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Objective and subjective aspects of an urban square's human comfort - case study in Szeged (Hungary) -

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Abstract

This paper deals with the first comprehensive thermal comfort study made in the centre of Szeged, a southern Hungarian town. We calculated the *Predicted Mean Vote* index with the RayMan model from measured meteorological parameters (objective approach). Within the frameworks of a simultaneously conducted social survey people estimated their thermal comfort (*Actual Sensation Vote*), so we could compare these subjective values with the objective results. We recorded also a number of subjective features on questionnaires in order to determine which factors influence the thermal comfort the most.

1. Introduction

Due to the increasing urbanization people spend less and less time in the open air. City parks and squares could play an important role in the recreation and outdoor activities of city-dwellers. But what makes a given (urban) public space appropriate? To answer this question thorough human biometeorological examination of the factors behind the outdoor thermal sensation (or rather thermal comfort) is necessary.

This includes not only objective approach based on comfort indices. Since thermal sensation – especially in the open air – depends on countless variables (see on Fig. 1) application of subjective approach is needed too (Eliasson et al., 2007; Knez and Thorsson, 2006; Nikolopoulou and Steemers, 2003). This paper outlines the methods and some of the issues of the first complex Hungarian case study made in Szeged in summer.

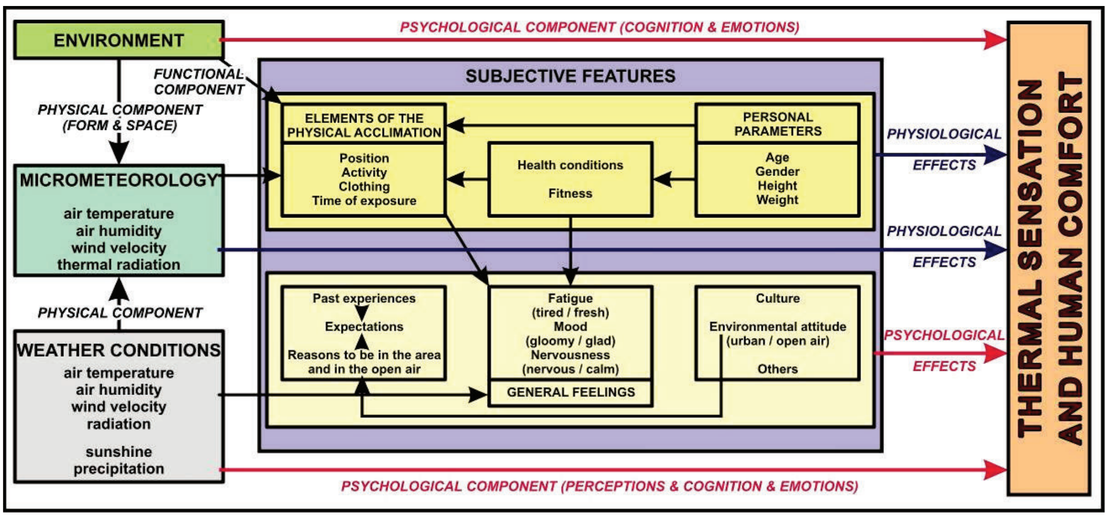

Fig. 1: Factors influencing the thermal sensation as well as human comfort and their relationships with each other

2. Case study in Szeged

Szeged (Fig. 2) (46°15’N, 20°16’E) belongs to the Köppen's Cf (warm-temperate with even distribution of precipitation) or the Trewartha's D.1 (continental climate with longer warm season) climate zone. We took our examinations at the Aradi square (Figs. 2 and 3) on 17th and 22nd August and 12th of September 2006 from 11.00 am to 4.00 pm. The area of the square is about 7300 m^2. Its west side is covered with pavement among grass courts, the east side is dominated by asphalt cover, and plenty of trees give shadow in the vegetation period on both side.

