First results of case studies on thermal comfort and occupant behavior in office buildings in Amman/ Jordan

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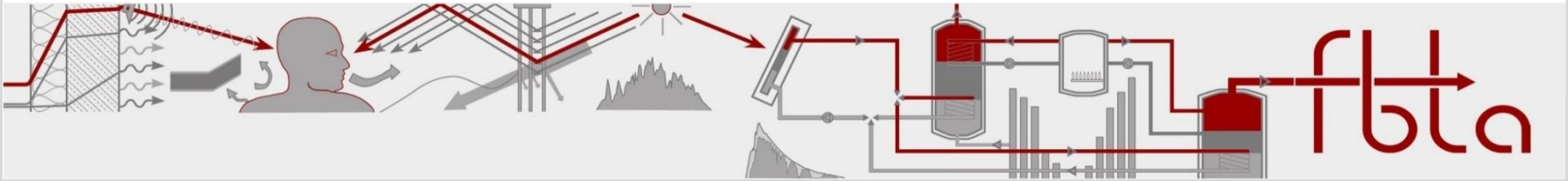


Research:

Development of Adaptive Thermal Comfort Model and Understanding the Effect of Perceived Control on Occupant's Satisfaction in Office Buildings in Amman/ Jordan

Objectives:

- The overall objective of this research is to investigate whether the Adaptive Thermal Comfort Models which are included in the ASHRAE 55 or EN 15251 standards, can be applied to an office workplace context under Jordan's climate conditions.
- Furthermore, this study aims to increase understanding of adaptive opportunities and perceived control at office workplaces.

- This presentation focuses on some first results on temperature perception and adaptive opportunities.

Overview of the buildings

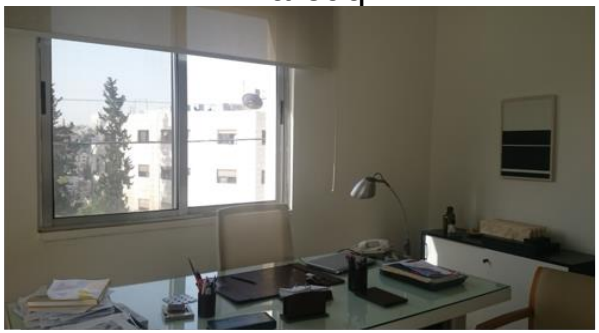
Photo of the building	Energy performance evidence	Adaptive opportunities	Type of offices
	World Health Organization (WHO) LEED 'Gold' completed in 2011	Room-wise adjustable thermostats Operable Windows Operable Shading Personal Fans/ Heaters Flexible Clothing	Single offices Multi person offices (2 -3 persons) open plans (Up to 12 persons)
	Middle East Insurance Company LEED 'Gold' completed in 2014	Room-wise adjustable thermostats Operable Windows Operable Shading	Single offices Multi person offices (2 -5 persons) Open plans (Up to 7 persons)
	Farouq Architects Traditional Building	Operable Windows Operable Shading Personal Fans/ Heaters Flexible Clothing	Single office and one open plan office shared between 6 persons

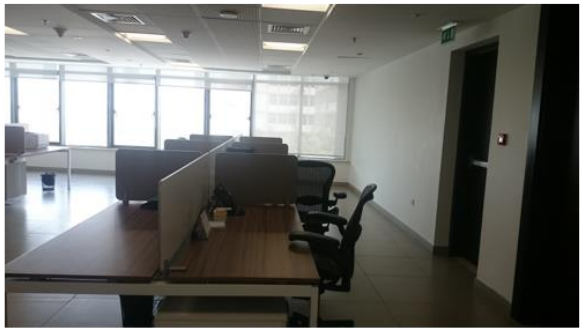
Interior environment of the buildings

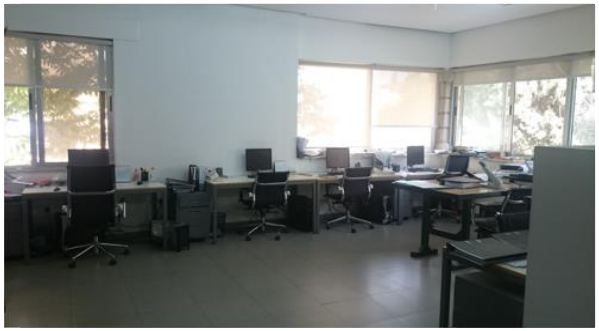
WHO

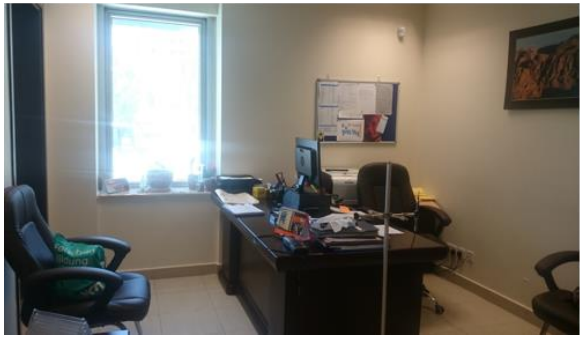
MEI

Farouq









Schedule of the surveys

April	May	June	July	August	September	October	November	December	January	February	March

