Seminar 15 - Occupant-centric Control Technologies: Assessing Comfort, Energy Use and Cost Tradeoffs

Stefano Schiavon, PhD

Center for the Built Environment
UC Berkeley

schiavon@berkeley.edu

Personalized Comfort Modeling for Occupant-centric Environmental Control

Acknowledgements

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Indoor Environmental Quality survey

How satisfied are you with your ability to adjust your furniture to meet your needs?

Very Satisfied  Very Dissatisfied

Overall building

Overall workplace

Acoustic quality

Air quality

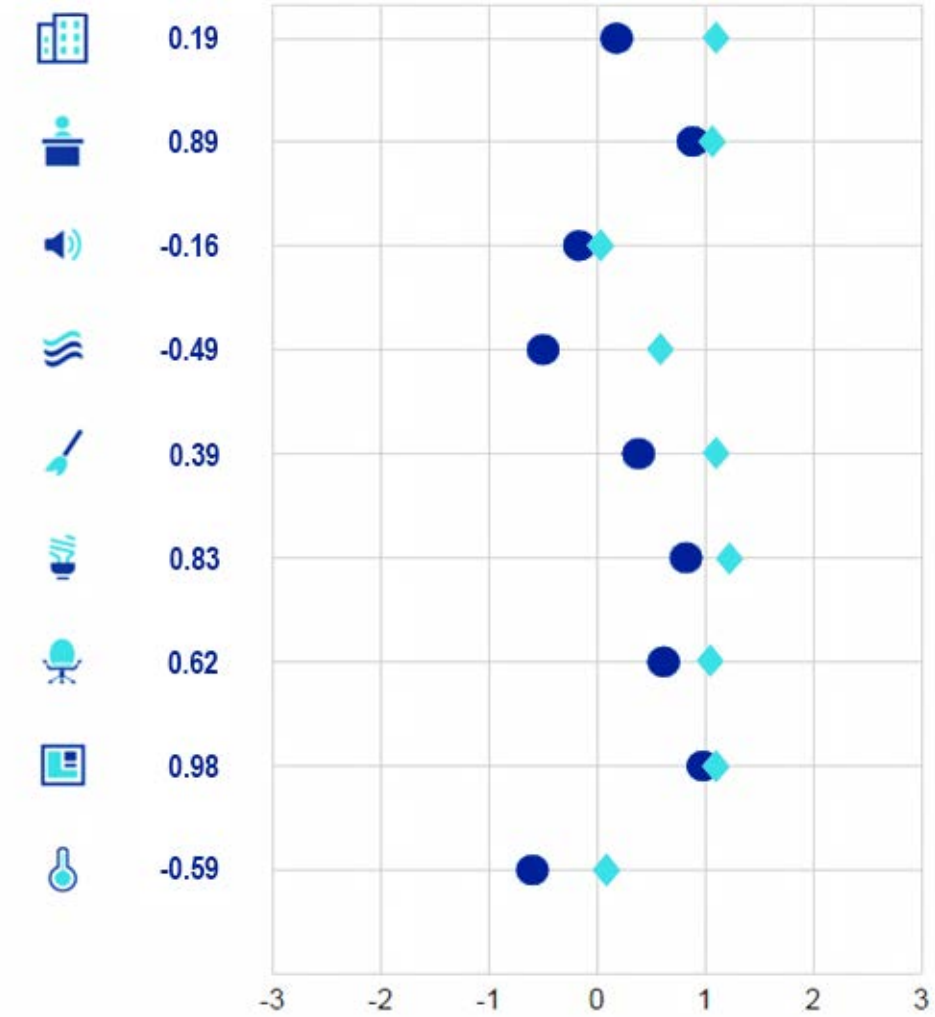
Cleaniness & maintenence

Lighting

Office furnishing

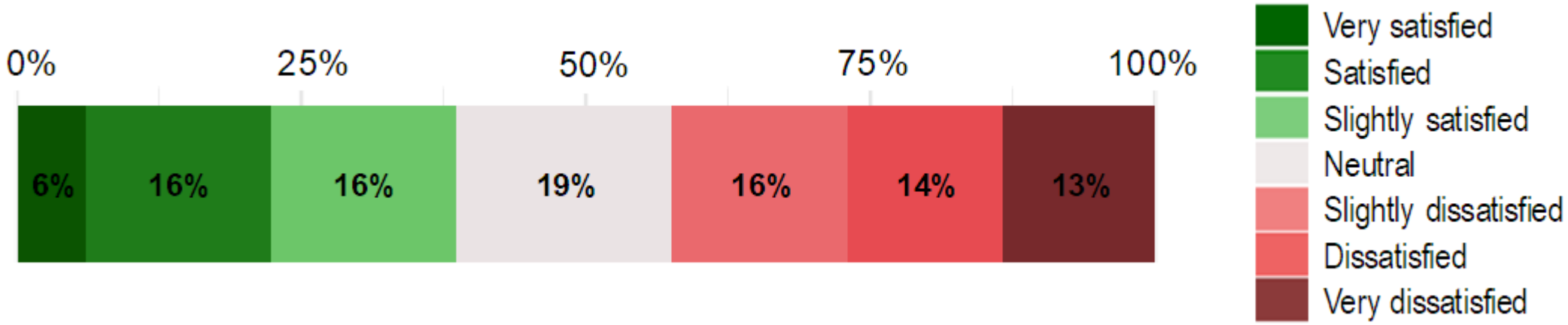
Office layout

Thermal comfort



Leader: Lindsay Graham

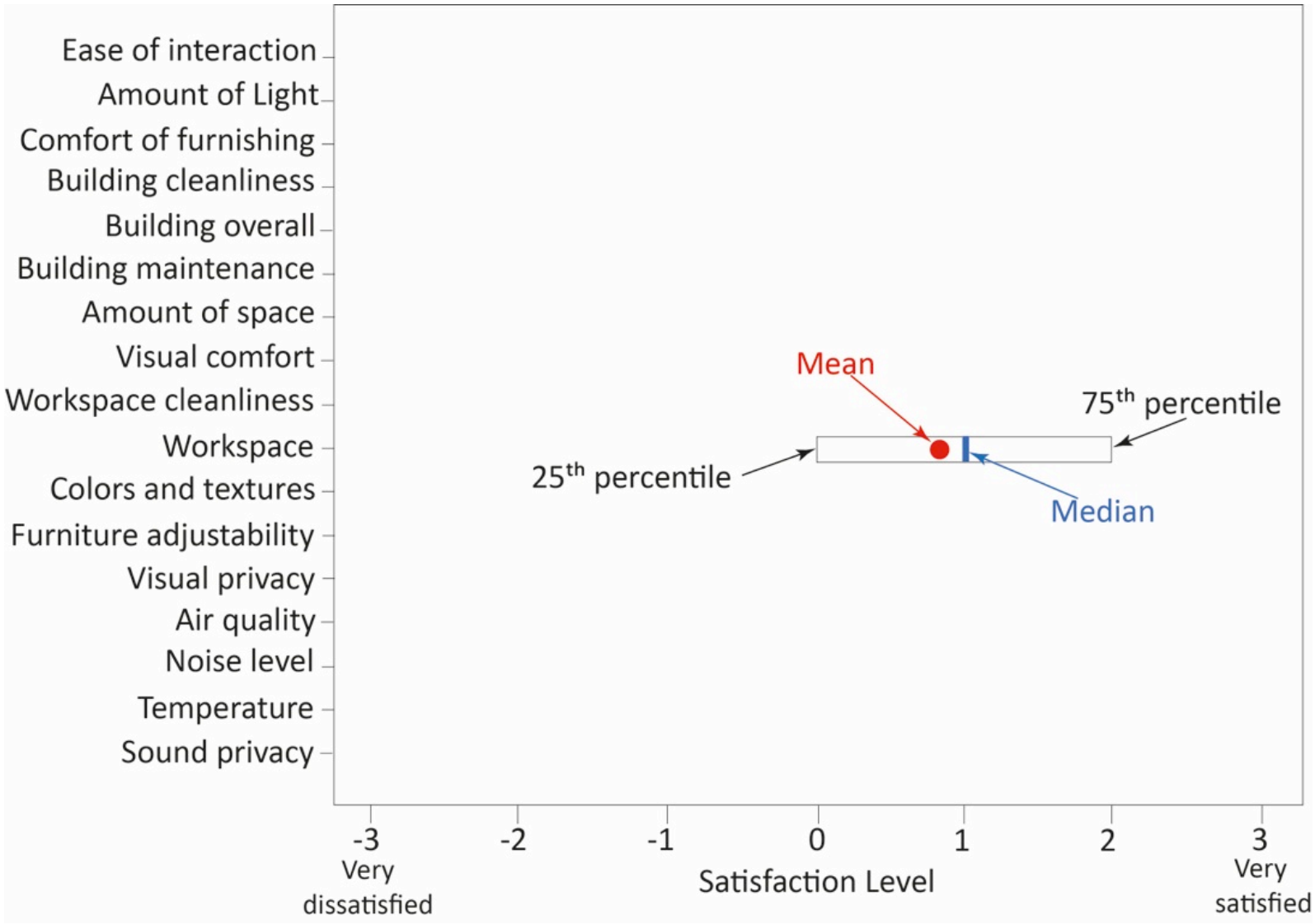
How satisfied are you with the temperature of your workspace?