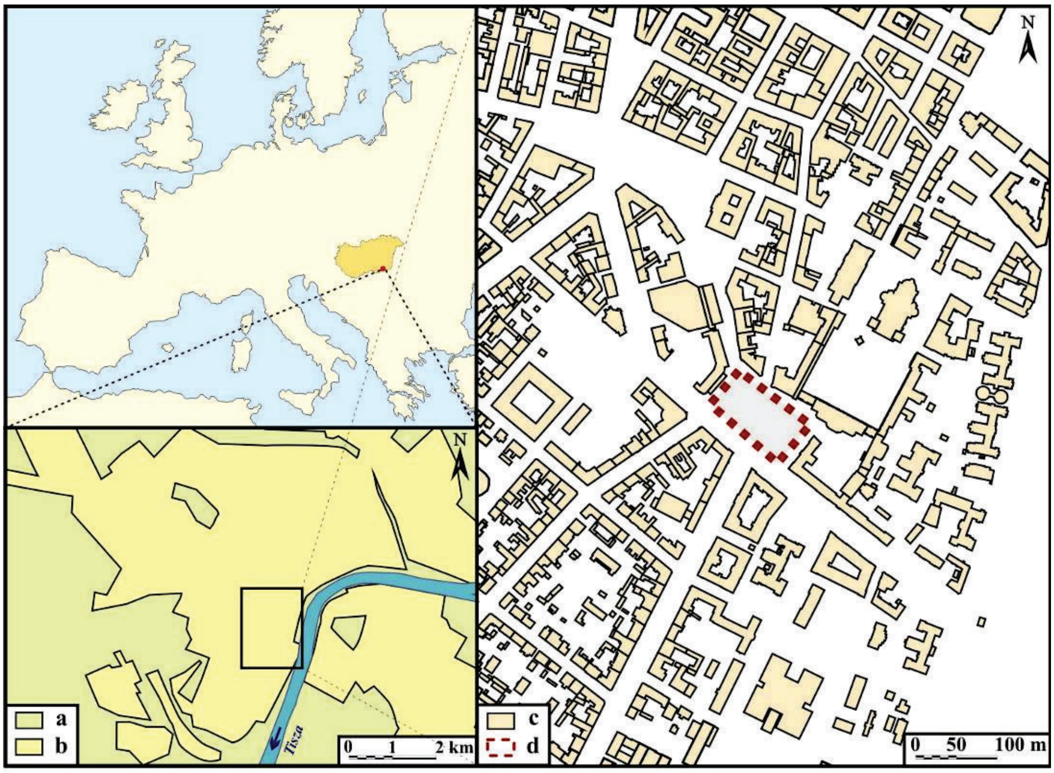

Fig. 2: Location of Szeged in Hungary as well as the location of the examined Aradi square: (a) open area, (b) built-up area, (c) buildings, (d) border of the study area

Fig. 3: Photos taken at the examination area

3. Objective approach

Meteorological parameters were recorded on the square by a station which was exposed to direct radiation during the measuring period. The *Predicted Mean Vote* index was calculated from the 10 minutes averages of air temperature, relative humidity, wind velocity and global radiation. *PMV* predicts the mean assessment of the thermal environment for a large sample of humans with values according to the ASHRAE comfort scale (Fig. 4).

For the index calculation the RayMan model was used (Gulyás et al., 2006). This model needs surface morphological (3D data of buildings and trees) and personal data too. The calculation was taken on a 35 years old, weight of 75 kg and 1.75 m high, sedentary man in light summer clothing (0.5 clo).

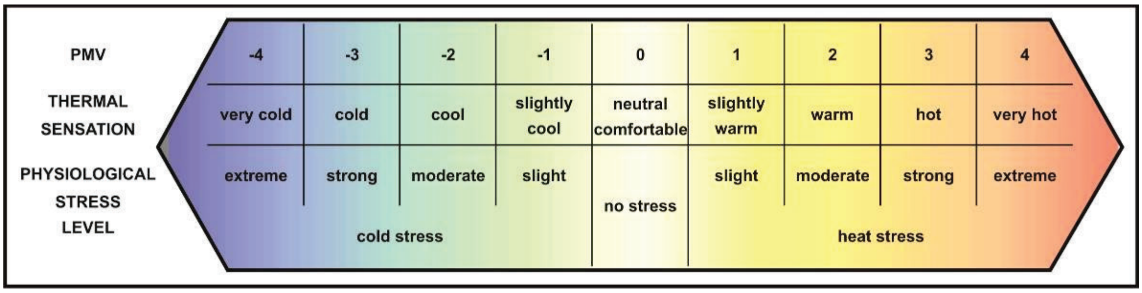

Fig. 4: PMV ranges for different thermal sensations and physiological stress levels

4. Subjective approach

Simultaneously with the meteorological measurements a social survey was conducted with structured interviews. 410 questionnaires were filled with the answers from randomly selected people during the three days.

First we recorded the starting time of the interviews, then we noted some personal features and asked people (among others) about their general feelings and environmental attitude (Table 1). At the end, interviewees estimated their thermal comfort according to a 9 point scale ranging from -4 (very cold) to +4 (very hot), with a score of 0 rating as comfortable (by analogy with scale on the Fig. 4). This value is referred to as *Actual Sensation Vote – ASV* (Knez and Thorsson, 2006).