3 Weeks survey
2 Days a week
Once a day
(initially twice a day, was changed to once a day)

Year 2016

3 Weeks survey
2 Days a week
Once a day

Year 2016

3 Weeks survey
2 Days a week
Once a day

Year 2016

3 Weeks survey
2 Days a week
Once a day

Year 2017

WHO building

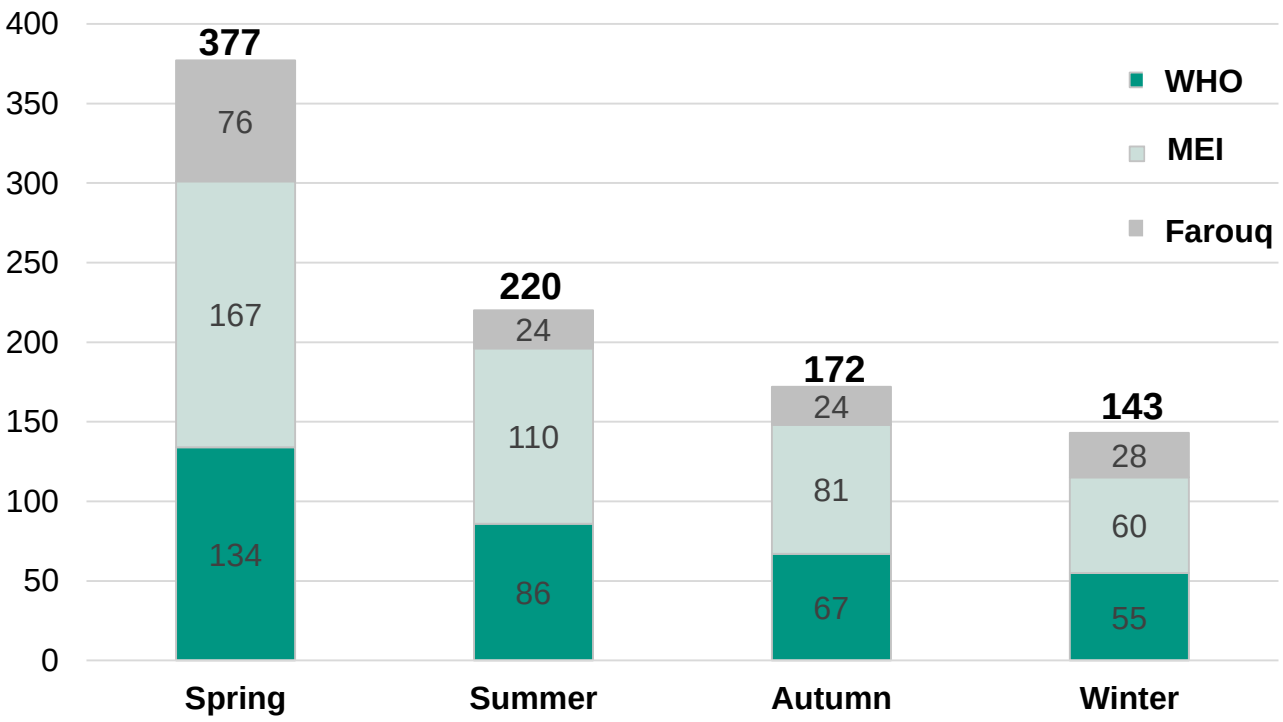
Week 1							Week 2							Week 3						
Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat

MEI building

Week 1							Week 2							Week 3						
Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat

Subjects and responses

Surveyed Buildings	Number of Subjects		
	Female	Male	Total
WHO	21	16	**37**
MEI	19	23	**42**
Farouq	4	3	**7**



Questionnaires

A- General questionnaire

B- Thermal comfort questionnaire

- Thermal sensation, acceptability and preference
- Self-assessment of the indoor air conditions
- Importance and need of change concerning comfort zones
- Behavioral opportunities and actions with respect to thermal comfort
- Perceived Control
- Clothing and metabolic rate.

Example from the thermal comfort questionnaire

Please write down the date and time when you start filling out the questionnaire

Date ___.___.2016 Time ____:____

1- At what time did you arrive in your office this morning?

2- How do you perceive the Air Temperature at the moment in your office?

cold	cool	slightly cool	neutral	slightly warm	warm	hot
☐	☐	☐	☐	☐	☐	☐

3- How do you prefer the Air Temperature at the moment in your office?

much cooler	cooler	no Change	warmer	much warmer
☐	☐	☐	☐	☐

4- How do you rate the temperature in your office?

not Comfortable	👎	☐	☐	☐	☐	☐	👍	Comfortable

5- How do you rate the Humidity in your office?

not Comfortable	👎	☐	☐	☐	☐	☐	👍	Comfortable

6- How do you perceive the Air Quality at the moment in your office?

very bad	👎	☐	☐	☐	☐	☐	👍	Very good

7- Do you perceive at the moment any air movement?

no	very slight	slight	strong	very strong
☐	☐	☐	☐	☐

13- What were the reasons you did not take the given 'options to control indoor climate?

	Wanted to exhaust other control options first	Was not agreeable to others in the space	Not sure if it would be OK with management	Not worth asking others' permission	Not worth obstruction to my work	Would not have helped	Cannot adjust option any further	No need- co worker did this	I was comfortable enough	Not Applicable
Operable window	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Door to interior space	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Door to exterior space	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Blinds	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Personal Fan	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Personal Heater	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Thermostat	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

14- How much control do you have to change 'the thermal conditions' of your office (at the moment)?