Karmann, Schiavon, Arens 2018 Percentage of commercial buildings showing at least 80% occupant satisfied with their thermal comfort

Building occupant satisfaction

CBE survey on 351 bldg. and 52,980 occupants



Frontczak, Schiavon et al. 2011 Occupant satisfaction and IEQ Indoor Air

Building occupant satisfaction

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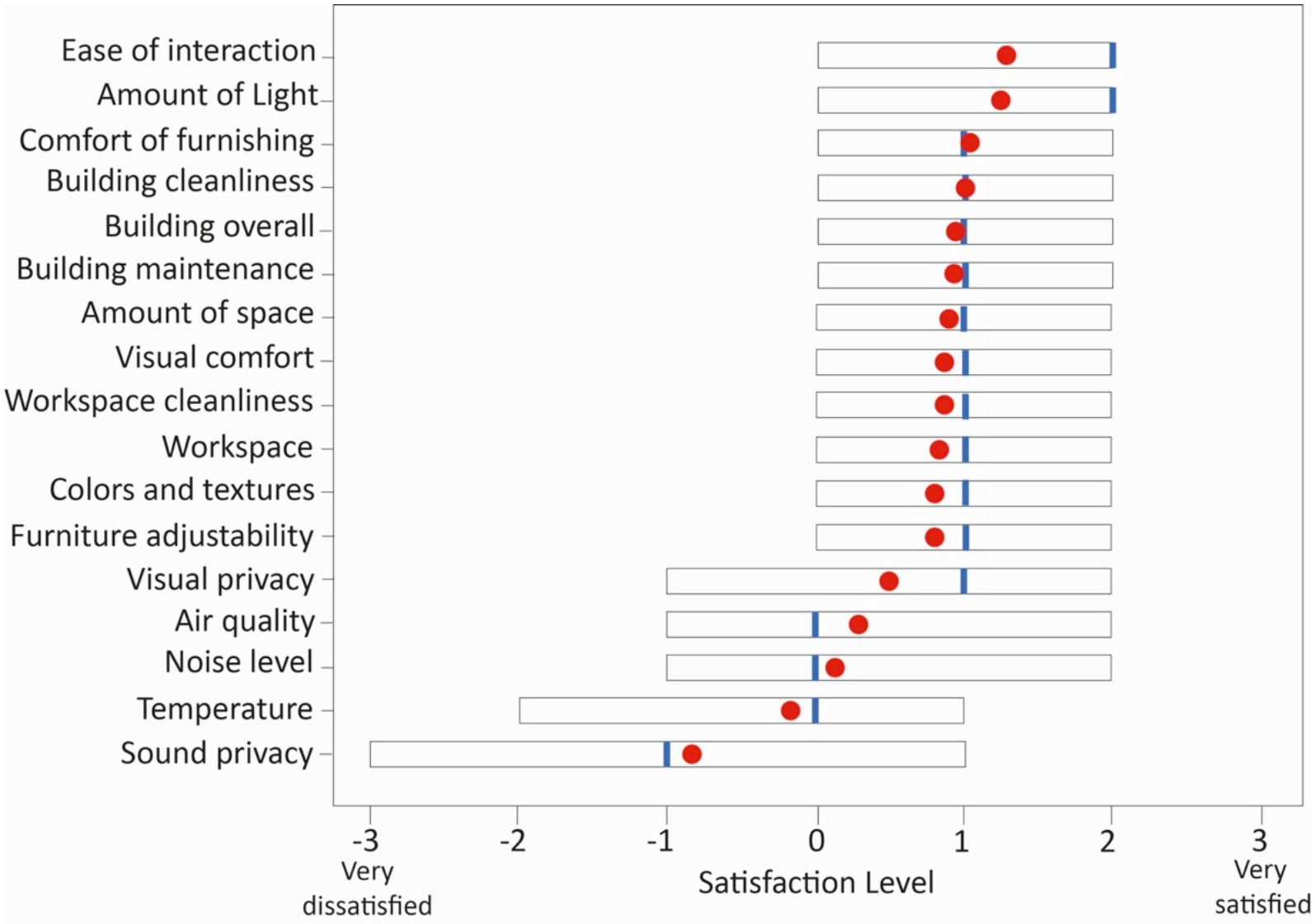
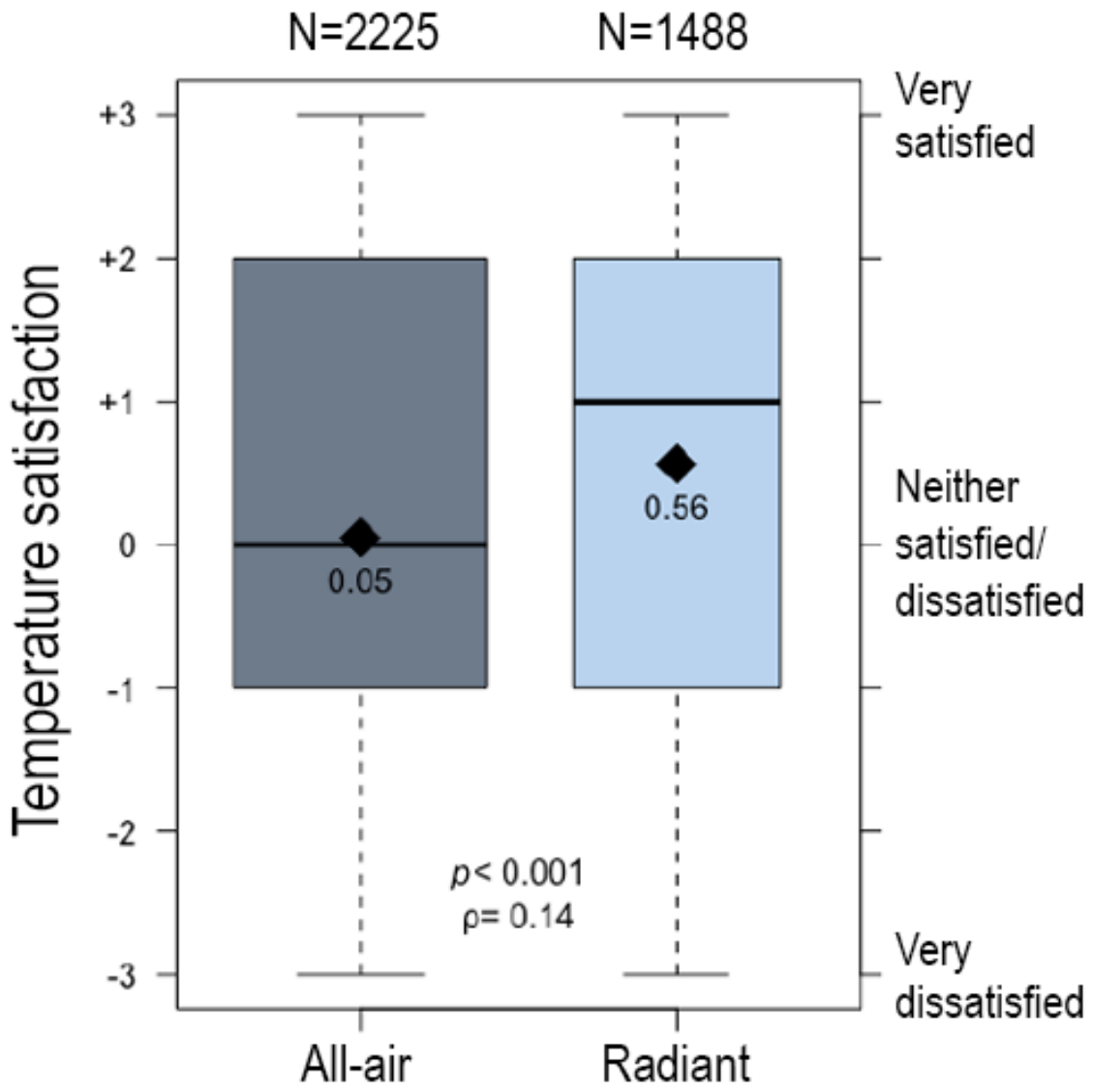


