Short-term acclimatization effects in an outdoor comfort study

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Presentation’s outline

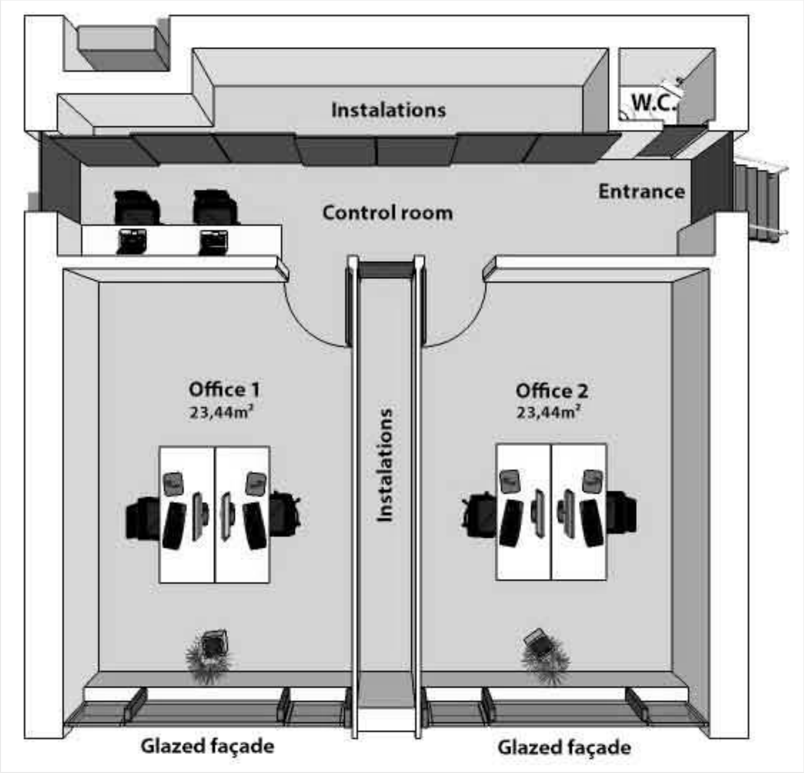
- Research purposes
- Field study
- Research methods
- Research outcomes

Research purposes

- **Purpose:** to investigate short-term acclimatization effects on a subject’s thermal perception outdoors. In addition, the effect of thermal expectation is evaluated, from the presence/absence of visual clues of the outdoor climatic conditions.

Experimental conditions

Climate chamber located at the Karlsruhe Institute of Technology (KIT): semi-controllable climate chamber with operable windows consisting of two adjacent office spaces with triple-paned windows and a window-to-wall ratio of approximately 75%. Innovative feature: chamber sits on top of a circular railway track, which allows it to rotate to diverse façade orientations.



Experimental conditions

Set-up and configurations

1. *16 participants (average height 1.80m, weight of 80kg and about 25 years old)*
2. *Insulative value of clothing 0.5 clo inside and 1.25 clo outside*
3. *Estimated indoor metabolic rate 1.2 Met, outdoors 2.3 Met (light walking condition)*
4. *Conditions monitored indoors and outdoors: air temperature, humidity and speed and globe temperature*
5. *Time period inside the chamber: 5-hour acclimation period, followed by a 30-minute permanency outdoors*
6. *Standard comfort questionnaire administered at three different timestamps: 1) immediately after leaving the test chamber; 2) after 15 minutes of light walk around the facility; and 3) after further 15 minutes walking outside.*
7. *Thermal index for indoors PMV (ISO 7730); for outdoors UTCI index*