no control	☐	☐	☐	☐	☐	much control

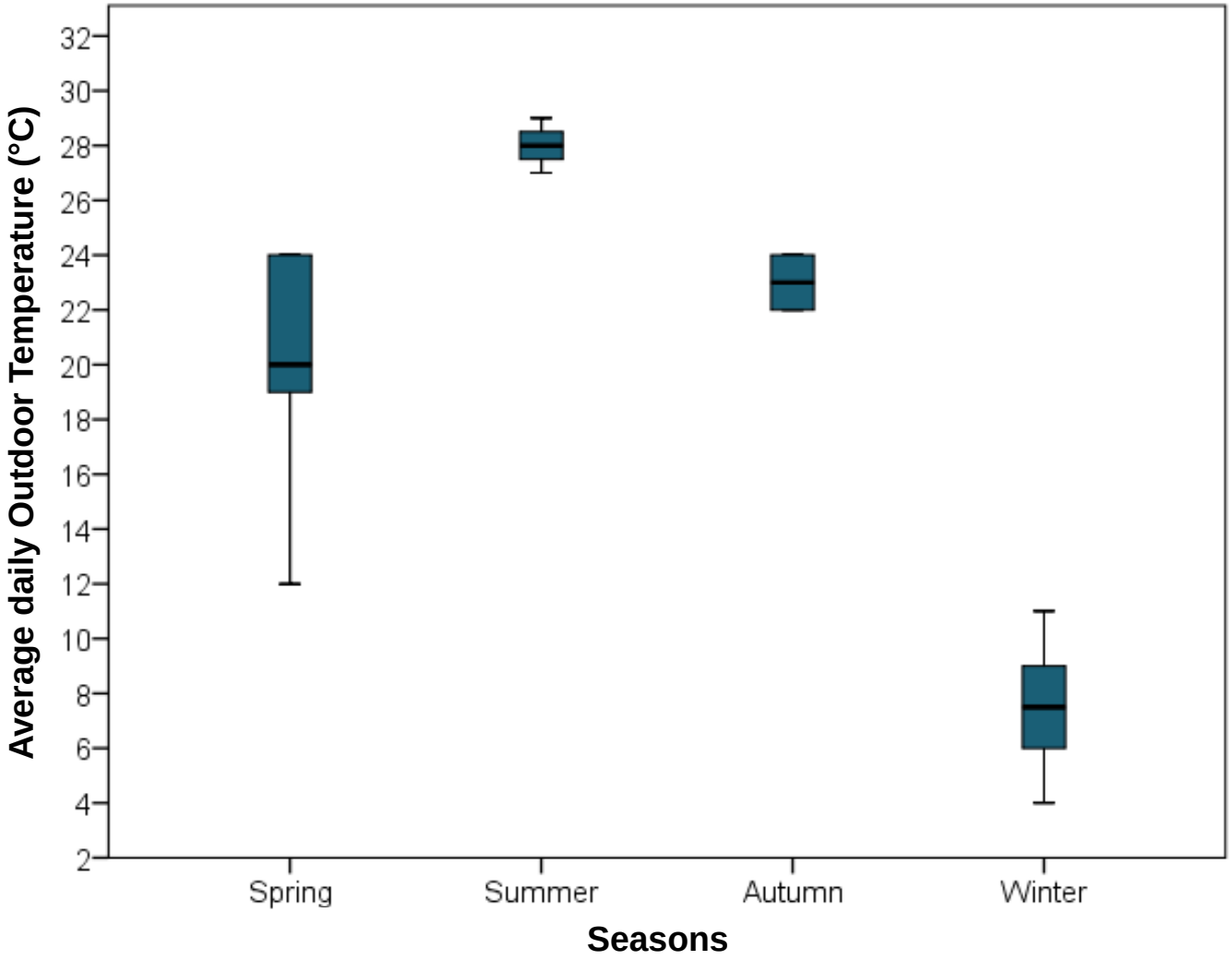
15- Would you like to have more control to change the indoor climate (at the moment)?

no control	☐	☐	☐	☐	☐	much control

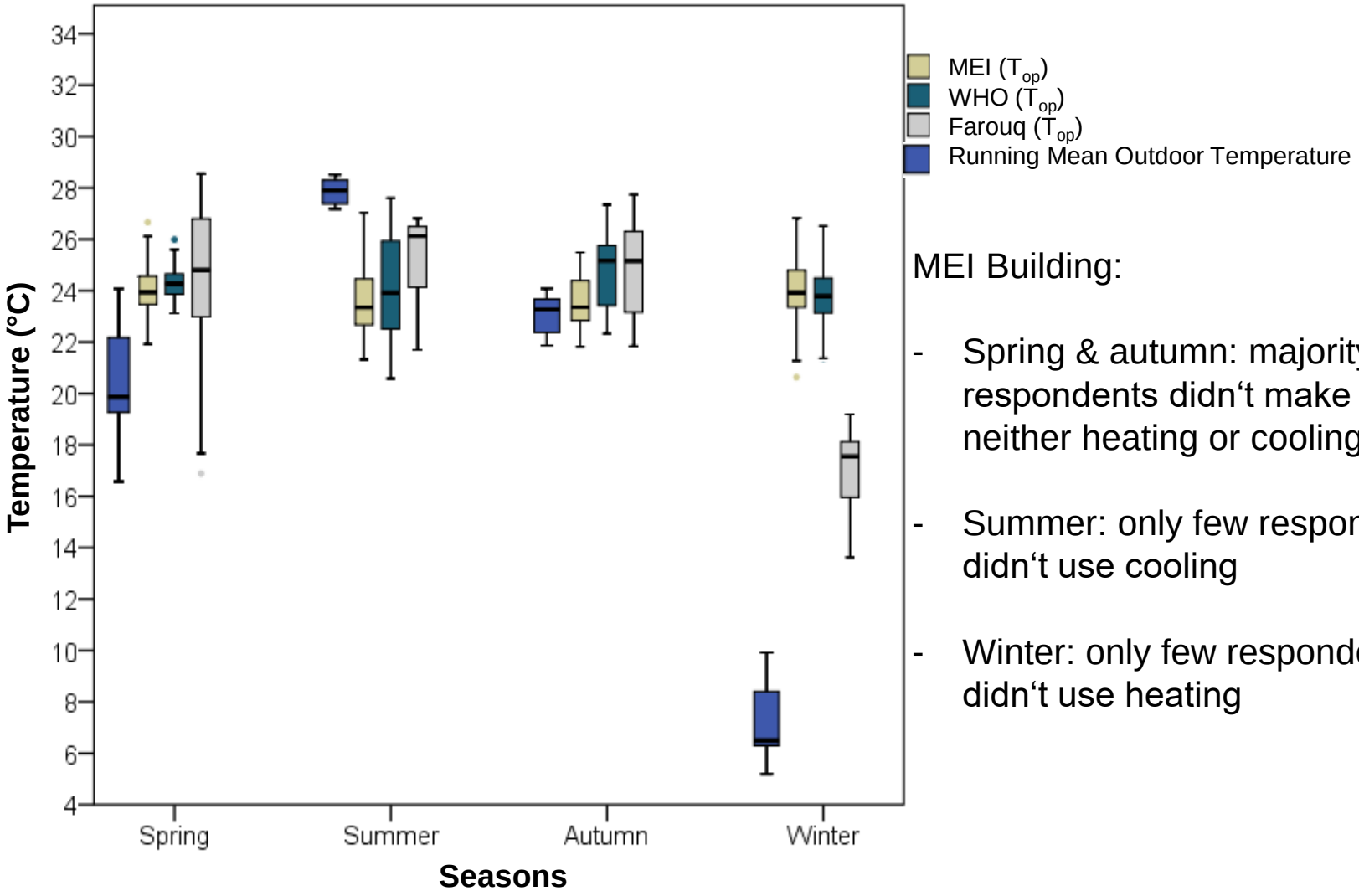
16- Do you prefer having control to adjust these 'options to control indoor climate (at the moment)?