Table 1: List of the subjective variables recorded during the interviews

<table>
<tr><td rowspan="4">personal features</td><td>position</td><td>sun / shade</td><td rowspan="3">general feelings</td><td>fatigue</td><td>tired / fresh</td></tr>
<tr><td>activity</td><td>sit / stand / walk</td><td>mood</td><td>gloomy / glad</td></tr>
<tr><td>gender</td><td>male / female</td><td>nervousness</td><td>nervous / calm</td></tr>
<tr><td>age</td><td>different age groups</td><td colspan="2">environmental attitude</td><td>urban / open air</td></tr>
</table>

5. Results

We will answer to the following questions:

i. To what extent predict the calculated *PMV* values the subjective thermal sensation of people?

ii. Which subjective parameters influence significantly the human thermal comfort?

The tendency between the participants' *ASV* and the *PMV* values belong to the time of the interviews looks very well. Since the high number of subjects (n = 410) the value of $R^2 = 0.2$ means a significant ($\alpha = 1\%$) relationship between the objective and subjective measures of the thermal sensation. However, due to the multifarious subjects the scatter of the *ASV* values at a given *PMV* is great, and the latter predicts more unacceptable thermal conditions on the whole (Fig. 5).

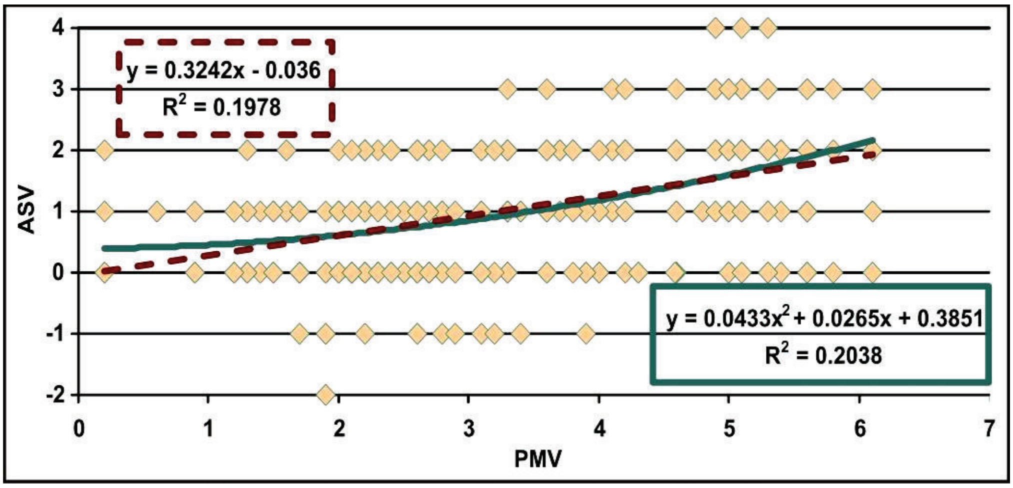

Fig. 5: The people's *ASV* in the function of the momentary *PMV* according to the data from the three investigated days

Fig. 6 shows the *ASV* distributions of the various groups of people according to the subjective parameters. Subjects, who were sitting had more frequently *ASV* values of 0 than standing and walking interviewees (Fig. 6/a). Likewise, people stayed in the shade and were less tired felt themselves more comfortable according to their lower *ASV* values, than the others (Fig. 6/c, e).

Women and the elder interviewees seem to react more sensitively against the thermal extremities - the "hot" and "very hot" votes occurred more frequently in these groups. However it should be noticed, that also negative *ASV* values appeared in the same groups often than in the cases of males and younger participants (Fig. 6/b, d).

In the case of environmental attitude we did not found strong correlation with the thermal comfort (Fig. 6/h). Since the sample sizes were too little in the groups "gloomy" and "nervous" we could not make valid comparisons in the cases of subject's mood and nervousness. Presumably the lower number of interviewees makes the distributions largely different in the mentioned groups (Fig. 6/f, g).

