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Outdoor thermal comfort - experimental investigations on two recreational urban spaces in Szeged, Hungary

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Study area

Szeged, Hungary
46°N, 20°E
82 m a.s.l.
temperate warm climate


ADY SQUARE


HONVÉD SQUARE

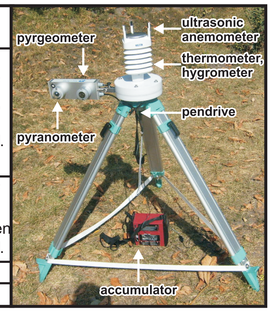
location	inner city	inner city
size	ca. 5500 m^2	ca. 6000 m^2
surface cover	grass	gravel, grass
vegetation	young and old trees	old trees
shading conditions	different	mainly penumbra
function	resting place	resting place, playground
visitors	mainly students	all age groups

- 2009: 14 investigation days in early **autumn** Ady: 9 days / Honvéd: 5 days
- 2010: 15 investigation days in late **sring** Ady: 7 days / Honvéd: 8 days

In the early afternoon: from **12 to 3 p.m.**
Simultan conducted on-sie meteorological measurements and questionnaires

Meteorological measurements

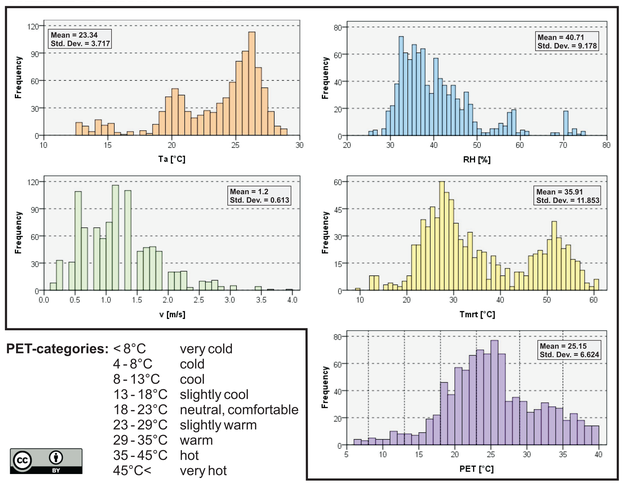
MEASURED PARAMETER	INSTRUMENT	
air temperature **Ta [°C]**	THERMOCAP thermometer	as part of WXT 520, Vaisala, 1.2 m a.g.l.
relative humidity **RH [%]**	HUMICAP hygrometer	
wind speed **v [m/s]**	WINDCAP anemometer	
short-wave radiation K [W/m^2]	CM 3 pyranometer	as part of CNR 1, Kipp & Zonen 1.1 m a.g.l.
long-wave radiation L [W/m^2]	CG 3 pyrgeometer	
data recording	pendrive	
averaging period	1 min	



CALCULATED PARAMETERS

Tmrt [°C] mean radiant temperature (from the individual K & L fluxes)
PET [°C] physiologically equivalent temperature (from Ta, RH, v and Tmrt)

THERMAL ENVIRONMENT



PET-categories:

< 8°C	very cold
4 - 8°C	cold
8 - 13°C	cool
13 - 18°C	slightly cool
18 - 23°C	neutral, comfortable
23 - 29°C	slightly warm
29 - 35°C	warm
35 - 45°C	hot
45°C<	very hot

Questionnaires

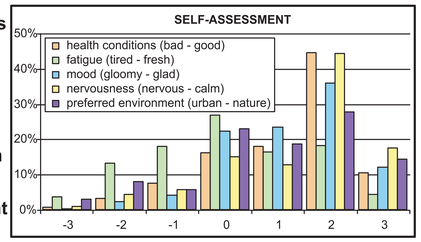
Ca. 3-5 min / interview, 967 filled questionnaires / 29 days
Interviewees near by the meteorological station - same solar exposure

PERSONAL FACTORS

Demographics	Behaviour	Health conditions	Life style
gender	clothing	cardiovascular diseases	smoking
age	solar exposure	blood pressure	alcohol consumption
height	activity	pulmonary diseases	caffeine consumption
weight	body posture	pollinosis	sport
		weather front sensitivity	

