

Microclimate perception analysis through cognitive mapping

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Abstract

Outdoor thermal comfort is not only determined by microclimate, but also by perceptual factors. As environmental psychology has brought forward, people develop cognitive “schemata” about the physical settings they are exposed to. It can be assumed that this mechanism influences thermal perception as well.

To investigate this question a research project has been conducted in Dutch urban public spaces. This firstly revealed that people’s long-term microclimate experience is predominantly based on more extreme microclimate situations and secondly that people assign microclimate schemata to certain spatial configurations. Microclimate perception in relation to spatial perception often matches quite well with physical reality, but this is not always the case. Therefore, these results question the purely physical methods (measurements or simulations) normally used to map microclimate preceding urban redesign projects. To calibrate the physical approach with an experiential approach to thermal comfort a cognitive mapping method is proposed. This time- efficient method can be similar to the one used in the research project described in this paper and brings about easily usable results for the urban designer because they are explicit and place-related.

Keywords: outdoor comfort, experience, schema, spatial configuration, cognitive mapping

1. Introduction

The perception of sojourn quality of urban outdoor places is determined by psychological and physical parameters. For the acceptance or avoidance of urban places microclimate plays an important role and extensive research has been conducted in this field with respect to the physical factors [1,2,3,4].

However, the psychological factors that determine thermal comfort, have not gained sufficient attention yet. Only recently some important studies that took these factors into account were conducted such as the extensive research project on the Actual Sensation Vote (ASV) [5,6] or studies on the influence of culture or personal backgrounds on climate perception [7,8]. Yet, for the urban designer the outcome of these studies yields only few applicable results because they do not focus on spatial issues that can be influenced by urban design.

Consequently the research project presented in this paper was launched focussing on the relation of the physical environment with thermal perception that can lead to concrete spatial design guidelines.

The results of these inquiries described in section 2 and 3 will help to support the main objective of this paper: the evaluation of the method of “cognitive mapping” that was used in this project. This method was applied to gather information on people’s microclimate perception in urban spaces. The paper will conclude with an assessment of the usefulness of this method in the analysis and inventory phase preceding urban re-design projects.

Theory underlying the approach in this research project originates from classical physical microclimate research but more importantly from environmental psychology.

Research in that field during the last decennia has yielded important knowledge on human perception mechanisms. One of the commonly accepted insights of environmental psychology is that perception is a selection process of external stimuli that is guided by “schemata”. Schemata could be circumscribed as “images”, “labels” or even “prejudices” that people assign to places, situations, events, etc. [9]. In extensive research on schemata it was proven that human behaviour including the avoidance or preference of places, etc. is guided by these schemata [10,11,12]. So it can be concluded that human behaviour responds more to the schemata than the “real” situation. Of course, there is a strong relation between schemata and “reality”, because schemata depend on learning [13]. These learning processes for schemata on places are constituted of interpretations and judgements of environmental “cues”. These are physical objects or circumstances (also microclimate can be a “cue”) in the environment that are assigned certain qualities through the experiences made with or in them. Still, schemata, although being subject to change through learning can linger for a long time as a “prejudice” -even when the “real” situation has changed for a long time [14, 15].

The assumption that people develop schemata on places which sometimes include microclimate was brought forward in an earlier study on

opinions of the general public about Dutch squares. People described urban places not only by spatial attributes, but also with terms coming from climate. “Windy”, “cold” and “sunny” often were descriptors for a place [16].

The fact that schemata linger for longer and that the physical spatial configurations (that form “spatial cues”) that urban designers create consist of rather immobile, permanent elements (buildings, vegetation, earth- and water- bodies, etc.) made it necessary to inquire about the long-term microclimate perceptions.

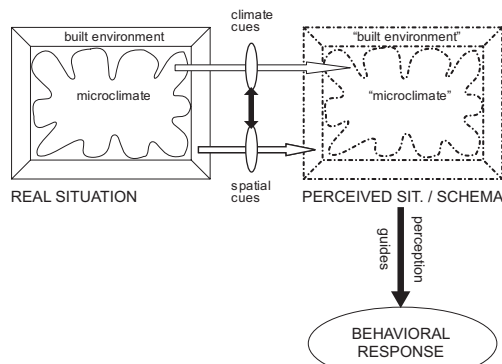


Fig 1. theoretical research framework

The research framework (fig. 1) based on environmental perception theory illustrates how microclimate and spatial perception can correlate.

2. Method

In the project described here the microclimate perceptions in relation to spatial perception of people in public places were studied. Interviews were conducted amongst long-term users of the places about their “cognitive microclimate maps” representing their space- related microclimate schemata. In one part of the inquiry they were also compared to measurement data that represent the long- term microclimate in the case-study places.

2.1 Fieldwork in case-study squares

The field- study was conducted in three Dutch squares, being the Spuiplein in Den Haag, the Neckerspoel in Eindhoven and the Grote Markt in Groningen.

The squares chosen for the project are quite similar in size. Yet, in terms of surrounding building structure and function, the squares differ. The series of interviews and measurements were taken during the outdoor seasons spring, summer and autumn in 2005 and 2006 on 4 days per season. Winter was left out because the research focuses on sojourn in public places and people in The Netherlands do not use public space for sojourn during winter.