Frontczak, Schiavon et al. 2011 Occupant satisfaction and IEQ Indoor Air

Temperature satisfaction for radiant vs. all-air systems

Radiant and all-air spaces have equal indoor environmental quality with a tendency towards improved temperature satisfaction in radiant buildings

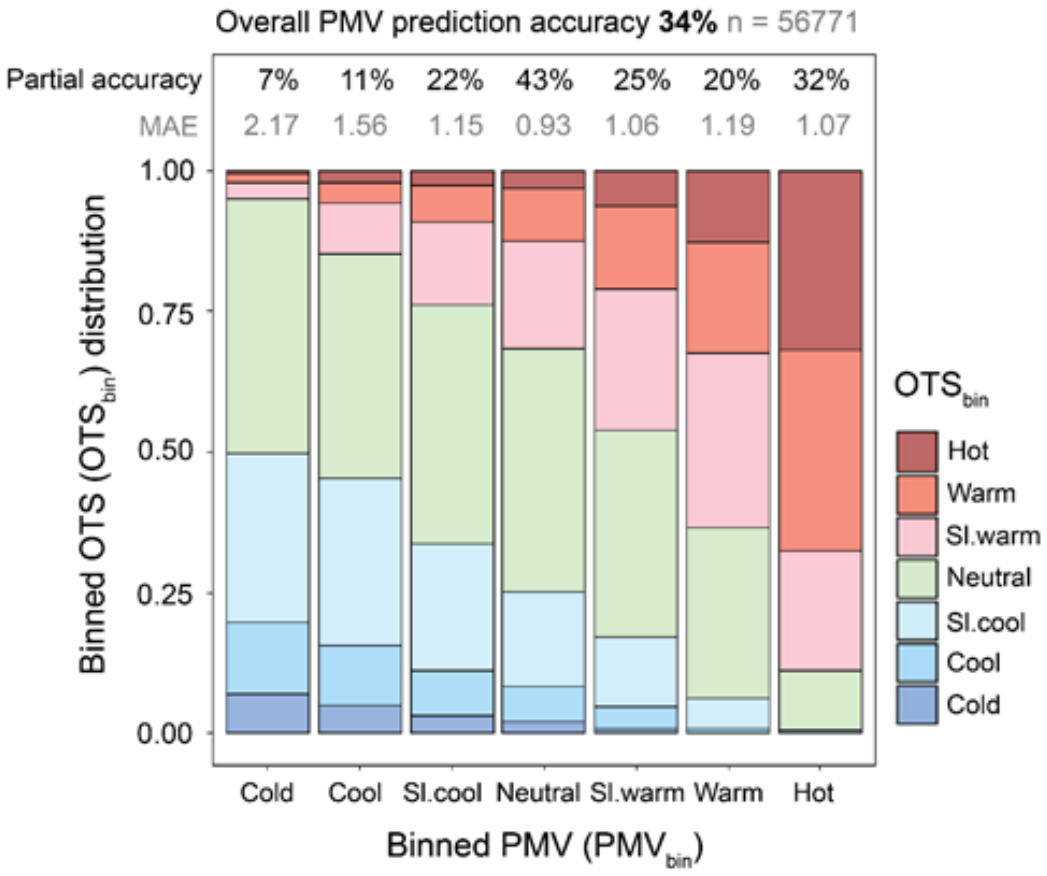


Climatic chamber thermal comfort study in Denmark

How accurate is the PMV-PPD model?

PMV predicted thermal sensation correctly only one out of three times

PMV had a mean absolute error of one unit on the thermal sensation scale



Cheung, Schiavon, Parkinson, Li, Brager (2019) Analysis of the accuracy on PMV – PPD model using the ASHRAE Global Thermal Comfort Database II