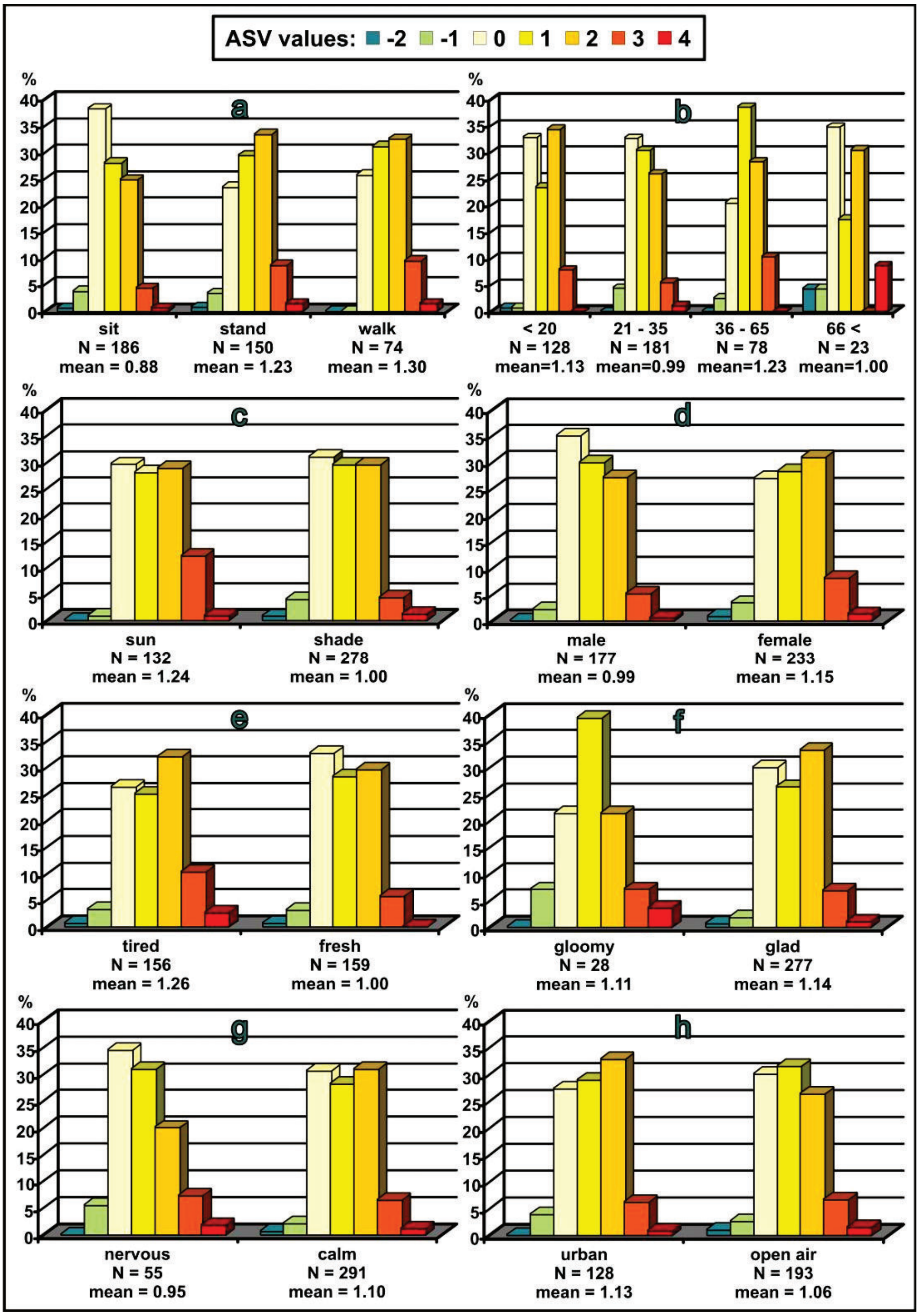

Fig. 6: *ASV* distributions according to the examined subjective parameters: (a) activity, (b) age, (c) position, (d) gender, (e) fatigue, (f) mood, (g) nervousness and (f) environmental attitude

To find out which personal features have significant effects on the thermal sensation the Spearman's correlation coefficient was used (since the ordinal nature of the variables).

Significant effects on *ASV* were found only in the cases of the activity (R = -0.094, α = 5%), the position (R = 0.173, α = 1%) and the fatigue (R = 0.109, α = 5%).

6. Conclusions

The participants' comfort level was better than the more extreme *PMV* values predicted (Fig. 5). This indicates the people's higher tolerance against the thermal extremities in the outdoor environment, presumably thanks to the psychological reactions triggered by the open air environment (naturalness, environmental stimulation etc.) (Nikolopoulou and Steemers, 2003). On the other hand, *PMV* values were calculated from meteorological data measured on the sun, since the two-thirds of the interviewees avoided the sunny places. During the time of (summer) heat people are looking for shadow as part of the naturally physical acclimatization. The visitors dwell longer on a public space if it offers variable microclimatic conditions and shading principally by trees (like the examined Aradi square).

We needed much more interviews to conduct as well as more sophisticated and detailed questionnaires to use if we will obtain a comprehensive picture on the comfort conditions evolved in an open air environment. Principal parts of our future studies will be the people's perceptions about the examined public spaces (design, orientation etc), as these factors also influence the open air human comfort − besides the micro-bioclimatological conditions.

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