocity. Questionnaires following the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 55 standard were distributed to occupants during working hours. Thermal comfort votes were analyzed together with behavioral adaptation votes. When we plotted thermal environment values on a psychrometric chart, they were inside 1.0 clo rather than 0.5 clo. Out of 2,028 samples, 50.2% of occupants voted neutral. However, they felt colder than neutral rather than feeling warmer than neutral (36%:14%). Occupants who felt comfortable were 45% of total occupants, and 59.7% of them preferred “no change”. Considering adaptive behavior, the highest activity was changing of clothes (50%). Those who wore more clothing (68.9%) voted for feeling slightly cool to cold. Of those, 34% changed clothing during the day. The median of clothing increased from 0.56 clo to 0.61 clo to reduce the feeling-cold sensation and increase thermal neutrality. Other adaptive behaviors were drinking hot or cold water (31.3%), doing nothing (26.2%), moving around (24.5%), wearing a scarf (14.7%), using a pedestal fan (11.8%), taking a rest (8.6%), washing hands or face (8%), and opening or closing window blinds (7.7%). These adaptive behaviors were strongly relevant to thermal sensation votes and maintaining thermal comfort. These adaptive actions were adopted by both the feeling-hot persons and the feeling-cold persons. This study would be applicable to offices in Thailand in terms of both thermal satisfaction and human behavior.

1. Introduction
Thermal comfort plays an important role in office buildings where people normally stay over 8 h a day. It has been defined by subjective assessment enhancing satisfaction and productivity [1]. In the tropical region, the indoor thermal environment in office buildings is mostly controlled in the cooling state to maintain thermal comfort, while outside the building it is usually hot and humid throughout the year [2]. Due to the energy required to maintain reduction of heat and humidity inside the office, air conditioning systems and ventilation systems consume 30%–60% of the total energy used [3–5]. It is critical to be
concerned about saving energy and extend building life cycle while also improving the occupant satisfaction.

The commercial buildings in the hot-humid climate are often installed with air conditioning and mechanical ventilation systems to sustain and improve indoor thermal comfort. Most of the time, these systems consume the most energy among all building services, which comprises 30–60% of the total energy consumption and has been identified in various studies to have the largest potential for energy savings. Recently, not only has the concept of the green building been encouraged for the new building construction, but also the concept of wellbeing is being taken into consideration to promote quality of living [6]. Sick building syndrome caused by poor indoor air quality could be solved by both passive and active design. It has been mentioned that an indoor thermal environment that is too cold or too high in humidity could affect people in terms of physical health and mental health [7]. The characteristics of the tropical region result in high annual average outdoor temperatures ranging between 20°C and 34°C. The high humidity ranged between 77%–88% during summer [8]. Comparing with those values in Tokyo, Japan, the average air temperature could reach 29°C, and it is possible for the humidity to reach 78% in the similar season [9]. According to a well-known standard, ASHRAE 55 [10], the conventional HVAC design must be in the range of 40% to 60% in relative humidity and between 25°C to 27°C in air temperature. The difference between those values is provided by the HVAC system for humidifying and cooling–conditions.

Due to the adaptive thermal comfort theory, people tend to adapt themselves to the surroundings, overcoming thermal discomfort by several adaptive behaviors when heat exchange computation is not possible to be used in all climatic zones [11]. Thermal adaptive behavior depends on the personal lifestyles of the occupants and how well the occupants fit into the thermal environment in the actual situation. Initially, a study was conducted in free-running mode buildings and then expanded to cooling-mode buildings [12]. Damiati et al. [13] studied thermal environments in some countries in Southeast Asia, comparing that environment with that in Japanese offices during summer. The results reveal some adaptive behaviors, such as changing clothes and opening a handheld fan, that occur more frequently than those in Japan. It seems that occupants in the tropical region tolerated cooling conditions better than those in Japanese offices where a higher number of occupants voted in a questionnaire as being warmer than neutral.

Based on the above background, this study aims to clarify occupants’ perception of thermal variables and how they adapt themselves in air-conditioned offices in Thailand. To reduce excessive adaptive behavior to be less frequent and more effective, it would be better to investigate the actual thermal environment inside the office. It could apply to temperature setpoint policy in the office by being more concerned about the occupants’ behaviors in supporting a better living.