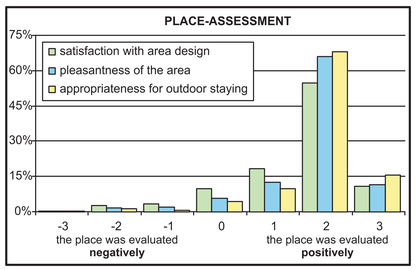
7-point semantic differential scales were used to measure the level of:

- overall **health conditions**
- general feelings:
  fatigue
  mood
  nervousness
- urban vs. open-air person attitude:
  preferred environment



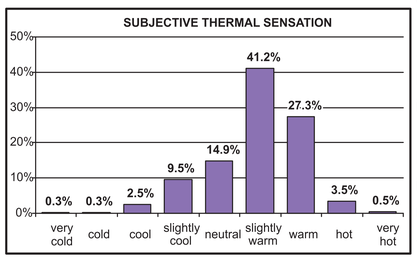
SUBJECTIVE ASSESSMENTS

Different semantic differential scales were used to measure the visitors' **subjective evaluations** of the **place** and the **thermal environment:**



PLACE-ASSESSMENTS
- satisfaction with the **design** of the area
- **pleasantness** of the area
- the area's **adequacy** for **outdoor** staying

7-point scales

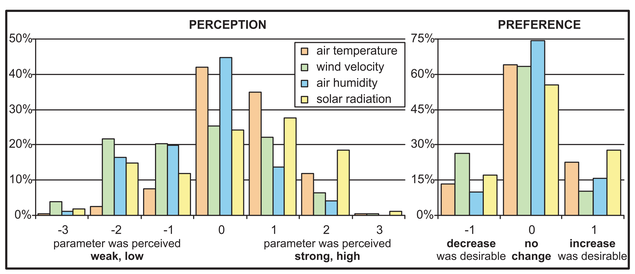


ASSESSMENTS OF THE MOMENTARY THERMAL CONDITIONS

Thermal sensation
9 main nominal categories

Perceptions of the individual **climate parameters**
7-point scales

Preferences for changes in the case of these **climate parameters**
3-point scales



Statistical analyses

DEPENDENCE OF THE INDIVIDUAL CLIMATE PARAMETER PERCEPTIONS, PREFERENCES AND THE THERMAL SENSATION ON THE...

SUBJECTIVE ASSESSMENTS OF THE THERMAL ENVIRONMENT

Spearman's rho (ρ) rank-correlation coefficient were used to reveal significant interrelationships between the subjective evaluations of the thermal environment, and to show the influence of the momentary thermal conditions and personal parameters on these assessments (N=967).

perceptions (-3, -2, -1, 0, 1, 2, 3)				preferences (-1, 0, 1)				(-4 ... 4)		
air temperat.	wind velocity	air humidity	solar radiation	air temperat.	wind velocity	air humidity	solar radiation	thermal sensation		N = 967
	-0.132	-0.153	0.505	-0.482	0.267	0.094	-0.390	0.558	ρ	air temperature
	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	α	perception
		0.115	-0.045	0.209	-0.415	0.015	0.161	-0.182	ρ	wind velocity
		0.000	0.166	0.000	0.000	0.631	0.000	0.000	α	perception
			-0.179	0.151	-0.007	-0.365	0.187	-0.163	ρ	air humidity
			0.000	0.000	0.822	0.000	0.000	0.000	α	perception
				-0.370	0.218	0.137	-0.457	0.502	ρ	solar radiation
				0.000	0.000	0.000	0.000	0.000	α	perception
					-0.403	-0.113	0.565	-0.417	ρ	air temperature
					0.000	0.000	0.000	0.000	α	preference
						0.098	-0.297	0.283	ρ	wind velocity
						0.002	0.000	0.000	α	preference
							-0.162	0.090	ρ	air humidity
							0.000	0.005	α	preference
								-0.356	ρ	solar radiation
								0.000	α	preference
									ρ	thermal sensation
									α	