10 15 20 25 30
°C
10 15 20 25 30

Desk fan, foot warmer, heated and cooled chair

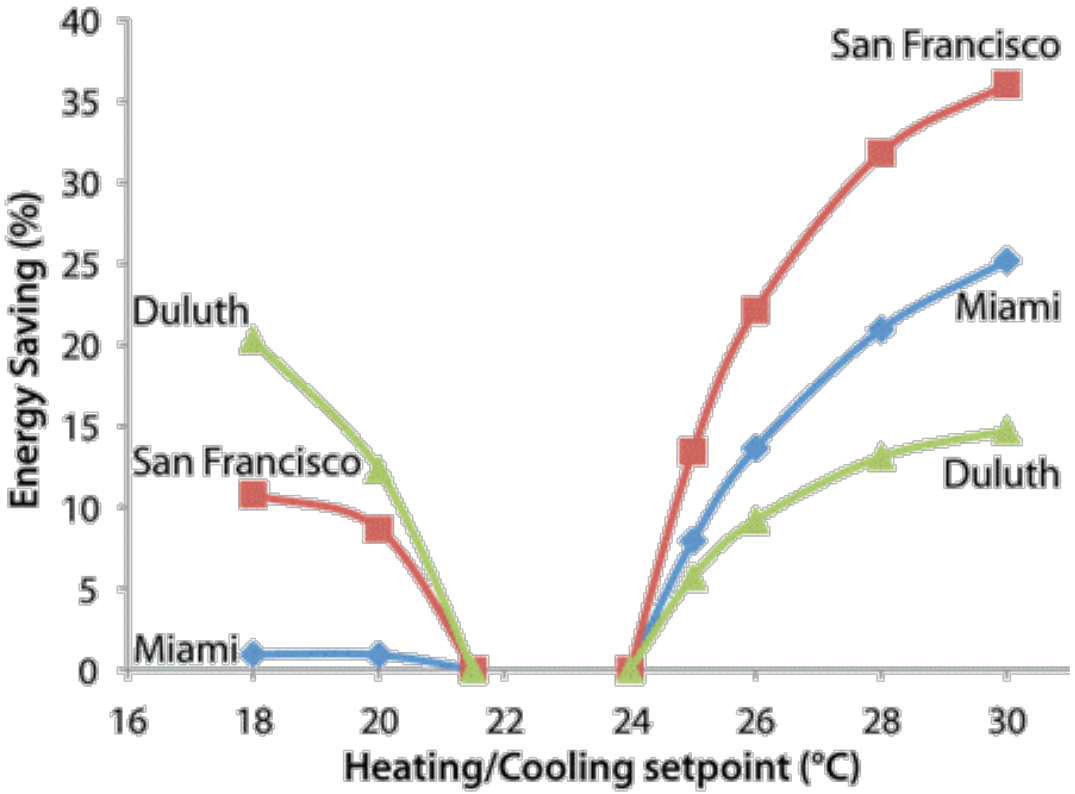
Energy savings

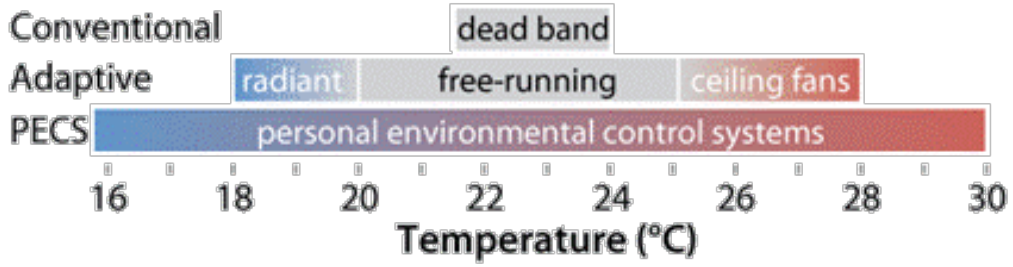
500 – 1500 W

2-100 W

Energy savings

Wider dead band reduces HVAC energy 7-15% per degree C

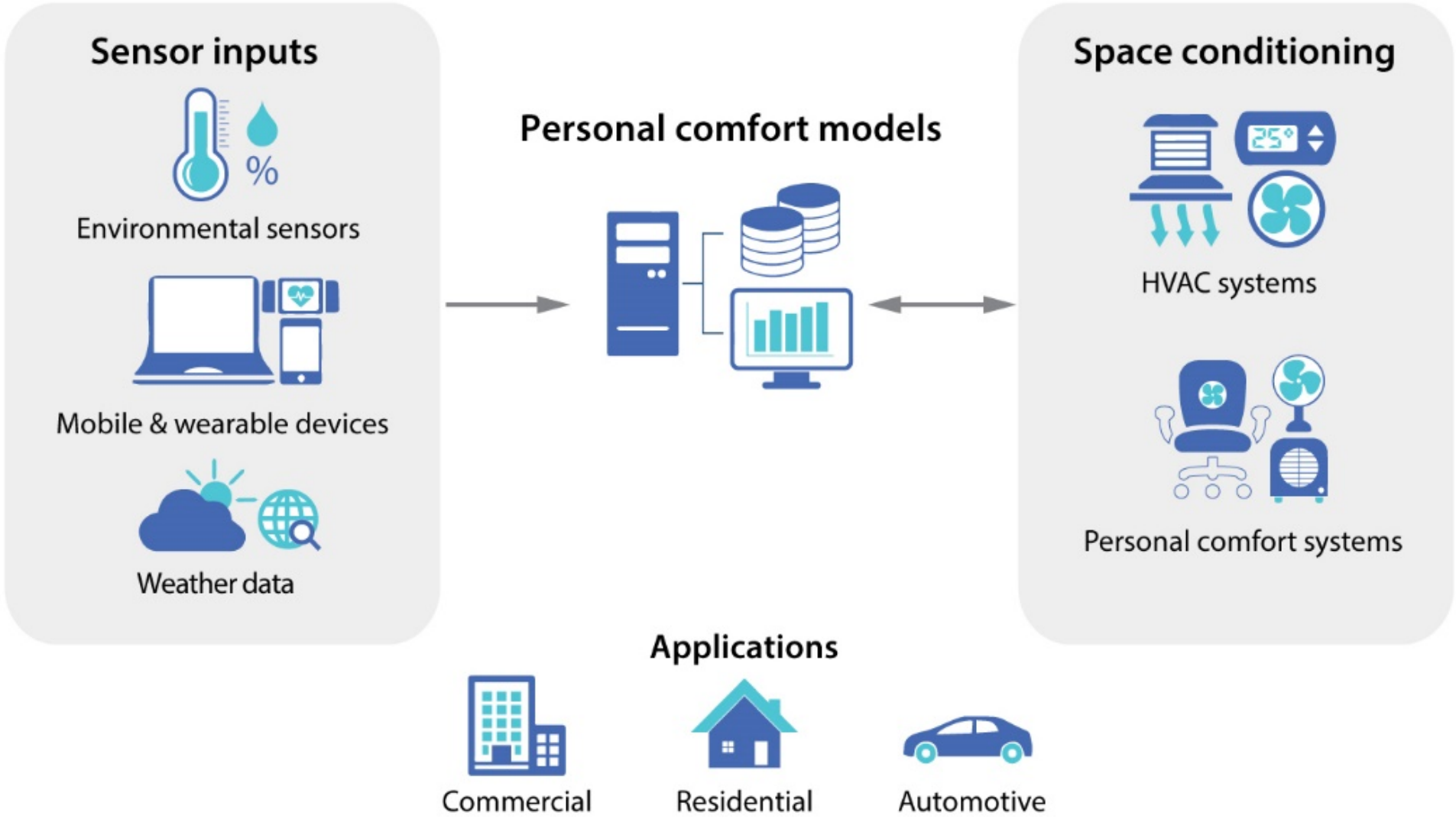




Schiavon and Melikov 2008 Energy saving and air movement Energy and Buildings

Hoyt et al. 2015 Extending air temperature setpoints Building and Environment

Personal comfort systems and models



Modified from Kim, Schiavon, Brager 2018 Personal comfort models - a new paradigm in thermal comfort Building and Environment

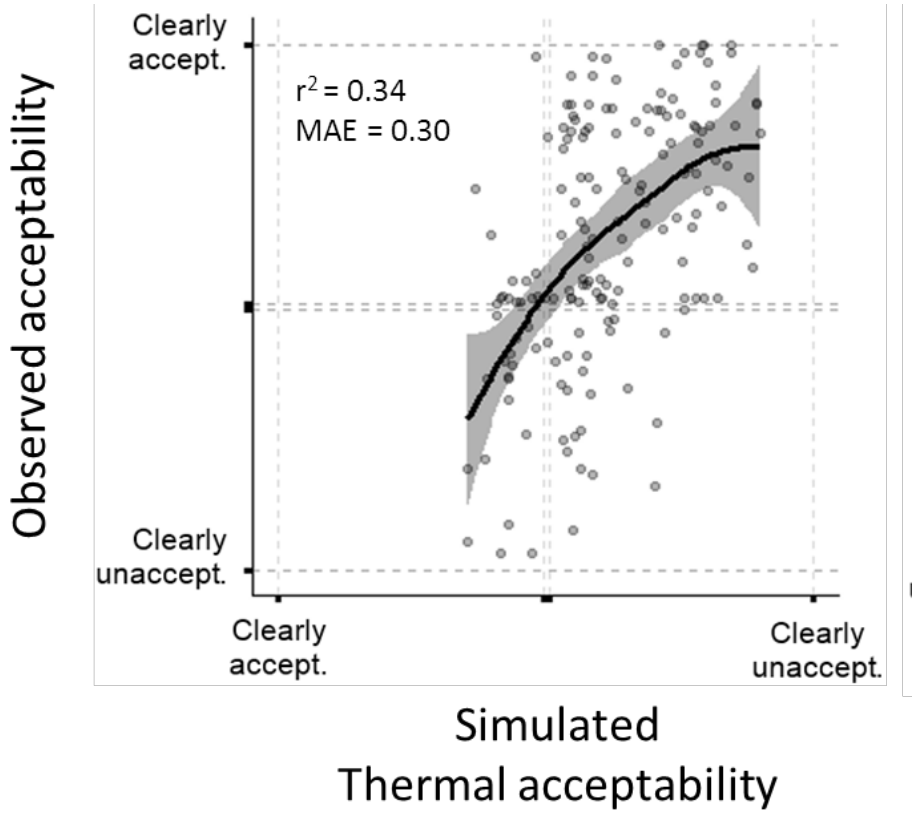
Personal comfort model is a new approach to thermal comfort modeling that predicts individuals' thermal comfort responses, instead of the average response of a large population