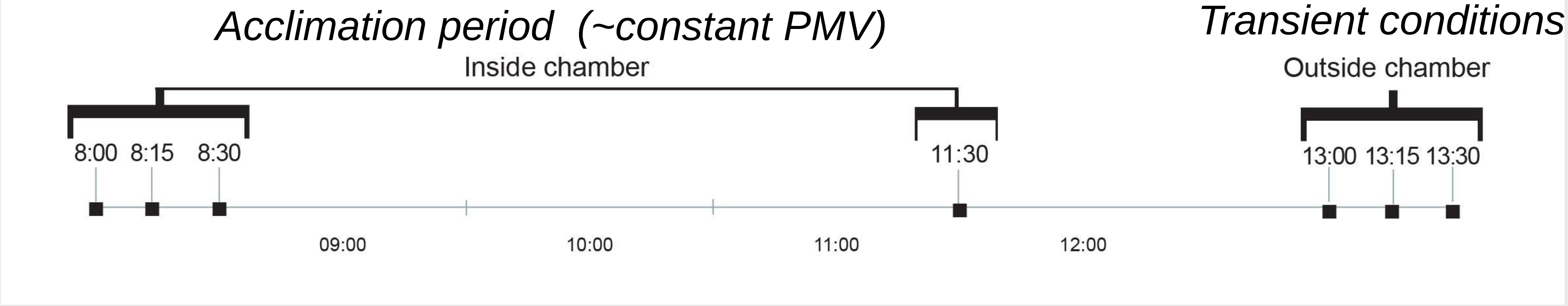
Experimental conditions

Tab 1 – Breakdown of sessions and configurations

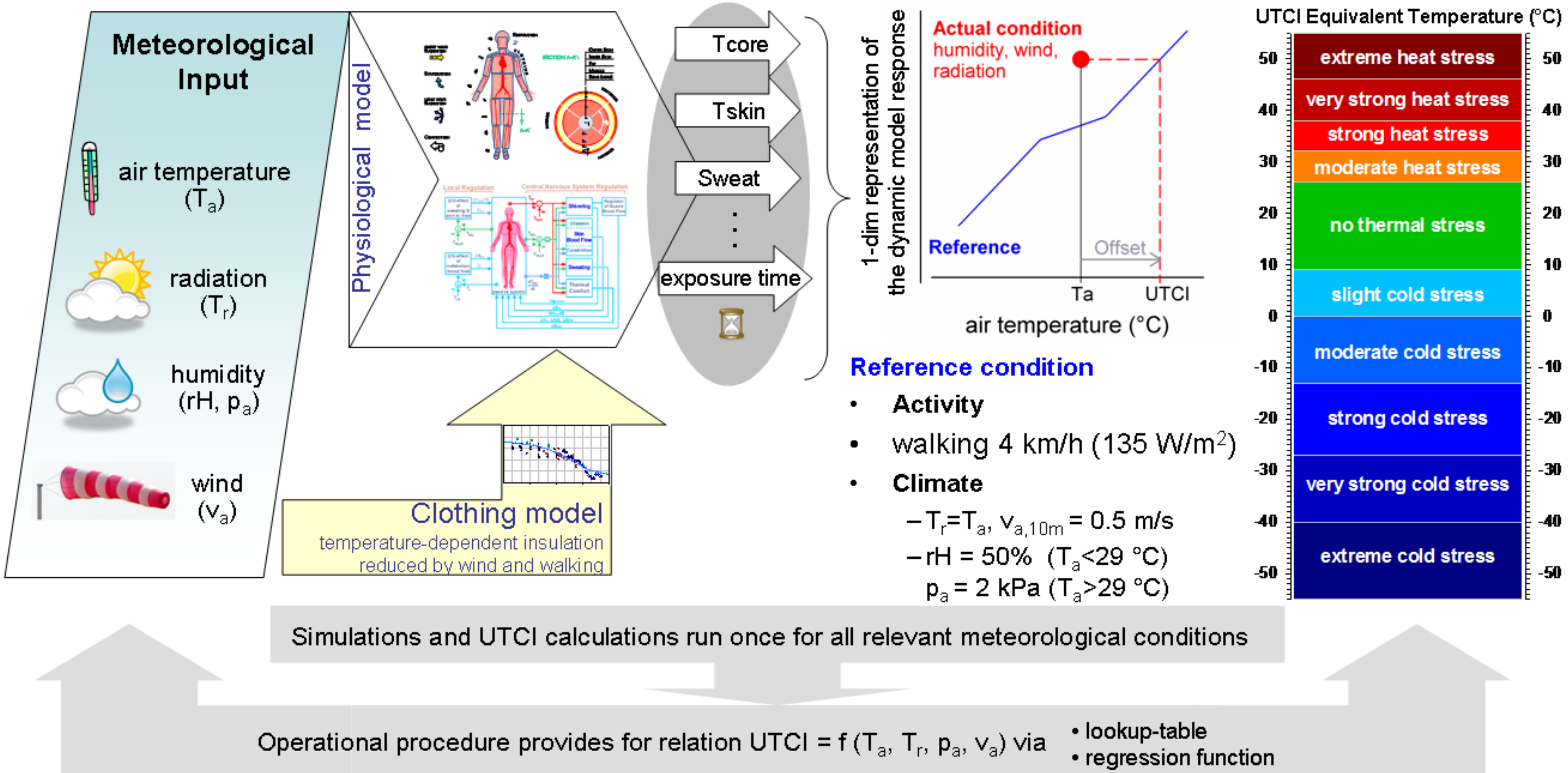
Office configuration	**Dates**
NW orientation of the glazing	15th, 21st, 28th January, 3rd February
SW orientation of the glazing	13th, 22nd, 27th January, 4th February
Shading device on window (external louvers)	14th, 20th, 29th January, 5th February