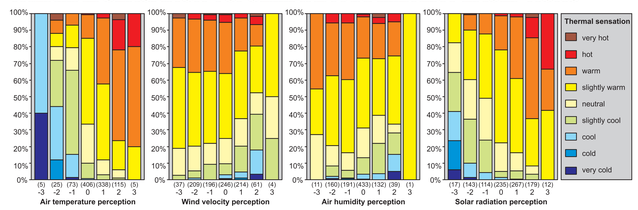
THERMAL ENVIRONMENT

measured parameters			calculated parameters		N = 967	
Ta [°C]	v [m/s]	RH [%]	Tmrt [°C]	PET [°C]		
0.321	**-0.087**	**-0.110**	**0.384**	**0.478**	ρ	air temperature
0.000	0.007	0.001	0.000	0.000	α	perception
-0.277	**0.345**	**-0.012**	**0.007**	**-0.218**	ρ	wind velocity
0.000	0.000	0.700	0.839	0.000	α	perception
-0.245	**0.005**	**0.172**	**-0.132**	**-0.204**	ρ	air humidity
0.000	0.870	0.000	0.000	0.000	α	perception
0.160	**0.056**	**-0.208**	**0.492**	**0.450**	ρ	solar radiation
0.000	0.080	0.000	0.000	0.000	α	perception
-0.441	**0.184**	**0.052**	**-0.187**	**-0.407**	ρ	air temperature
0.000	0.000	0.105	0.000	0.000	α	preference
0.324	**-0.300**	**-0.010**	**0.061**	**0.295**	ρ	wind velocity
0.000	0.000	0.759	0.057	0.000	α	preference
0.123	**0.001**	**-0.153**	**0.098**	**0.138**	ρ	air humidity
0.000	0.979	0.000	0.002	0.000	α	preference
-0.372	**0.088**	**0.172**	**-0.265**	**-0.400**	ρ	solar radiation
0.000	0.006	0.000	0.000	0.000	α	preference
0.262	**-0.087**	**-0.115**	**0.442**	**0.507**	ρ	thermal sensation
0.000	0.007	0.000	0.000	0.000	α	

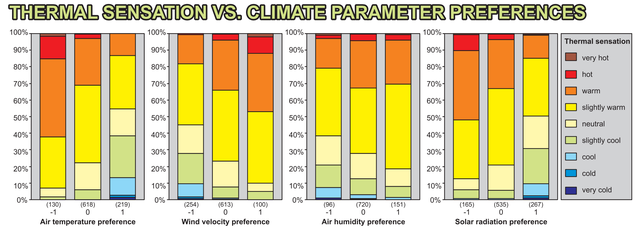
PERSONAL FACTORS

self-assessments (-3, -2, -1, 0, 1, 2, 3)					
health cond.	fatigue	mood	nervousn.	preferred environm.	
0.047	**0.075**	**0.063**	**0.054**	**0.062**	ρ
0.148	0.020	0.050	0.286	0.054	α
-0.025	**-0.059**	**0.051**	**-0.006**	**-0.012**	ρ
0.430	0.231	0.114	0.850	0.702	α
-0.010	**0.020**	**0.026**	**-0.013**	**0.023**	ρ
0.763	0.530	0.416	0.680	0.478	α
0.008	**0.053**	**0.011**	**0.025**	**-0.071**	ρ
0.988	0.100	0.743	0.441	0.511	α
0.042	**0.054**	**0.105**	**0.024**	**0.055**	ρ
0.190	0.094	0.001	0.460	0.273	α
0.019	**0.024**	**-0.044**	**-0.013**	**-0.012**	ρ
0.556	0.458	0.170	0.690	0.709	α
-0.011	**-0.077**	**-0.003**	**-0.052**	**0.078**	ρ
0.730	0.017	0.934	0.109	0.015	α
0.051	**0.049**	**0.058**	**-0.001**	**0.020**	ρ
0.110	0.125	0.074	0.971	0.526	α
0.082	**0.034**	**0.039**	**0.078**	**0.040**	ρ
0.011	0.286	0.229	0.016	0.214	α