PCM could be based on:

- Environmental sensors
- Occupant feedback & behavior
- Physiological parameters

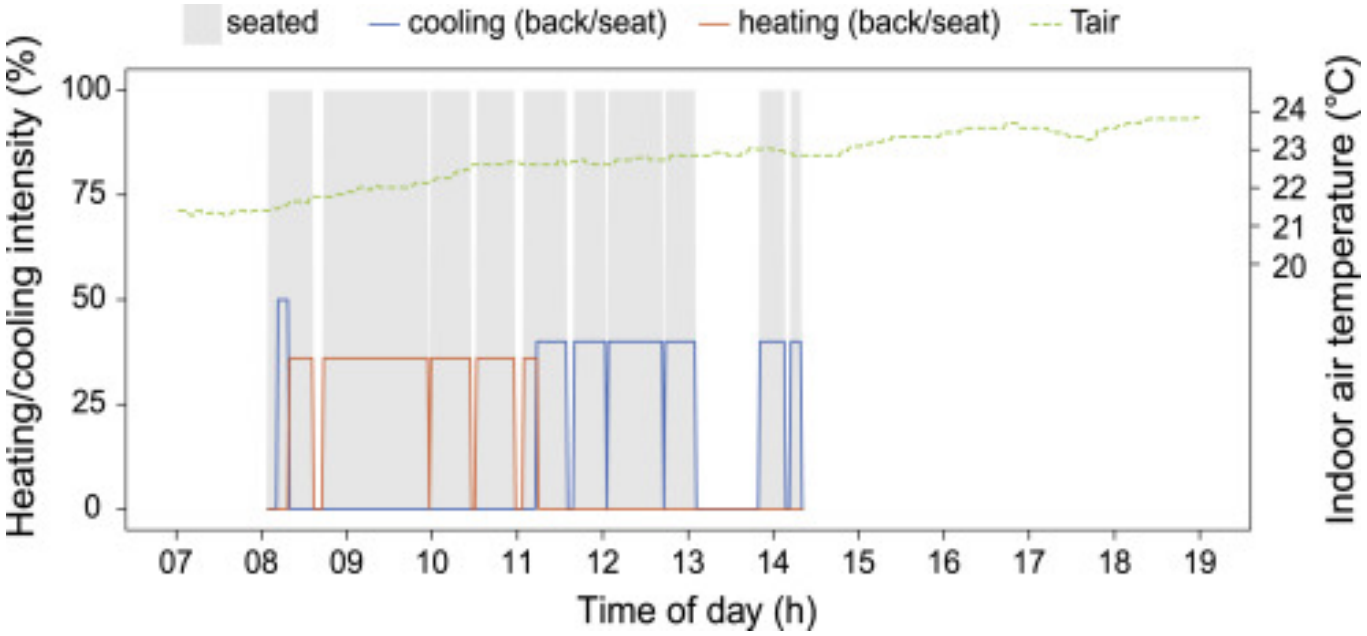
Kim, Schiavon, Brager 2018 Personal comfort models - a new paradigm in thermal comfort Building and Environment | Imagine: comfyapp.com and nest.com

Environmental sensors



Gall, Cheung, Luhung, Schiavon, Nazaroff 2016 Real-time monitoring of personal exposures to carbon dioxide Building and Environment

Occupant behavior with chair



Kim et al 2018 Personal comfort models: predicting individuals' thermal preference using occupant heating and cooling behavior and machine learning B&E

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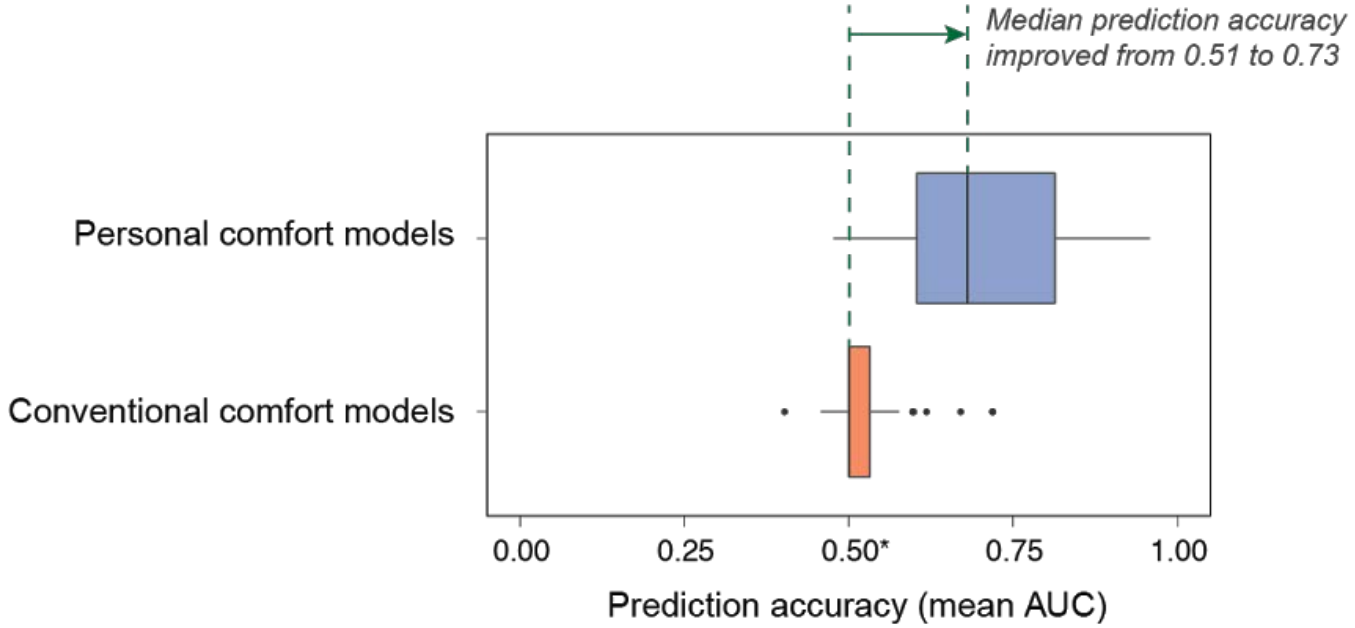