Statistical significance was tested either by means of the mixed-model ANOVA for repeated measurements (Littell et al. 1996) or by applying the F-test for testing the equality of variances combined with a t-test for determining the statistical significance of the pair-wise differences found at the 0.05 significance level.

Schedule for filling in the thermal comfort questionnaire



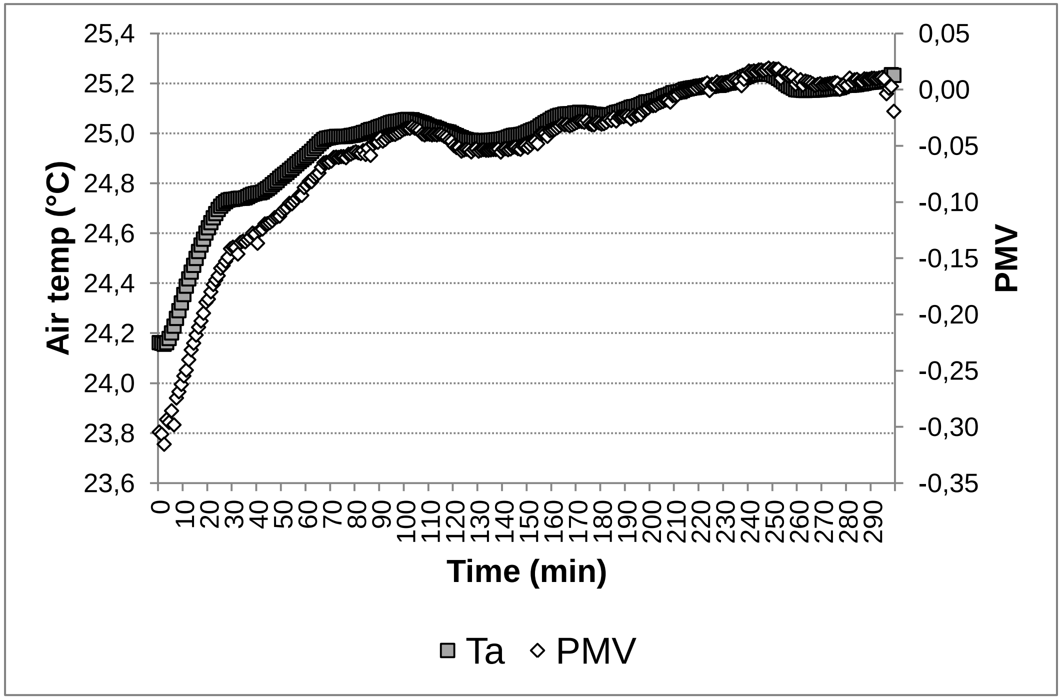
UTCI concept and elements



Results

PMV control indoors

Stable thermal conditions, with a short, gradual warm-up phase in the first hour and no significant changes in PMV during the next four hours. When subjects went to outdoor environment, mean PMV was just around the thermal condition (PMV=0). At that moment, in all sessions (12 days/each office) PMV ranged -0.5 to +0.2.