2. Methodology
The study was conducted by measuring the thermal environment and by using a questionnaire. There were six office buildings in the Bangkok metropolitan region, Thailand, investigated from April to September 2018. Table 1 indicates information gathered for case studies which were large-scale and open-plan offices equipped with air-conditioning systems. The offices were occupied by both private companies and the government sector and were constructed from 1988 to 2017. There were three types of air conditioning systems, which were individual control, water cooled package, and central water chiller. As shown in Table 2, the offices were monitored to collect the indoor environmental metrics, i.e. temperature, relative humidity, air movement velocity, carbon concentration, and illuminance. Indoor environment quality (IEQ) measuring devices were installed at approximately 1.0-m intervals attached to partitions close to the occupants both sitting in the perimeter zone and sitting in the interior zone covering all working space. To measure air temperature and relative humidity, the study used TR-74Uvi sensors measuring at intervals of every 10-minutes. RTR-52A 7” Globes were set at 10-minute intervals to measure mean radiant temperature (MRT). Air velocity was measured by anemometer every 60 seconds in each location. The anemometer was installed with a tripod and was moved from location to location. The questionnaire addressed the following details: (i) personal information, which was about
gender, age, health condition; (ii) current clothing insulation, which was separated into 3 parts, including upper part, lower part, and shoes; (iii) thermal sensation vote (TSV); (iv) thermal comfort vote (TCV); and thermal preference vote (TPV). These votes were derived from the ASHRAE standard [10] and ISO 9920 [14] translated into the Thai language. Each type of vote was used in different scales as shown in Table 3. An additional question was asked about possible adaptive behavior related to the previous studies [13, 15–17], asking occupants how they would behave when feeling hot or cold to fit in the thermal environment. The total number of subjects was 660 persons, consisting of 424 males and 236 females. Occupants answered the questionnaire twice a day in the morning and the afternoon (at 11.00 and 15.00) which were completely counted as 2,028 votes in total. Mean radiant temperature was estimated by following ISO 7726 [18] using a standard globe of 0.15 m, MRT = [(GT+273)\(^4\)+2.5\(\times\)10\(^8\)\(\times\)V\(_s\)\(^0.6\)\((GT-T_s)\)\(^{1/4}\) - 273], where GT, V\(_s\), and T\(_s\) represent globe temperature, wind velocity, and air temperature, respectively. The operative temperature was calculated by the equation; t\(_o\) = t\(_a\) + (1-A)(t\(_o\)-t\(_s\)), where t\(_o\) is the operative temperature, t\(_a\) is air temperature, A is the coefficient value of the air velocity (A=0.5 when air velocity is ≤ 0.2 m/s) [19].

### Table 1. Information gathered for case studies

| Office | A | B | C | D | E | F |
|--------|---|---|---|---|---|---|
| **Date of investigation in 2018** | 24th-30th, 2nd-8th, 12th-15th, 19th-22nd, 17th-19th, 24th-26th | April, May, June, June, September, September |
| **Building Information** | | | | | | |
| Building type | Private office | Rental office | Rental office | State enterprise policy office | Head office | Private office and rental office |
| Opening year | 1988 | 2008 | 1988 | 2010 | 2014 | 2017 |
| Location in Thailand | Bangkok | Bangkok | Bangkok | Nonthaburi | Bangkok | Bangkok |
| Number of above-ground floors | 7 | 40 | 19 | 25 | 22 | 25 |
| Floor of measurement | 4th | 14th | 14th | 7th | 17th | 11th |
| Gross area (m\(^2\)) | 11,685 | 89,029 | 41,000 | 41,500 | 22,476 | 56,000 |
| Office area (m\(^2\)) | 1,416 | 3,250 | 1,212 | 1,828 | 778 | 1,400 |
| Floor to floor (m) | 3.2 | 3.8 | 3.2 | 3.7 | 4.0 | 4.2 |
| Floor to ceiling (m) | 2.7 | 2.9 | 2.7 | 2.6 | 2.9 | 3.2 |
| HVAC System | Individual | Water cooled package | Water cooled package | Central water chiller | Central water chiller | Central water chiller |
| Cooling set point (°C) | 23-24 | 21-22 | 20.8-26 | 24 | 24-25 | 23 |
| A/C operation time | 7.30-17.00 | 5.00-18.00 | 7.00-12.00 | 7.00-17.00 | 7.00-18.00 | 8.00-18.00 |
| **Occupants** | | | | | | |
| Number of males | 23 | 24 | 18 | 36 | 39 | 41 |
| Number of females | 14 | 35 | 30 | 49 | 46 | 76 |
| Total | 37 | 59 | 48 | 85 | 85 | 117 |
| Office working hours | 8.00-17.00 | 8.00-16.00 | 9.00-18.00 | 7.30-15.30 | 8.00-17.00 | 8.30-17.30 |

