

# Mapping Thermal Personality for Occupant-centric Environment Control

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## SUMMARY

This study investigated varying thermal preferences for occupant-centric environment control. Employing unsupervised-learning clustering techniques, the research sought to uncover underlying pattern in thermal comfort responses of participants. Four distinct thermal personality groups surfaced, each characterized by diverse personal and thermal comfort profiles. Strong discomfort sensitivity was observed in TP3 and TP4, each favouring different thermal conditions, whereas TP1 and TP2 displayed relatively low sensitivity. The findings underscore the intricate nature of individual responses to thermal conditions. The study emphasizes the importance of recognizing these differences for improving comfort in shared spaces. Furthermore, the insights could contribute to the development of personalized comfort models and innovative HVAC controls, allowing for a more responsive approach to creating indoor environments that cater to diverse thermal needs.

## KEYWORDS

Thermal preference, Thermal comfort profile, Clustering

## 1 INTRODUCTION

In recent years, there has been growing emphasis on understanding occupants' perceptions of indoor environment, underscoring the significance of thermal comfort in influencing occupants' well-being and productivity (Wargoeki et al., 2017; Luo et al., 2022). However, various factors, including gender, age, body composition, and thermoregulatory ability, lead to distinct thermal preferences among individuals. Studies revealed substantial diversity in comfort profiles, emphasizing the limitations of a one-size-fits-all approach or aggregated profile (Daum et al., 2011; Wang et al., 2018). To address this, person-centric thermal zones has been proposed, offering a tailored approach to thermal environment control (Gauthier et al., 2020). This approach seeks to design micro-climatic condition based on the thermal profile of occupants in multi-occupancy spaces' HVAC control. Hence, this study aims to develop distinct thermal preference groups, enabling customized thermal conditions that align with individual occupant preferences in shared spaces.

## 2 METHODS

The primary objective was to construct a comprehensive dataset to discern distinct thermal preferences. Participants with similar contextual background (including climate and cultural factors), no health conditions, and within the age range of 20 to 30 were selected – resulting in a total of 30 participants. Chamber experiments were conducted with temperature ranging from 20°C to 32°C, RH50% (PMV -1.7 to PMV 2.3). This temperature range encompass typical office environment in Korea, while also providing enough variability to evoke comfort and cold, hot discomfort, for creating the profiles. Throughout the experiment, various thermal responses - thermal sensation vote (TSV), thermal comfort, thermal preference, and thermal acceptability – were collected. Additionally, physiological signals like skin temperature and electrodermal activity were recorded. Employing data-driven approaches, specifically unsupervised techniques like clustering, the underlying patterns of thermal preferences within the participant population were explored.

### 3 RESULTS & DISCUSSION

Four distinct groups emerged; each assigned a unique label as a different thermal personality (TP). Except one person who consistently voted the same across all measures. Analysis of these groups showed significant variations in personal factors, including gender, lean body mass (LBM). The optimal TSV is derived from the regression of thermal sensation and comfort votes, reflecting the thermal sensation associated with the peak comfort state and the optimal temperature was calculated based on the comfort probability for each group (Table 1). TP2 and TP4 reported relatively higher thermal sensation under the same conditions. TP4 exhibited the lowest converged TSV value, comfort temperature range, and optimal temperature. In contrast, TP3 demonstrated highest converged TSV, reporting comfortable at warm sensation and preferred higher temperatures.

Table 1. Thermal comfort profile of each thermal personality group

Cluster	n (M,F)	LBM	Comfort Temperature range	Optimal TSV	Optimal Temperature
TP 1	12 (4M, 8F)	45.4 (SD7.5)	23.7 – 26.9°C	-0.34	24.9°C
TP 2	6 (4M, 2F)	48.4 (SD 7.8)	22.5 – 29.2°C	-0.42	24.0°C
TP 3	6 (1M, 5F)	43.1 (SD 10.5)	25.4 – 29.2 °C	-0.37	26.5°C
TP 4	5 (5M, 0F)	59.3 (SD 7.7)	21.2 -23.5 °C	-1.25	23.3°C

These findings suggest that distinct thermal personality groups exhibit varied thermal sensations and preferences along with differences personal characteristics. Strong discomfort sensitivity is evident in TP3 and TP4. TP3 exhibits sensitivity to cold, favouring warmer conditions, while TP4 prefers cooler sensations and low thermal conditions. TP1 and TP2 show relatively low sensitivity, with TP1 leaning slightly towards cold sensitivity. The implications of these findings extend to the potential development of personalized comfort models, which, in turn, could be applied to predictive modelling and the formulation of thermal zoning plans. For instance, incorporating multi-zonal controls influenced by real-time input from sensors could enhance the adaptability of indoor environments.

### 5 CONCLUSIONS

This study emphasizes the importance of recognizing and comprehending individual differences in thermal preferences. The exploration of four distinct thermal personality groups, each characterized by a unique thermal profile, contributes valuable insights. The potential applications of these findings span from improving comfort in shared spaces to advancing the development of personalized comfort models and innovative HVAC controls. These insights could contribute to a more responsive approach to creating indoor environments that cater to the diverse thermal needs of individuals.

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### 6 REFERENCES

- Daum, D., F. Haldi, and N. Morel. 2011. *Building and Environment*. 46(1): p. 3-11.
- Gauthier, S., et al. 2020. *Energy and Buildings*. 216: p. 109936.
- Luo, W., Kramer, R., de Kort, Y., Rense, P., & van Marken Lichtenbelt, W. 2022. *Indoor Air*. 32(1): p. e12951.
- Wang, Z., de Dear, R., Luo, M., Lin, B., He, Y., Ghahramani, A., & Zhu, Y. 2018. *Building and Environment*. 138: p. 181-193.
- Wargoocki, P. and D.P. Wyon. 2017. *Building and Environment*. 112: p. 359-366.