Results

Reported Thermal Sensation Outdoors

The majority of thermal votes (*n=16 particip ×3 days ×3 timestamps=144 TS votes*) obtained outdoors lie within the cold discomfort range (23% of the votes for “-3”, 36% for “-2” and 29% for “-1”) with a few votes in thermal neutrality (12%).

Comparison of Thermal Sensation Votes (TSV) in three timestamps

	Timestamp 1	Timestamp 2	Timestamp 3
Mean	-1,59	-1,70	-1,72
SD	1,02	0,88	1,10
Minimum	-3	-3	-3
Maximum	1	0	0

Results

UTCI calculations versus reported thermal votes

Values of UTCI values did not change significantly with exposure time, as indicated by P-value = 0.259 in the mixed-model ANOVA.

UTCI showed a large variation between the 12 days, with values on one day lying within the “Thermal Comfort Zone” of 18ºC<UTCI<26ºC (Bröde et al. 2013), cold stress (UTCI<9ºC) observed on 9 days and intermediate stress on 2 days.

Results

UTCI calculations versus reported thermal votes

DTS scale corresponds to the 7-point scale used in the surveys; the mean for the whole sample (n=36, i.e. three timestamps distributed over 12 days) closely resembles reported TSV. Descriptive statistics for the three timestamps show a somewhat lower predicted mean DTS and corresponding minimum-maximum interval for timestamp 3, relative to the immediate exposure of the participants to the outdoor thermal conditions. UTCI values drop accordingly; larger fluctuations were found for the third timestamp.

UTCI and predicted DTS for the three timestamps

	Timestamp 1		Timestamp 2		Timestamp 3	
	UTCI	DTS	UTCI	DTS	UTCI	DTS
Mean	5,34	-1,73	4,91	-1,76	4,67	-1,76
SD	6,13	0,56	6,06	0,54	6,86	0,62
Minimum	0,54	-2,08	-0,68	-2,20	-2,54	-2,33
Maximum	20,77	-0,20	19,60	-0,33	21,54	-0,10

Results

UTCI/DTS calculations versus reported thermal votes

When comparing the individual thermal sensation votes (TSV) against the predicted DTS, **the mean bias of estimate (DTS-TSV) diminishes with time of exposure**. The first thermal sensation vote, reported immediately after the subject had left the chamber, had a slightly higher mean error indicating a slight underestimation bias of the index, and a higher fluctuation (range and standard deviation) than at timestamp 3, when the subjects had been for half an hour outdoors.

Mean bias of estimate (DTS-TSV) for the three timestamps

	Timestamp 1	Timestamp 2	Timestamp 3
Mean	**-0,17**	-0,05	**-0,04**
SD	1,08	0,73	0,90
Minimum	-1,80	-1,23	-1,08
Maximum	3,08	1,25	2,08