### Table 2. IEQ measuring devices and methods.

| IEQ parameters | Measuring devices | Record interval |
|----------------|-------------------|-----------------|
| Air temperature/ Humidity/ Illuminance | TR-74Uvi | 10 min |
| Mean radiant temperature | RTR-52A 7" Globe | 10 min |
| CO2 concentration | TR-76Uii | 10 min |
| Air Speed | Anemometer | 60 sec |
Table 3. Questionnaire scales

| Scale | Thermal sensation vote (TSV) | Thermal comfort vote (TCV) | Thermal preference vote (TPV) |
|-------|------------------------------|----------------------------|------------------------------|
| -4    | Very cold                    |                            |                              |
| -3    | Cold                         | Uncomfortable              | Colder                       |
| -2    | Slightly cold                | Slightly uncomfortable     | Slightly colder              |
| -1    | Cool                         | Neutral                    | No change                    |
| 0     | Neutral                      | Neutral                    | No change                    |
| 1     | Warm                         | Slightly comfortable       | Slightly warmer              |
| 2     | Slightly hot                 | Comfortable                | Warmer                       |
| 3     | Hot                          |                            |                              |
| 4     | Very Hot                     |                            |                              |

3. Results and discussion

3.1. Thermal environment variables

Showing the results from the IEQ measuring devices, Table 4 describes the median values of the thermal environment of each building. The median room temperature ranged from 22.8°C–24.2°C, while the median of operative temperature ranged from 22.5°C–24.3°C which was a difference of 1.8°C. Both types of temperatures were significant to each other. Globe temperature is in the majority in the range of 23.0°C–24.4°C. Values of mean radiant temperature were typically slightly lower than those of air temperature, with differences of 0.1–0.4°C. All types of temperature were nearly correlated to each other. Relative humidity was rated from 48% to 67% which was well controlled by the humidification control system. Absolute humidity value was between 0.008 and 0.016 (g/g). The reason for the high humidity was that there was rain in some days during the investigation (office A, B, and E), which was an uncontrollable factor from the outdoor environment. In addition, in office A, the of air velocity ranged from 0.06–0.14 m/s which was a usual situation in Thai offices. The study used the outdoor air temperature from Time and Date AS 1995–2019 [8]. Both quantities were mostly stable during the investigation (average outdoor temperatures = 31°C–34°C, outdoor humidity = 51%–64%).

Table 4. Thermal environment results

| Office | Room temperature | Operative temperature | Globe temperature | Mean radiant temperature | Relative humidity (%) | Absolute humidity (g/g) | Air velocity (m/s) |
|--------|------------------|-----------------------|-------------------|-------------------------|-----------------------|-------------------------|---------------------|
| A      | 24.2             | 24.3                  | 24.4              | 24.3                    | 61                    | 0.016                   | 0.14                |
| B      | 23.3             | 23.3                  | 23.3              | 23.2                    | 64                    | 0.016                   | 0.09                |
| C      | 22.5             | 22.5                  | 22.4              | 22.4                    | 53                    | 0.009                   | 0.09                |
| D      | 23.4             | 23.5                  | 23.3              | 23.3                    | 58                    | 0.011                   | 0.07                |
| E      | 24.1             | 23.8                  | 23.8              | 23.7                    | 67                    | 0.012                   | 0.08                |
| F      | 22.8             | 22.8                  | 23.0              | 22.9                    | 48                    | 0.008                   | 0.06                |

Operative temperature and absolute humidity of all offices were drawn on a psychrometric chart shown in Figure 1. The thermal environments of each building had some similar trends. Most thermal environments from office B, C, D, and F fell into the 1.0 clo comfort zone. When the operative temperature went higher, the humidity also increased, falling out of the 0.5 clo comfort zone. This evidence was probably caused by the humidification control and the temperature setpoint. Sorting from warm to cold thermal environments by using median values, they are office C, F, B, D, E, and A, respectively. In sum, these results emphasize that the thermal environment in office buildings in the tropics were being cooled more than the recommendation of the ASHRAE standard [10].
### 3.2. Occupants’ votes