	Yes	No
Operable window	☐	☐
Door to interior space	☐	☐
Door to exterior space	☐	☐
Blinds	☐	☐
Personal Fan	☐	☐
Personal Heater	☐	☐
Thermostat	☐	☐

Average daily outdoor temperature



Running mean outdoor and operative temperature

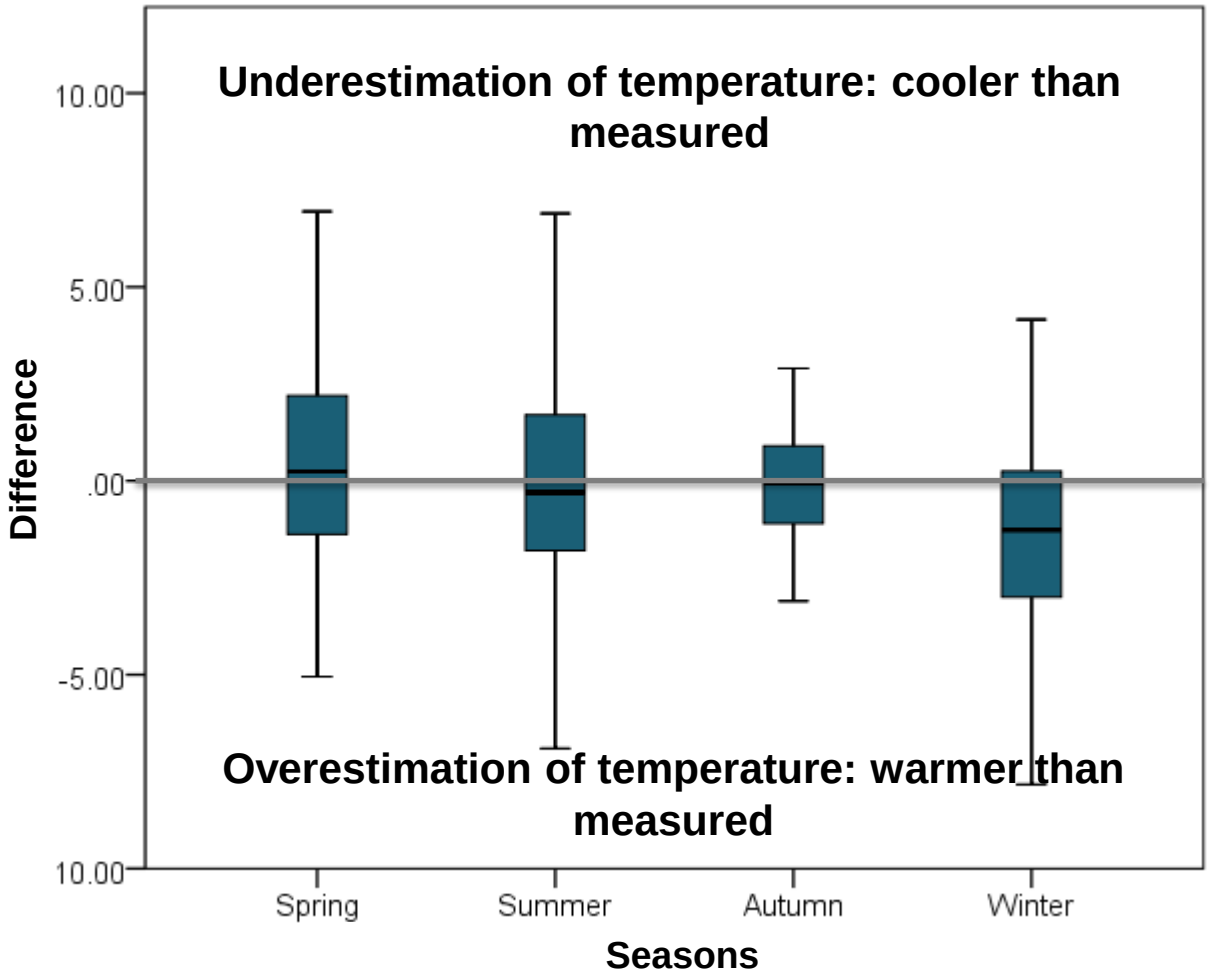


MEI Building:

- Spring & autumn: majority of respondents didn‘t make use of neither heating or cooling
- Summer: only few respondents didn‘t use cooling
- Winter: only few respondents didn‘t use heating

Guessed vs measured temperature- MEI

Please guess, how many degrees Celsius is the room temperature?