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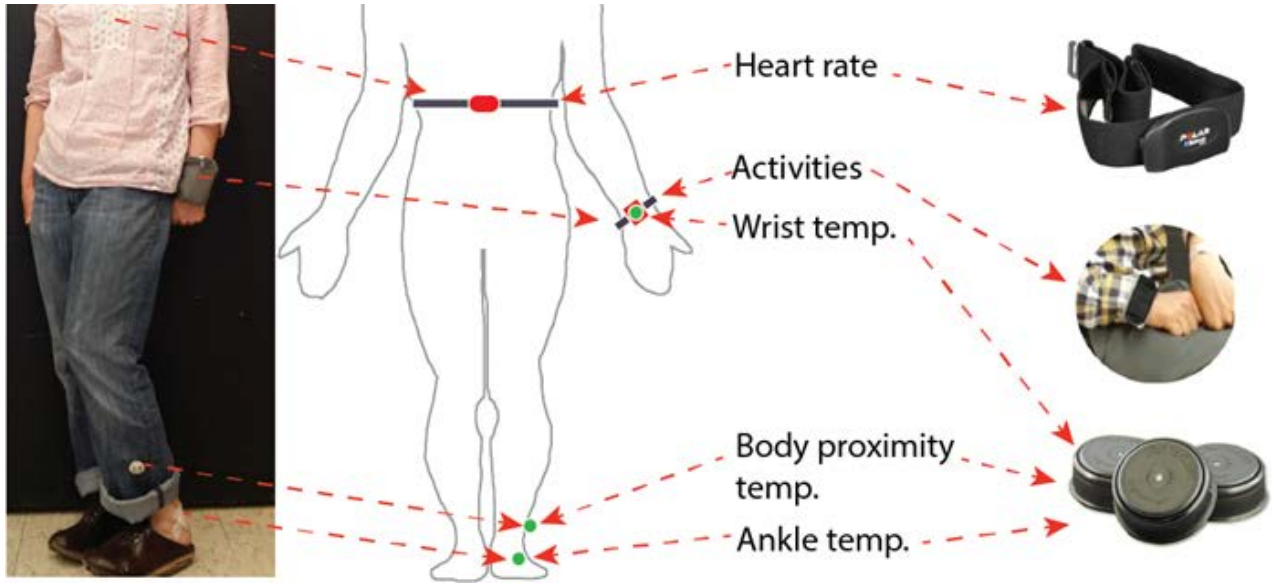
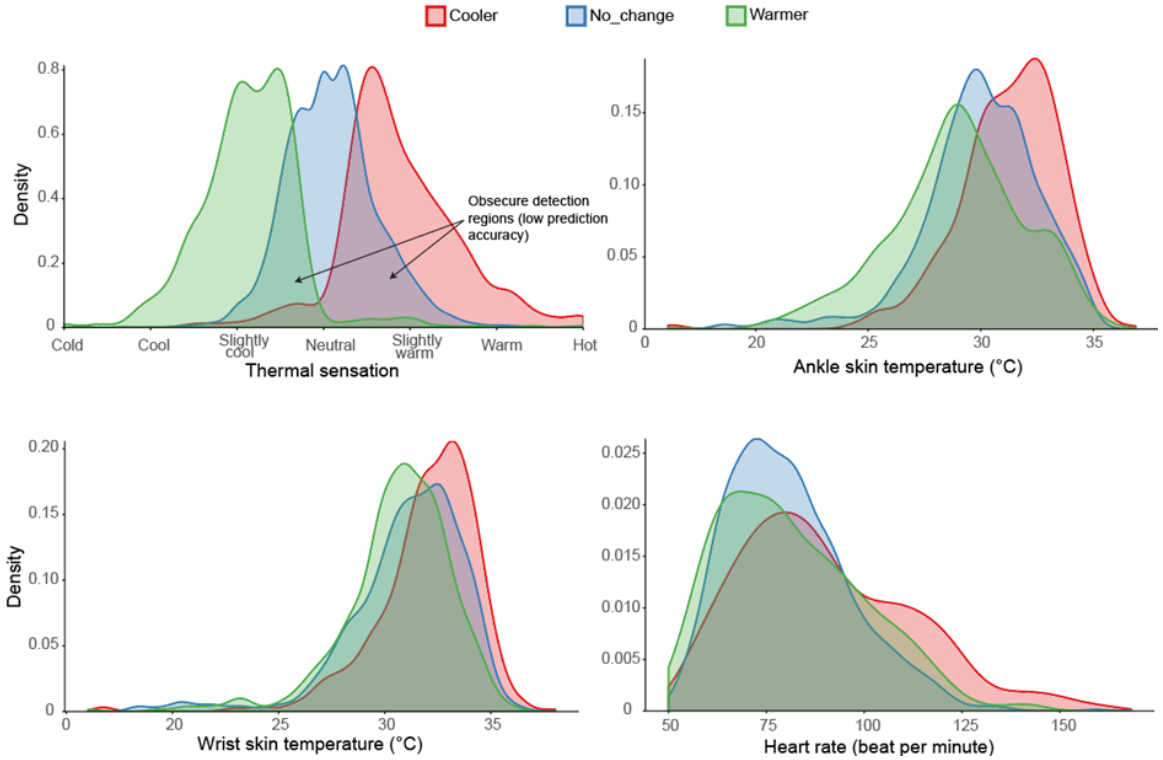
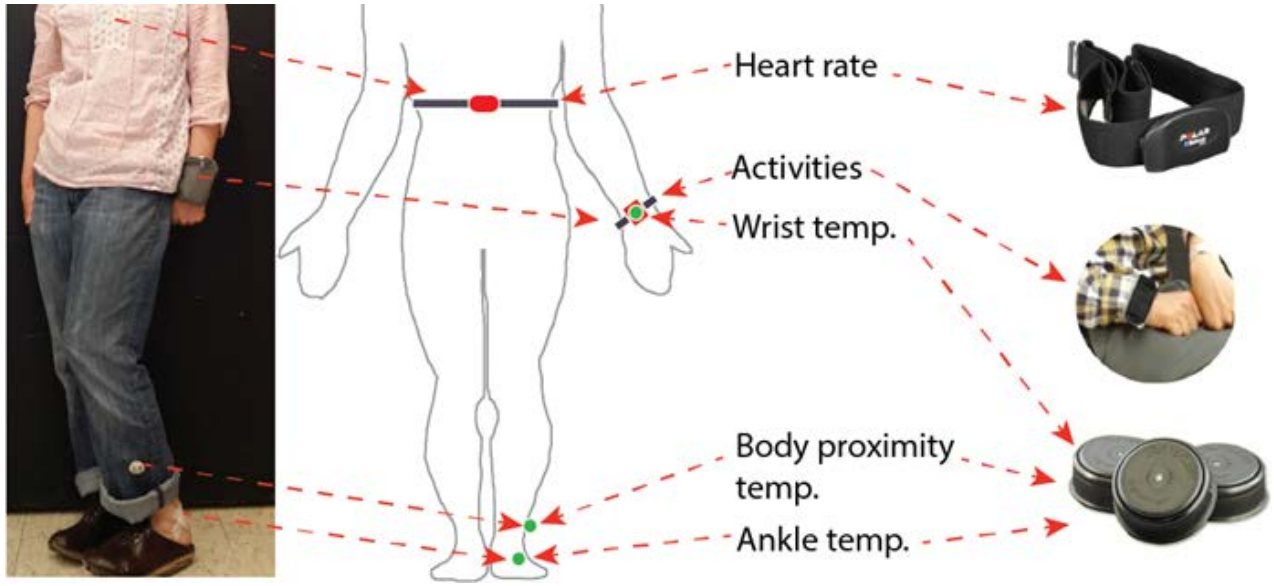
Physiological parameters