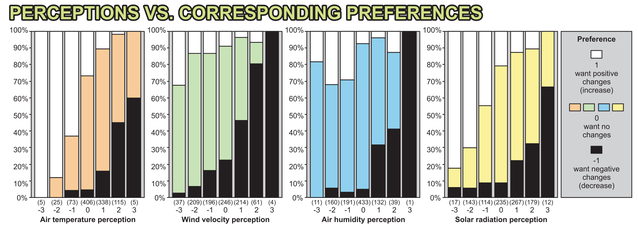
THERMAL SENSATION VS. CLIMATE PARAMETER PERCEPTIONS



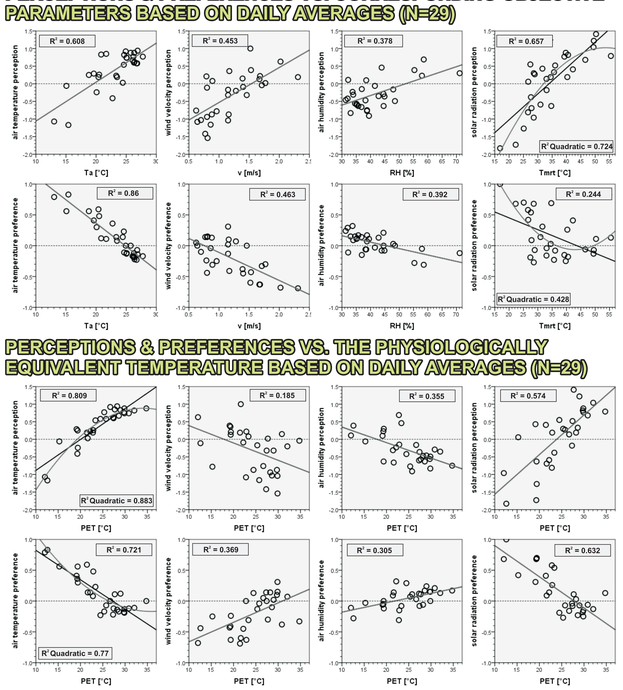
THERMAL SENSATION VS. CLIMATE PARAMETER PREFERENCES



PERCEPTIONS VS. CORRESPONDING PREFERENCES

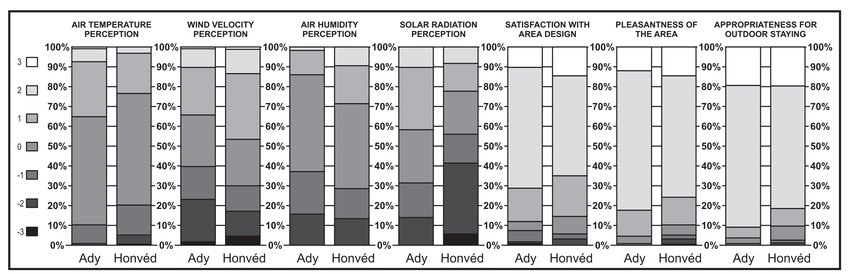


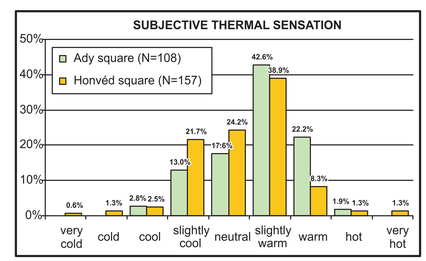
PERCEPTIONS & PREFERENCES VS. CORRESPONDING OBJECTIVE PARAMETERS BASED ON DAILY AVERAGES (N=29)



PERCEPTIONS & PREFERENCES VS. THE PHYSIOLOGICALLY EQUIVALENT TEMPERATURE BASED ON DAILY AVERAGES (N=29)

COMPARISON OF THE INVESTIGATED AREAS IN THE COMFORTABLE PET-RANGE (18-23°C)





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