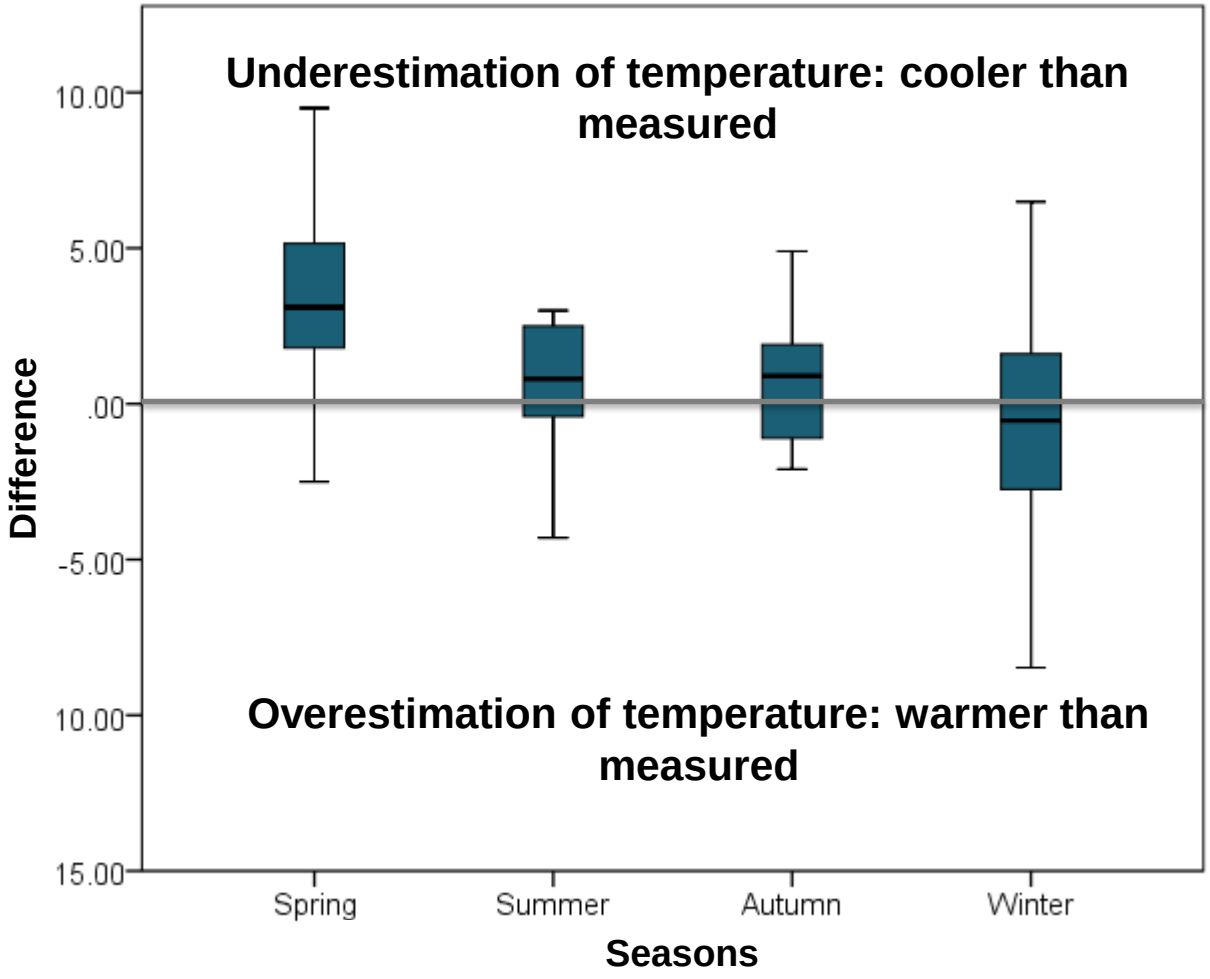
Difference=
Measured Temperature –
Guessed Temperature

Diff. > 0 → Underestimated

Diff. < 0 → Overestimated

Guessed vs measured temperature- Farouq

Please guess, how many degrees Celsius is the room temperature?



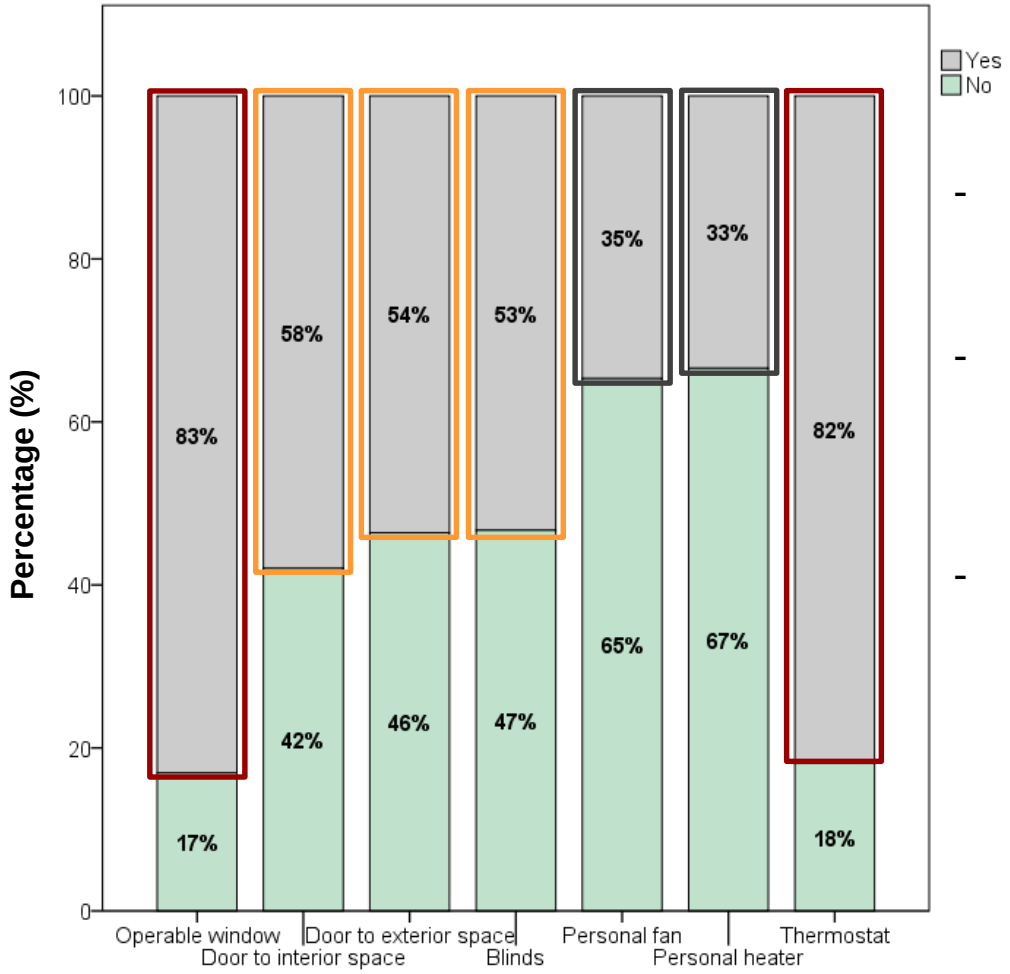
Difference=
Measured Temperature –
Guessed Temperature