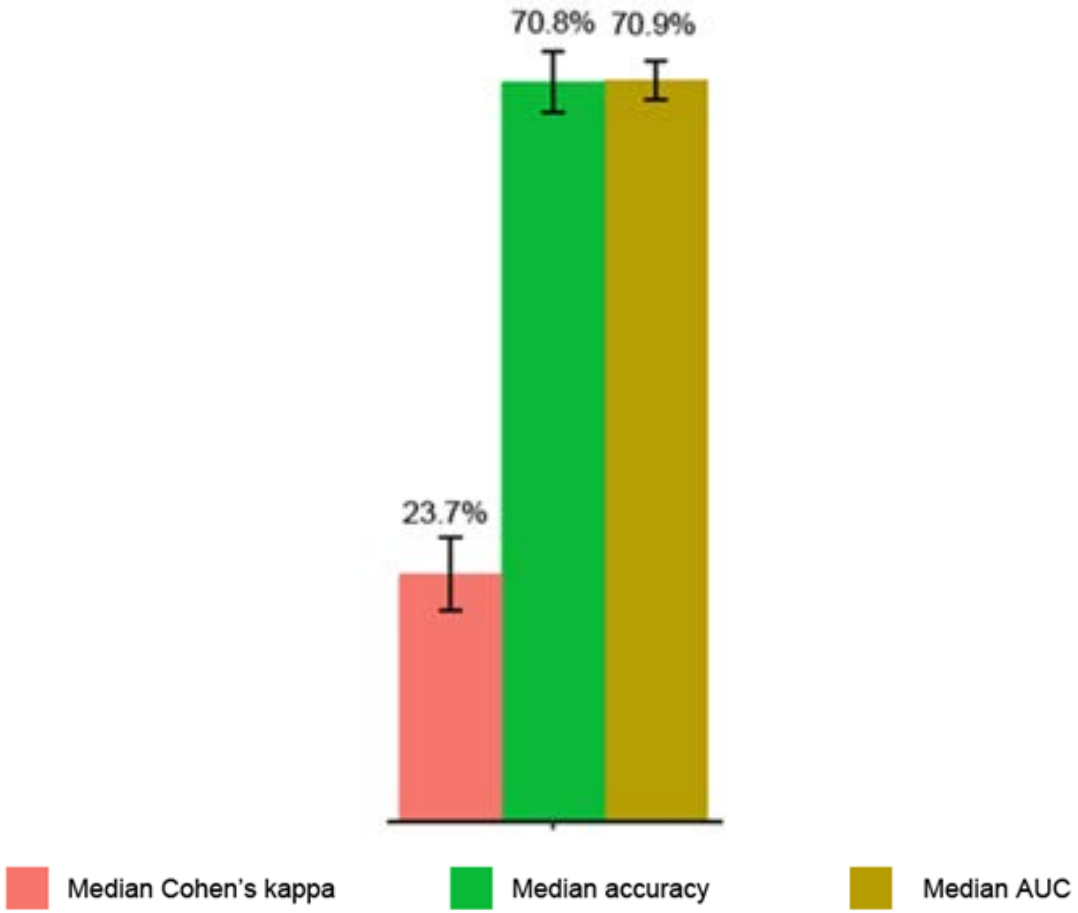




Liu, Ming, Das, Schiavon, Spanos (2018) Personal thermal comfort models based on physiological parameters measured by wearable sensors.

Physiological parameters

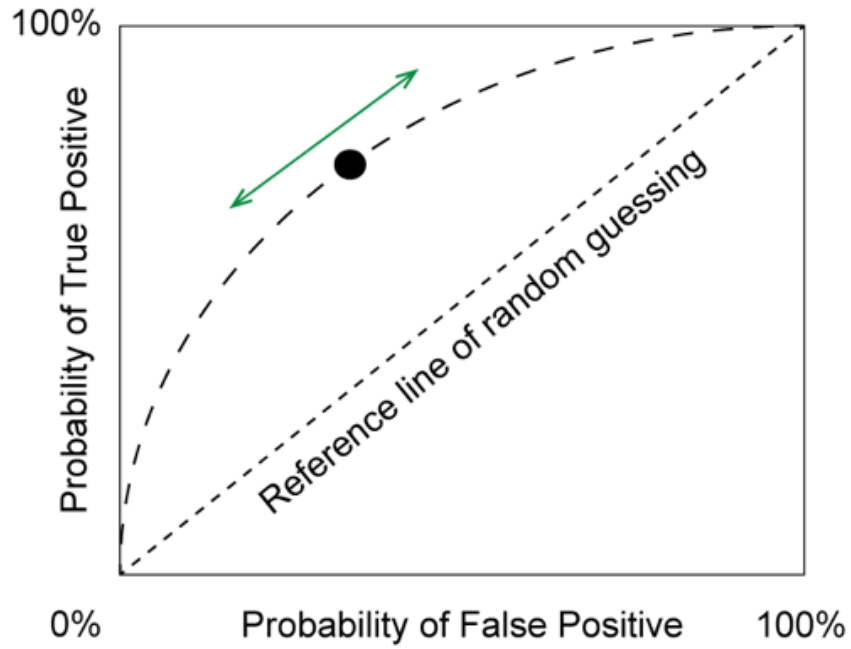


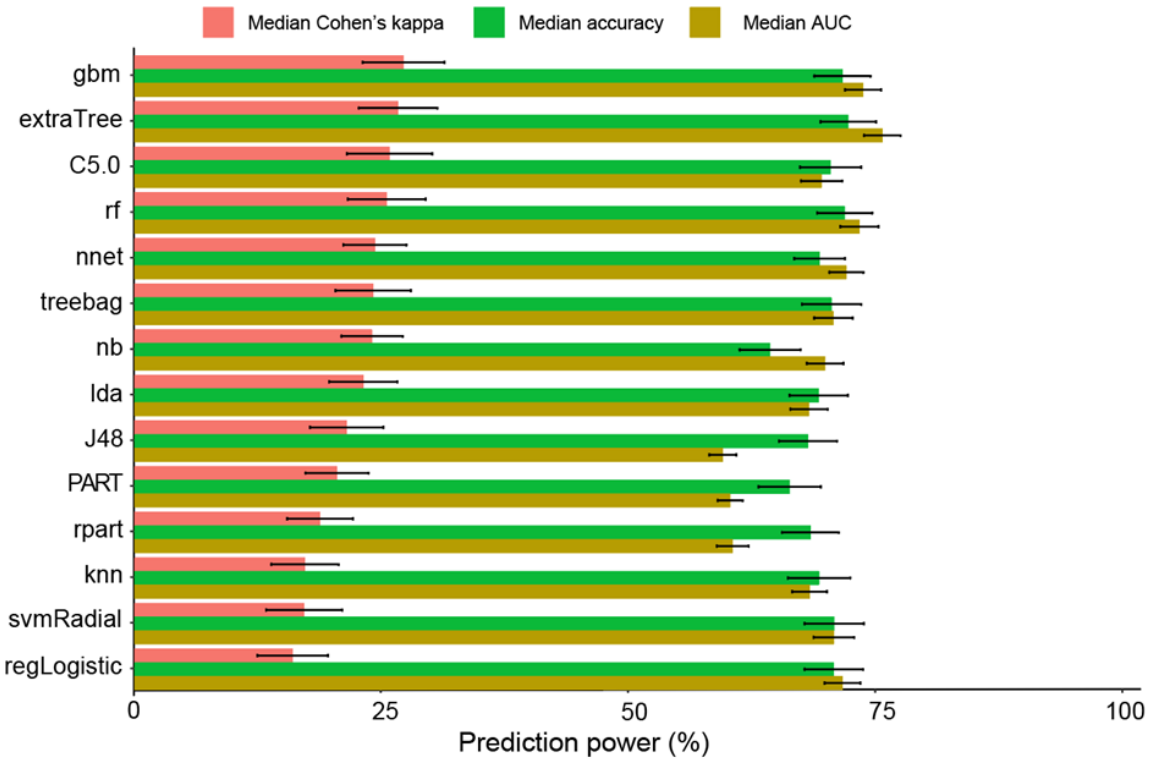


Liu, Ming, Das, Spanos, Schiavon (2019) Developing personal thermal comfort models with wearable sensors

Modeling process

Data collection → Data preparation → Model selection → Model evaluation → Continuous learning