The thermal sensation votes (TSV) in Figure 2 are divided into 3 groups: 1. neutral (0), 2. colder than neutral (-4 to -1), and 3. warmer than neutral (1 to 4). The TSV values were 52%, 37%, and 11%, respectively. The occupants of all offices voted neutral at the highest rate. However, feeling colder than neutral votes were higher over 3 times of the feeling warmer than votes. The thermal sensation vote is correlated to a psychometric chart that the lower the operative temperature in office was, the higher the numbers of the feeling cold votes than neutral votes were. This was especially true for the thermal environments in office C, F, and B where the median values of operative temperature went lower, between 22.5 °C to 23.3 °C. The thermal comfort vote (TCV) in Figure 3 indicates that, regardless of comfort neutrality (35.2%), the comfortable group votes were approximately two times higher than the uncomfortable votes (43.5%/21.4%). It could imply that even if the thermal environment was in a cold condition, the occupants felt comfortable rather than felt uncomfortable. Occupants could tolerate a cold environment more than a hot environment. In contrast, uncomfortable votes tended to increase when the thermal environment was warmer. Office A, which declared the highest temperature, had the highest number of uncomfortable votes at 28%. Neutral votes and comfortable votes were also highest in office E which was the warmest thermal environment. Setting a warmer indoor condition encourages occupants to do less adjustment rather than those in a cooler indoor environment. Considering the thermal preference vote (TPV) shown in figure 4, nearly all of the occupants sampled did not want to change temperature (61%). The number that preferred warmer temperature was twice as high as those who preferred cooler temperature (26%/13%). Even though occupants answered neutral in the TSV and TCV votes, they voted preferring a warmer condition. The number of occupants preferring a warmer condition was likely to decrease when the temperature went higher. It is obvious that the votes of office A and office E (warm condition offices) declined in preferring slightly warmer and preferring warmer temperature while votes of office C and F (cool condition offices) were greater in those scales with about a 10% difference.
3.3. Thermal adaptive behavior

Initial observation by asking occupants about their belongings is used for confirming the thermal adaptive behaviors. There are some adaptive actions that refer to the study of Damiati et al. [13] and there are new actions that are added in this study. The results in Figure 5 reveal that there are scarves (8.9% to 43.8%), sweaters (8.9% to 43.8%), and jackets (8.9% to 43.8%) that were found in the offices so that occupants could adjust to the cooling environment. The study found that occupants added clothing after staying in the office both in the morning and afternoon. In the morning, the clothing rate increased from before working hours as 0.3-0.6 clo while the rate in the afternoon was higher as 0.3-1.0 clo. It is relevant to the thermal environment results that most offices were getting much colder in the afternoon as outdoor temperature progressively increased to over 35 °C. Meanwhile, portable fans that were used to reduce the heating environment were also found in all offices. The higher numbers of portable fans were in Office A which had the warmest condition on average. A breakdown graph in Figure 6 mentions a proportion of each of the adaptive behaviors from 3,708 votes in total. Changing clothes was the highest number at 1014 votes (27%) while the action of opening or closing blinds was the lowest number at 157 votes (4%). The rest of the actions were wearing scarves, drinking hot or cold water, washing face or hands, opening fans, moving around, taking a rest or doing thing less vigorously, and doing nothing. The number of votes were counted as 8%, 17%, 4%, 6%, 13%, 5%, 14%, respectively. There were 3 types of action as follows. (i) using additional elements: changing clothes, wearing scarves, drinking hot or cold water, washing face or hands (ii) self-adjustment: moving around, taking a rest or doing thing less vigorously, and doing nothing (iii) changing environment: opening or closing blinds and opening fans.