Diff. > 0 → Underestimated

Diff. < 0 → Overestimated

Expectation and exercised control - MEI

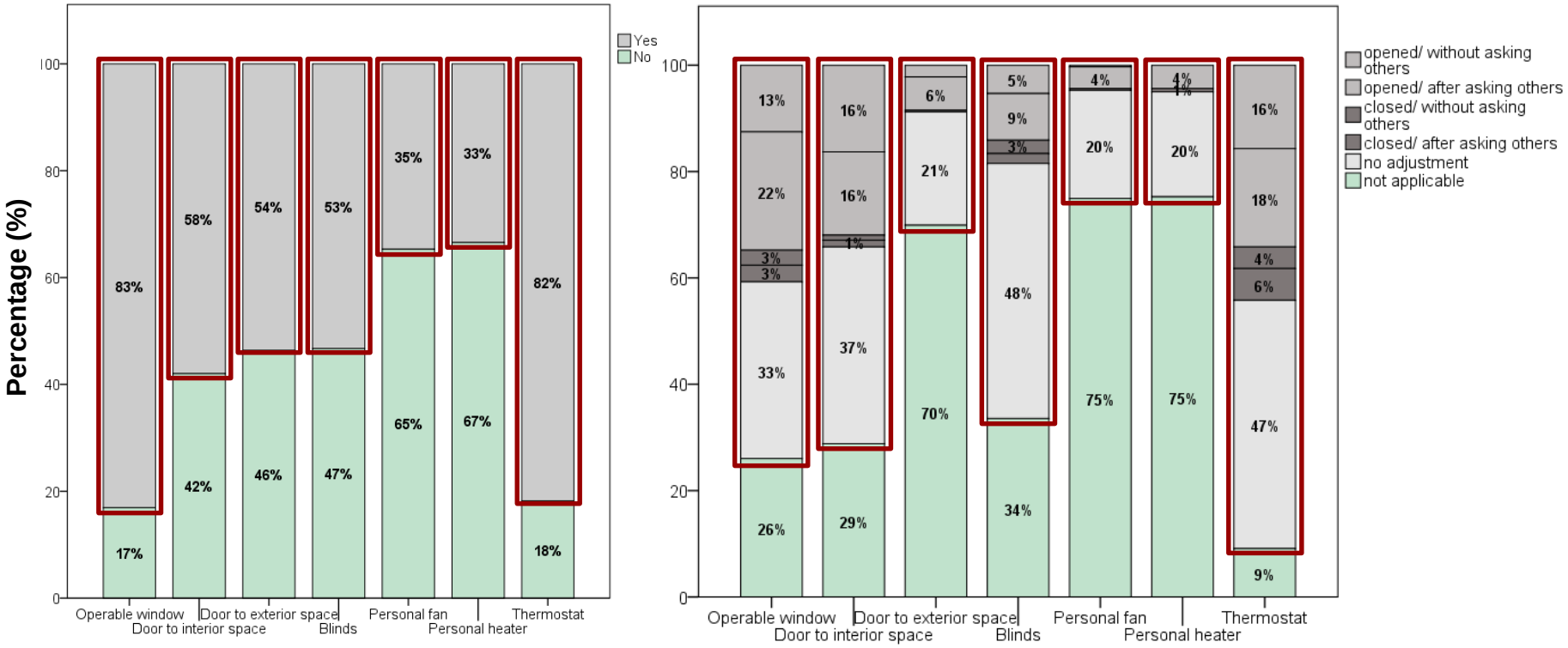
Expectation: Do you prefer having control to adjust these options to control indoor climate (at the moment)?



- **Circa 80% prefer having operable window and thermostat**
- **circa 50% prefer having door to interior space, door to exterior space and blinds**
- **circa 30% prefer having personal fan and personal heater**