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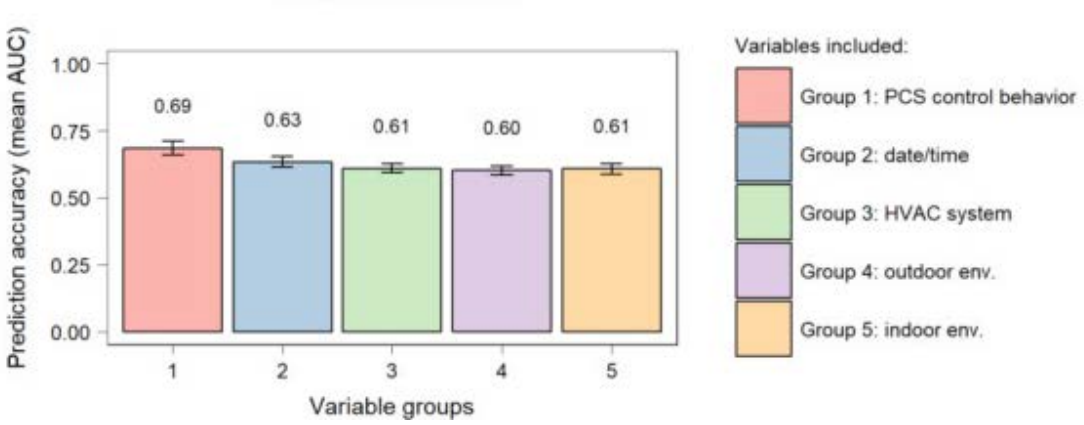
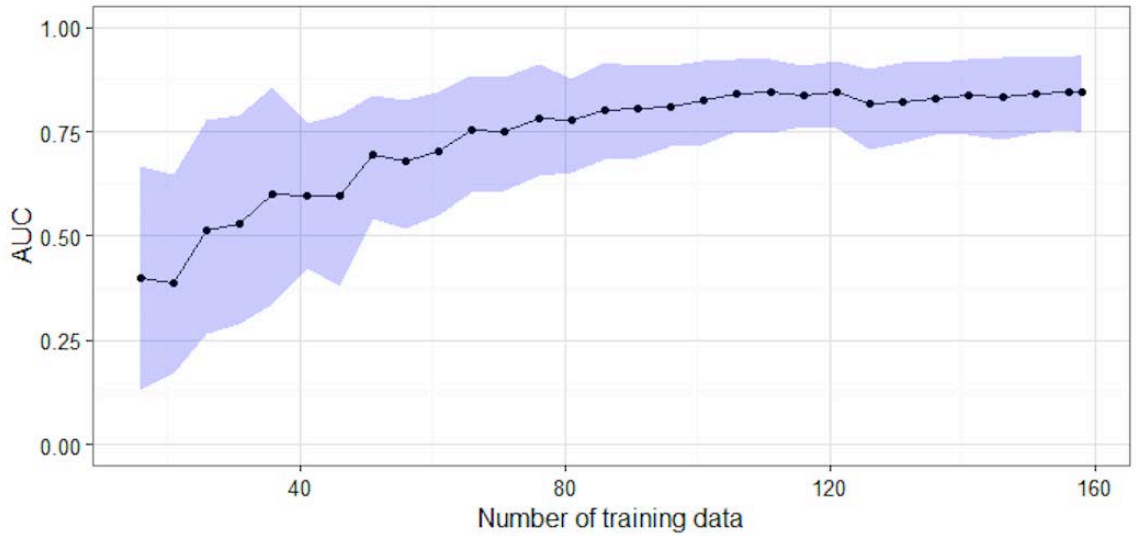
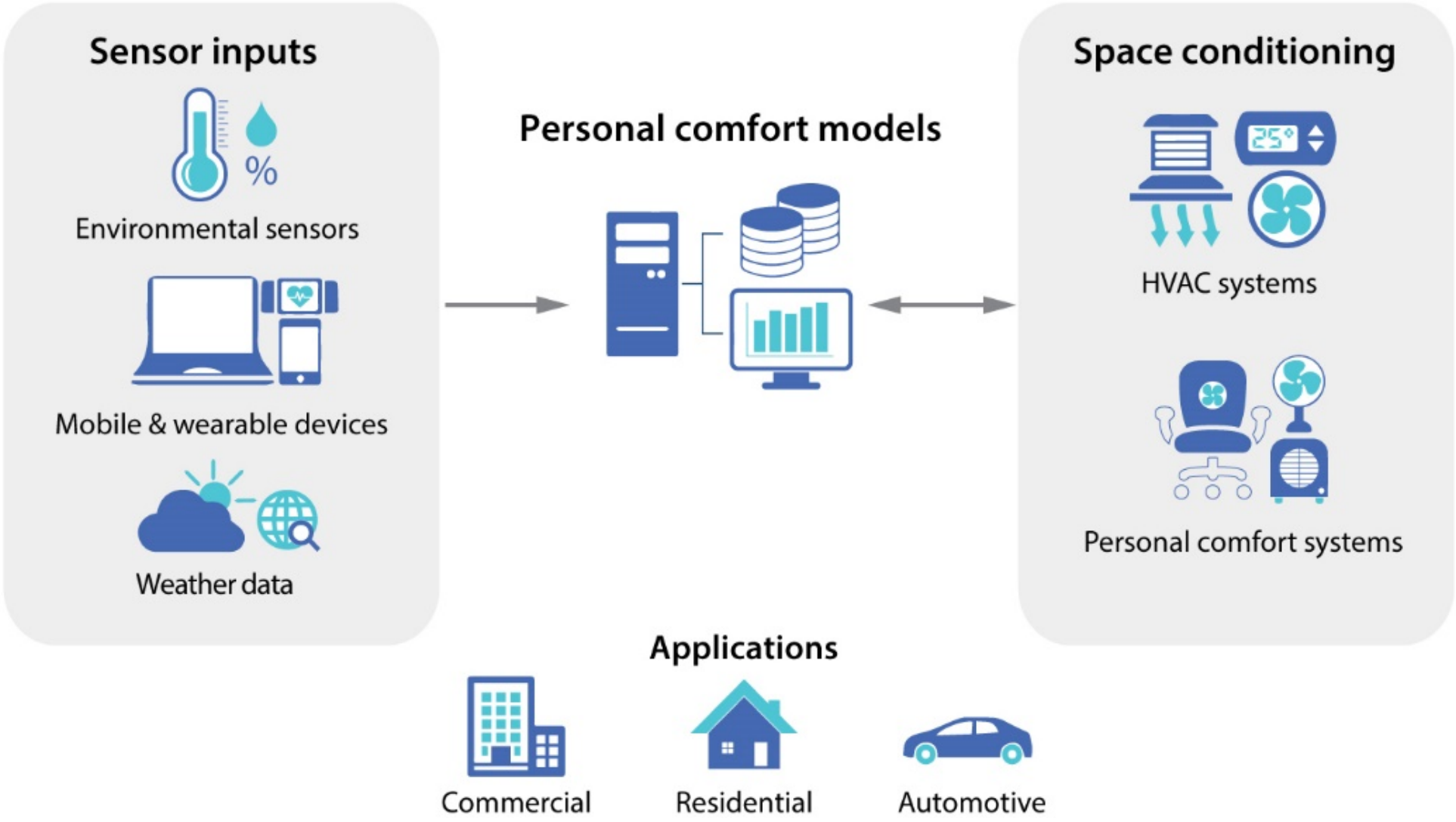




Personal comfort systems and models



Modified from Kim, Schiavon, Brager 2018 Personal comfort models - a new paradigm in thermal comfort Building and Environment

Conclusions

- Personal comfort models produce individual-specific and context-relevant predictions.
- They improve predictive power compared to PMV, Adaptive.
- The proposed framework provide a unified approach to develop and evaluate personal comfort models.
- Personal comfort models can be integrated into real-world systems (buildings, vehicles, aircraft, etc.) to enable intelligent comfort management.

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Questions

Joyce Kim joyce_kim@berkeley.edu

Stefano Schiavon schiavon@berkeley.edu