![Figure 5. Belongings of occupants](image)

Following the information in Figure 7, changing clothes and wearing scarves were categorized by the thermal sensation votes (4 to -4). Clothing insulation values were estimated from questionnaires by applying the following equation from ISO 9920 [14]: \[ I_{cl} = 0.161 + 0.835 \times \Sigma I_{clu} \], where \( I_{clu} \) is the effective thermal insulation according to the table of the insulation values of typical clothing pieces. It was found that the clothing insulation average values were 0.53 clo, 0.61 clo, 0.62 clo, 0.57, 0.68 clo, respectively. Most values were slightly higher than the standard calculation for 0.5 clo comfort zone. The lower the temperature in the office is, the more the clothing values increase. Occupants tended to adjust clothing by wearing more pieces when they felt colder at 50% of all votes. This study is also relevant to the previous study [13] which showed that more people would adjust their clothes during a cool thermal condition rather than a warm one. The percentage of those changing clothes was continuously increasing from 0% to 80%. Apparently, clothing insulation was collected by the questionnaire that showed the illustration of upper clothes, lower clothes, and shoes. Occupants put a checkmark for the option of adjustment of clothes assuming it meant the time of before arriving at work, 11.00, 15.00, respectively. The results from Figure x show that during working hours. In Japan, there is the campaign called Coolbiz that promotes wearing summer clothes without suits and ties at 28°C [20]. This campaign could reduce air-conditioning consumption. The difference of air temperature between a Japanese office and these cases was almost 4°C.

The median values of clothing insulation in Malaysia, Indonesia, Singapore, and Japan are similar to the study, as well as the previous cases in Bangkok and Thailand [21], that found each group of clothing
is rated to obtain different neutral temperatures ranging from 24.6°C to 25.2°C close to the study of Busch [22] that proposes the neutral temperature as 24.5°C. The clothing insulation was observed during the day from before working hours to 15:00. Figure 7 shows that mean of clothing insulation was likely to increase from 0.56 clo to 0.58 clo in the morning and 0.61 clo in the afternoon. The maximum increased from 1.22 clo to 1.45 clo when the thermal environment stayed colder than in the morning. The increase of clothing insulation is obviously due to the thermal environment in the afternoon when becoming colder.

The next factor, wearing scarves, is the adaptive behavior mainly focusing on women who tried to keep the neck warm. The frequency was 14.7% of total votes. This clothing piece could increase the value as 0.03–0.05 clo [20] higher than men who only wear the usual dress. Additionally, only the upper-body clothing was found in this research. It is because wearing more pieces of clothing in the upper part is flexible for both indoor and outdoor environments. Figure 8 expresses the other four activities, including drinking hot or cold water, closing or opening blinds, washing face or hands, and opening fans, respectively. Drinking water helped occupants to maintain comfort both voting a hot side (1 to 4) and voting a cold side (-1 to -4) for which percentage of the vote was 31.3% on average. The act of opening and closing blinds was the lowest occurrence of all the adaptive behaviors in this study. Only 7.7% of occupants were concerned about blind adjustment when feeling hot or cold. Occupants feeling hot tended to adjust the blinds more than those who felt cold. Washing the face was 8% while opening a fan was slightly higher as 11.8%. Occupants voting hot took action more than those voting cold. When considering the range from TSV=4 to TSV=−4, the washing face action gradually decreased from 54% to 11% while opening a fan continuously declined from 60% to 3%. The next factors tabulated are moving around, taking a rest or doing things less vigorously, and doing nothing. The frequency of moving around gained when occupants felt colder. It increased from 10% in feeling hot votes to 60% in feeling cold votes. Taking a rest or doing things less vigorously seems to have fluctuated similarly to doing nothing, for which occupants chose this action less than 20% in all thermal sensation scales.

![Figure 7. Clothing insulation change](image1)

![Figure 8. Thermal adaptive behaviors versus TSV](image2)