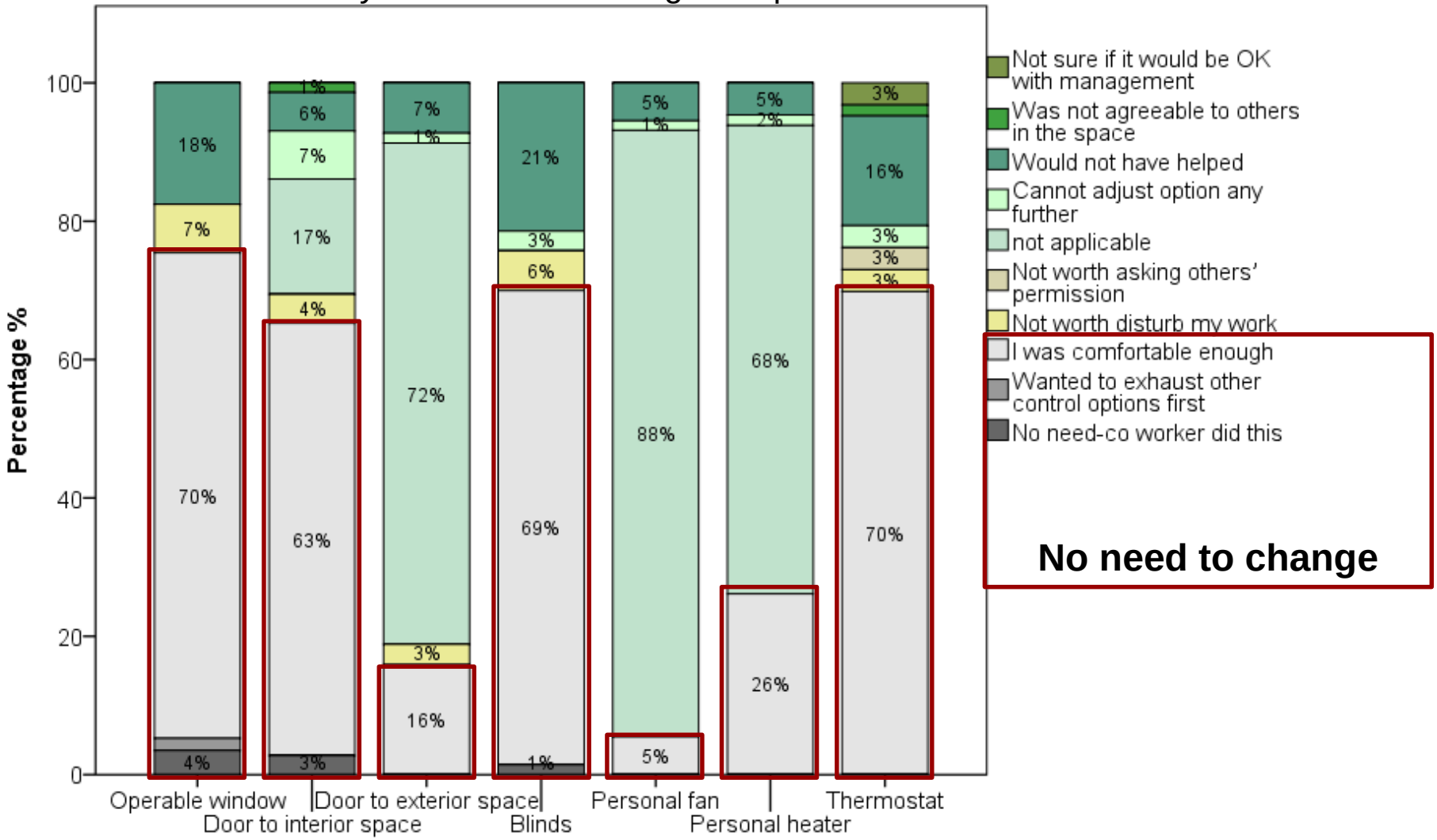
Expectation and exercised control - MEI

Exercised control: What type of adjustment did you make to the given options to control indoor climate during the last hours?



Reasons behind not taking control opportunities - MEI

What were the reasons you did not take the given options to control indoor climate?



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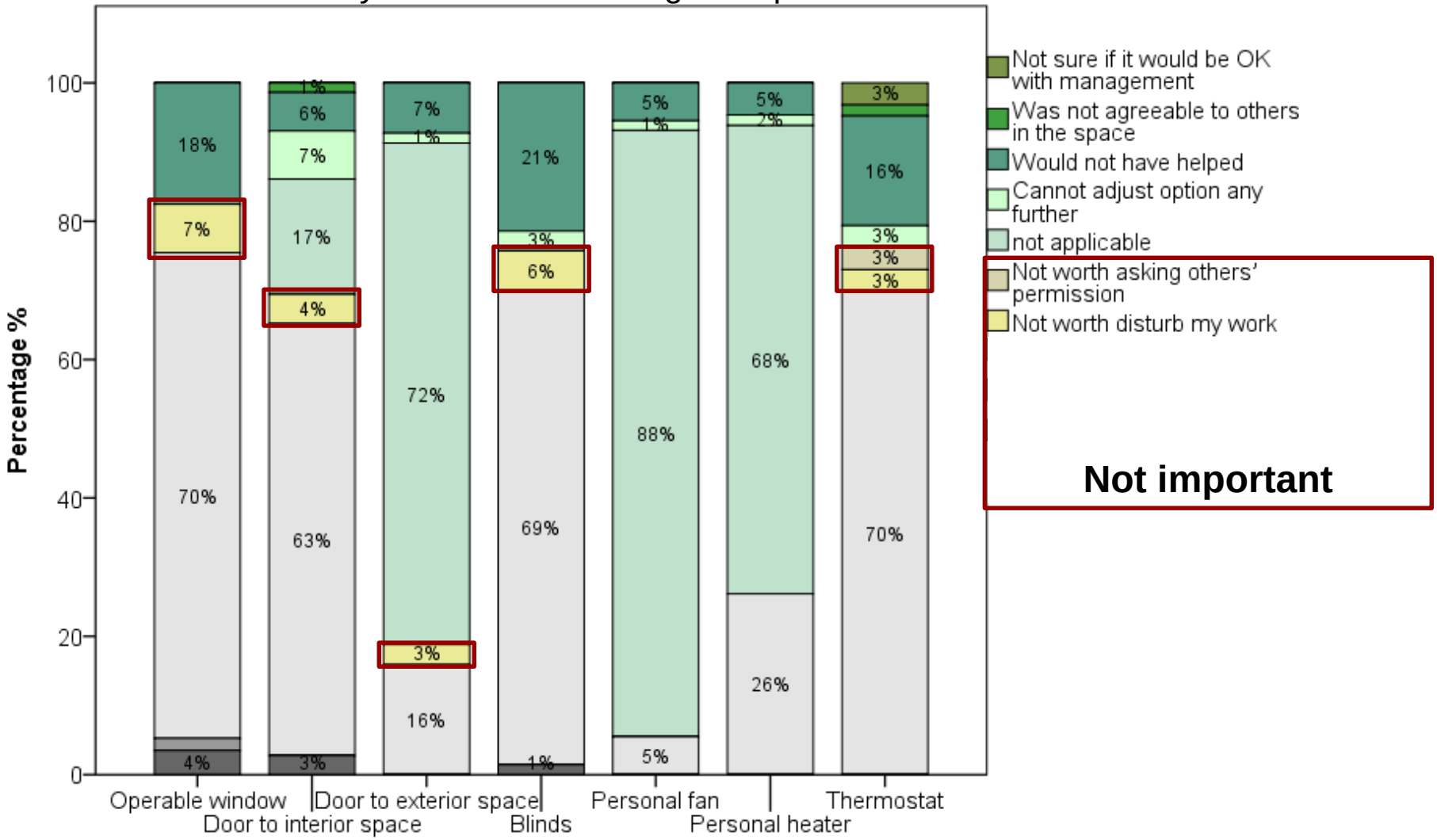