Results

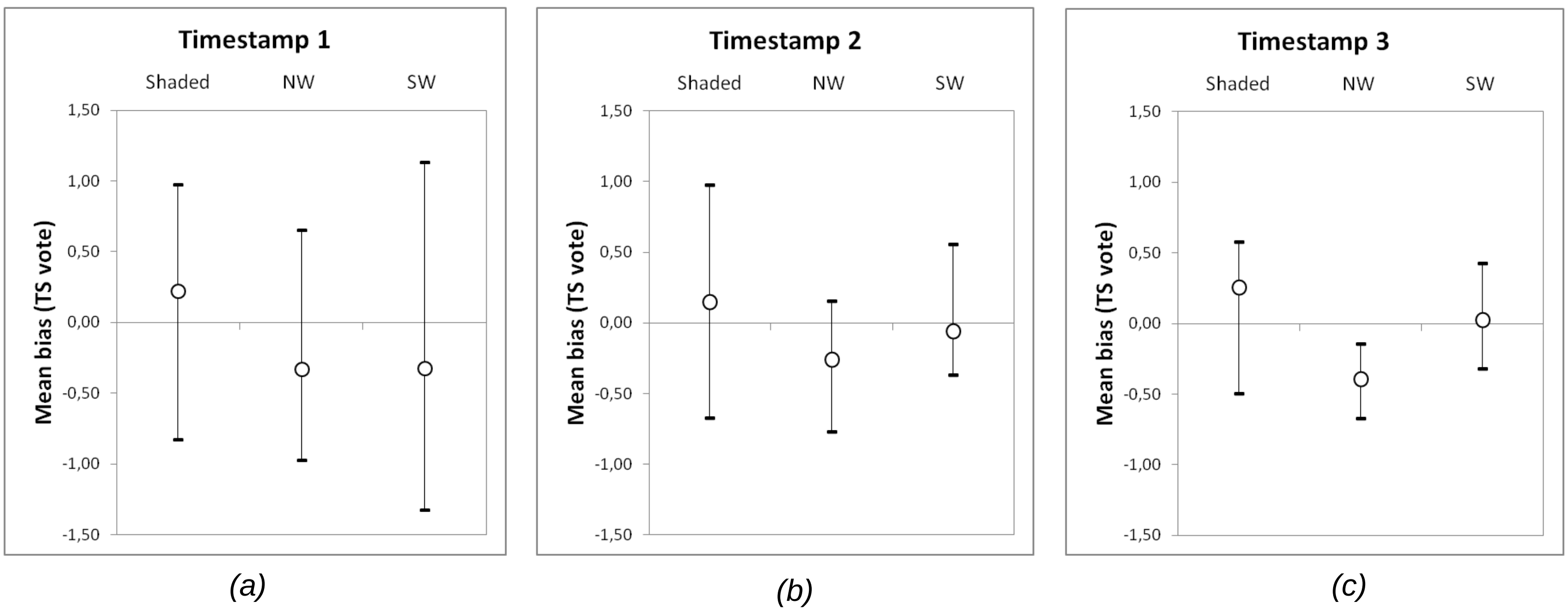
Effect of psychological expectation

The participants had three different configurations regarding the view to the outdoor environment: obstructed window (use of shading element, external louvers); view from a southwest glazing orientation **(more daylight)**; view to a northwest exposure **(less daylight)**.

Averages of the mean bias between predicted and reported thermal sensation votes using UTCI suggest that **a blocked window for the winter season would translate to an overestimation of the “actual” thermal sensation whereas the “sunniest” façade (SW) would bring a closer match between reported and predicted thermal sensation.**

Results

Effect of psychological expectation



Mean bias (DTS-TSV) with minimum and maximum bias as error bars for the three window configurations, a) immediately after leaving the chamber @ timestamp 1; b) after 15 minutes @ timestamp 2; c) after 30 minutes @ timestamp 3

Discussion

- *Höppe (2002) showed the use of steady-state models would be inadequate for outdoors, since the time needed to reach steady-state conditions in physiological terms would be longer than the usual time periods spent outside. In this study, we compare TSV against predicted thermal sensation with the non-steady state index UTCI. Results suggest that the longer exposure time will reduce mean bias of the estimates.*

- *Consistent with previous research on transient indoor conditions (de Dear et al. 1993) indicating that, when moving from indoors to outdoors during winter time, the initial thermal sensation responses could be biased against cooler TSV.*

➢ ***Take-home message 1: in outdoor comfort campaigns occupancy is a sensitive issue!***

Discussion

- *The effects of viewing conditions could be related to changes in visual comfort, which may have an effect on thermal comfort. However, this has to be followed by future studies.*

➢ ***Take-home message 2: visual clues are an important aspect of thermal expectation***

- *The reported survey was carried out during the winter season; the data base has already been be extended by campaigns under warmer spring and summer conditions (including the current heat wave episodes), which will allow more concrete conclusions to be drawn.*

Merci, Thank you!

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