The operative temperature was plotted against the percentage of votes. Figure 10 shows that the regression line of changing clothes gradually decreased when operative temperature increased. The percentage of votes of occupants changing clothes from 21 °C to 23.5°C reached 75%. The average frequency was 31% in overall temperature value. The percentage of votes for changing clothes also increased when the temperature increased from 24.5 °C to 26°C, but the occurrence is still a small portion compared to that of the lower temperature between 21.5°C to 23.5°C. People prefer changing clothes when staying in low temperature rather than when staying in high temperatures. The trend line of wearing a scarf is also similar to changing clothes, decreasing in higher temperatures. The percentage of the occurrence of opening or closing blinds, washing face or hands, and opening a fan, was less than 10% in every operative temperature value. Drinking hot and cold water also displayed a small number of votes but it was a bit higher than the other three actions. The frequency of moving around was unstable ranging from 19% to 0%. Taking a rest or doing thing less vigorously was lower than 15%. Doing nothing slightly decreased when temperature increased to higher values.
Focusing on the relation between the thermal sensation vote and the adaptive behavior, Figure 10 shows the ratio of occurrence in each action. Occupants voting for neutral had the highest rate in every action. The thermal sensation data was divided into 3 categories: colder than neutral (-4 to -1), neutral (0), and warmer than neutral (1 to 4). Changing clothes was rated as 44%, 51%, and 5%, respectively. Wearing scarves had the highest number in colder temperatures than the neutral group, which was 53%. The rates of the three categories were 42%, 47%, and 11%, respectively. Drinking hot or cold water was rated as 42%, 47%, and 11%, respectively. Opening or closing blinds was 36%, 50%, 14%, respectively. Washing face or hands was counted as 31%, 41%, and 28%, serially. Opening a fan was pointed as 15%, 58%, 26%, progressively. Moving around was 46%, 45%, 9%, respectively, for which the feeling colder than neutral category took a slightly higher rate than feeling neutral. Taking a rest or doing thing less vigorously was counted as 38%, 48%, and 14%, progressively. Doing nothing was 33%, 54%, and 12%, respectively. Considering average values, it was found that the adaptation rate was 38%, 48%, and 14%, respectively. In sum, occupants feeling cold took more adjustment actions to maintain their comfort than those feeling hot. It could be assumed that those feeling neutral adjusted themselves from feeling colder than neutral to feeling neutral. On the other hand, adjusting temperature found in many studies is not included in this study because not every building in this study allowed occupants to adjust thermostats by themselves. In these cases which involved a central air supply, management teams took responsibility for controlling the thermostat. Therefore, there is no mention of changing the temperature in this study.

**Figure 9.** Thermal adaptive behaviors versus operative temperature

**Figure 10.** Relation between adaptive behaviors and thermal sensation vote

### 4. Conclusions

In this study, field investigations were conducted in air-conditioned offices in Bangkok, Thailand, to examine the relation between the thermal sensitivity and adaptive behaviors of occupants. The significant conclusions are listed as follows:

1. Based on a psychometric chart, most of the thermal environment values were outside the 0.5 clo comfort zone and fell within the 1.0 clo comfort zone. The reasons are because of both lower temperature setpoint and high humidity. Temperature setpoint inevitably affects the thermal
performance. Most offices set the temperature lower than 24°C which could result in a freezing sensation, especially in the afternoon.

2. Occupants voted neutral as the highest rate in thermal comfort and thermal sensation vote. However, the feeling-colder-than-neutral votes were higher than the feeling-warmer-than-neutral votes. The thermal sensation vote is more relevant to the thermal environment in case studies than the thermal comfort vote. The thermal preference vote indicates that most of the occupants do not want to change temperature and preferred changing into warmer clothing rather than changing into colder clothing.

3. Personal belongings, including a sweater, scarf, jacket or suit, and portable fan were found as the tools of thermal adaptive behavior.

4. In this survey, there were 7 habits of occupants observed by the questionnaire, namely changing clothes, wearing a scarf, drinking hot or cold water, opening or closing blind, washing face or hands, opening a fan, moving around, taking a rest or doing things less vigorously, and doing nothing.

5. Clothing insulation value increased from 0.53 clo before the start of work to 0.68 clo in the afternoon on average which is higher than the standard used for a 0.5 comfort zone. It could slightly change the PMV.

6. Adaptive behavior fits to the thermal sensation vote. Occupants feeling cold were likely to adjust clothing, wear a scarf, drink hot water, move around. Occupants feeling hot tended to open a fan, drink cold water, or close blinds. Occupants feeling cold took more actions to maintain their comfort than those feeling hot.

7. Occupants voting for neutral had the highest frequency of adaptation. In addition, occupants voting for colder than neutral was the second rate. It could be assumed that those feeling neutral adjusted themselves from feeling colder than neutral to feeling neutral.

In conclusion, the thermal environment in Thai offices was chilled under low setpoint control. It inevitably affects people in terms of adaptability. Occupants may be able to tolerate thermal conditions by doing those activities. The thermal votes show a low discomfort rate declaring a high number of feeling colder than neutral. Occupants were likely to adapt themselves to the thermal environment to feel more comfortable. However, it is not sustainable for energy saving and quality of living in the long run. It would be better for occupants to change the thermal environment to a higher temperature range together with controlling humidity.

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