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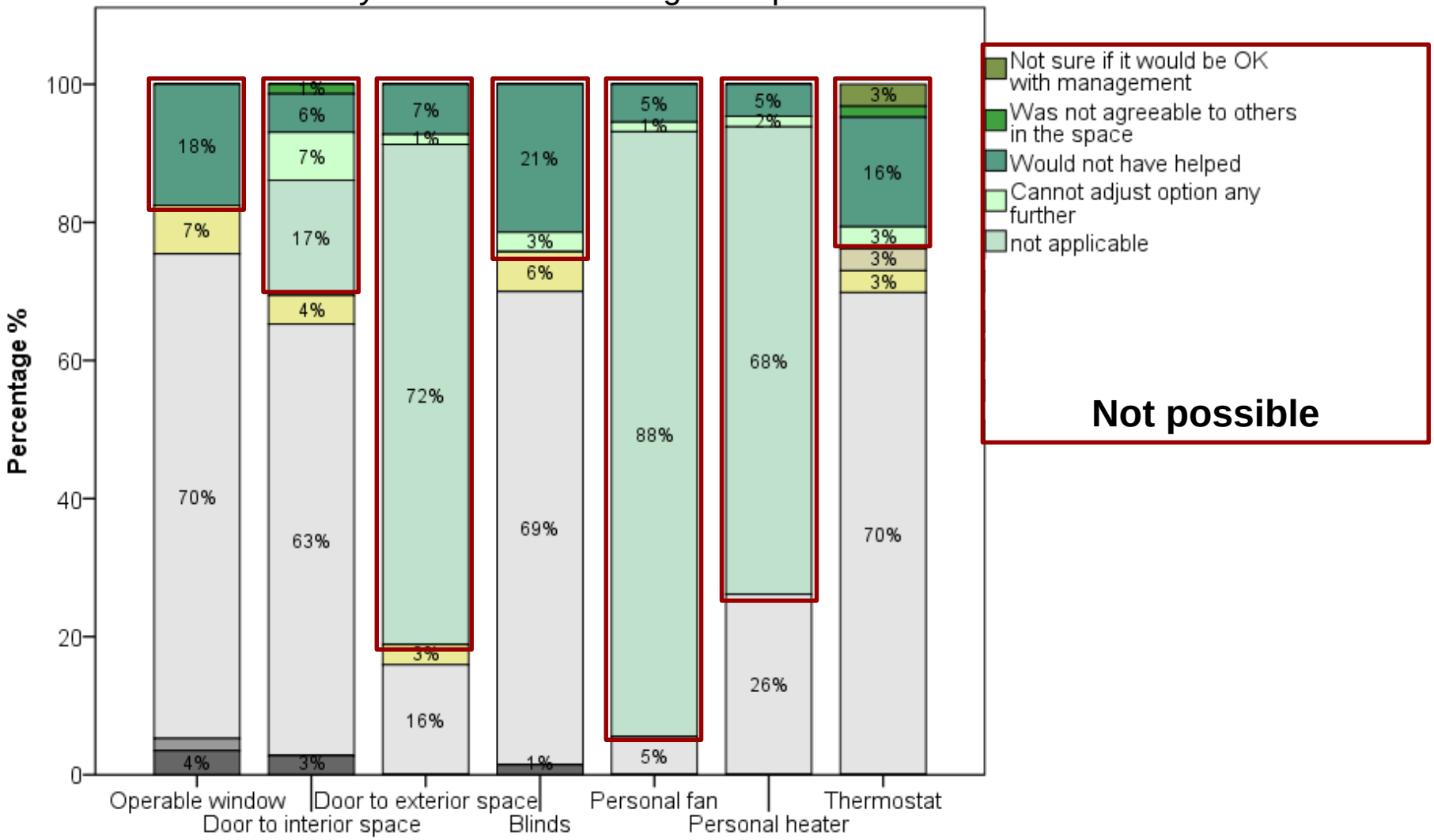

Summary

- For the mixed mode MEI building: temperature guesses are almost balanced between underestimation and overstimation of room temperature during spring, summer and autumn and with more guesses overestimating the temperature in winter.
- For the free running Farouq building: temperature guesses are almost balanced between underestimation and overstimation of room temperature during summer, autumn and winter and with more guesses underestimating the temperature in spring.
- Operable windows and thermostats are the most demanded adaptive opportunities.
- The highest percentage of responses reported to not taking any adaptive actions said they were comfortable.
- A considerable percentage of responses reported that the adaptive actions wouldn‘t have helped.

Outlook

- Taking advantage of the longtudinal approach especially the frequent responses of the same individuals.
- Further analysis on adaptive oppurtunities and perceived control in different seasons.
- investigate whether the Adaptive Thermal Comfort Models which are included in the ASHRAE 55 or EN 15251 standards, can be applied to an office workplace context under Jordan’s climate conditions.