2.2 Thermal comfort cognitive mapping

The method of cognitive mapping was identified as a main means to derive knowledge about space-related experience – and consequently as

a basis for urban design [17]. Researchers in the field describe a cognitive map as a spatially configured collection of “schemata” [18,19]. This makes the cognitive map method a suitable means for this study that tries to relate schemata about microclimate experience to places. In this case cognitive mapping was used to depict people’s long-term thermal experience related to the sub-zones and places of a square.

The cognitive maps were derived from interviews with people who reported to know the place for a longer period. Two main question complexes were discussed with them:

1. interviewees were asked to communicate their long-term knowledge about thermally comfortable and uncomfortable zones for sojourn in the respective case-study square.
2. interviewees had to give one of the following microclimate-related reasons why they perceive a zone in such a way:
 Wind comfortable- too windy
 Shade comfortable- too shady
 Sun comfortable- too sunny
 Good rain protection- bad rain protection
 Other reasons comfort- other reasons discomfort



Fig 2. example of an individual cognitive map derived from interview, Grote Markt, Groningen

Per interview a personal “cognitive microclimate map” was derived from people’s descriptions. This map showed zones to which people had assigned certain microclimate qualities (wind comfortable- too windy, shade comfortable- too shady, etc.). An example is shown in fig. 2. It has to be mentioned here that normally the individual interviewees did not have an idea about microclimate in the entire case-study squares. Their judgements were restricted to the places where they passed or stayed due to their normal activities, resulting in cognitive maps with “white spots”.

The individual cognitive maps from all interviewees were analyzed and accumulated in maps which show the percentages of votes of the total number of interviewees per issue (wind comfortable- too windy, shade comfortable- too shady, etc.). An example of an accumulated cognitive map for the perception of a square being “too windy” is shown in fig. 3. The complete

set of accumulated maps can be found on a special website [20].



Fig. 3 example of accumulated cognitive map: percentages of total votes "too windy", Grote Markt, Groningen

2.3 Measurements

The data measured for thermal comfort factors were air temperature, globe temperature, short-wave radiation, wind speed and wind direction. Measurements were collected on 4 days during the three outdoor seasons at 9,11,13,15 and 17 hrs. At these points in time measurements were taken at five spots in the square in Den Haag and six spots in the squares in Eindhoven and Groningen.

Tmrt and PMV values were derived from the measurements for the different spots. Tmrt was calculated according to the method proposed by Katzschner [21] and PMV according to Fanger [22].

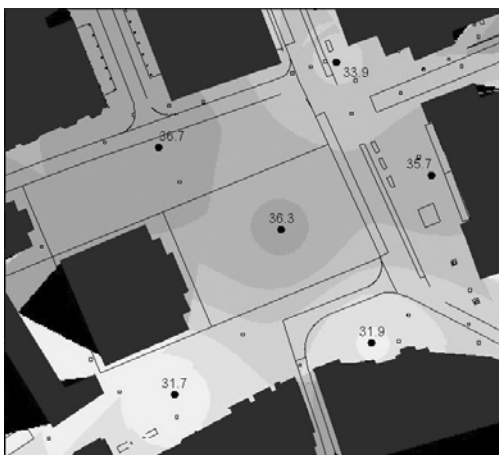


Fig. 4 example of map derived from measurements: average Tmrt, summer, 13.00 hrs, Grote Markt, Groningen

The measurement data are depicted in GIS-maps (ArcView) showing the situations in different seasons and at the different times during the day (examples, see fig. 4 and 5). The complete set of maps showing the average and extreme microclimate situation can be found on a special website [20].



Fig. 5 example of map derived from measurements: average wind speed/ wind direction, summer, 15.00 hrs, Grote Markt, Groningen

3. Data-analysis and results

The data were analyzed according to two main question complexes (also see theoretical framework, fig. 1), being:

1. how do people perceive microclimate- what are the "microclimate cues" or events that generate their schemata about microclimate in a space?
2. how do people interpret spatial configurations that are "spatial cues" with respect to its assumed microclimate?

3.1 long-term perception mechanisms for microclimate- the reading of "climate cues"

As a first step to get insight into the mechanisms steering people's long-term microclimate perception an analysis was conducted that focussed on the reading of "microclimate cues". In this context the term "microclimate cues" denotes the circumstances of microclimate that are relevant for people's microclimate perception. This can be achieved through the method of cognitive microclimate mapping that also provides the spatial information in relation to microclimate perception.

This was achieved by a comparison of the accumulated cognitive maps and the measured data. The following mapped data were compared:

1. experienced wind comfort/ discomfort with measured wind situation
2. experienced sun/shadow comfort/ discomfort with Tmrt calculated from measured data
3. addition of all experienced thermal comfort/ discomfort criteria with PMV values calculated from measured data
4. experienced rain protection with observations on site
5. other reasons with observations on site

This comparison was conducted under two assumptions. The initial hypothesis was:

- a) that spatial patterns of people's long term thermal experience for an urban square match with the spatial patterns gained from averaged measurements.

Because of some discrepancies in matches between the cognitive maps and the measured average data occurring in this first comparison, especially concerning negative, extreme experiences, a new hypothesis was formulated and a subsequent set of analysis was conducted. In that analysis maps from days with rather extreme weather were used and compared to the experience maps.

For this second analysis the hypothesis was:

- b) that spatial patterns of people's long term thermal experience match with the spatial patterns gained from measurements of days with more extreme microclimate conditions (rather windy or rather hot).

The results were summarized in order to get an overall picture on the matches between people's experience and measured data according to hypothesis a) (average measured data) and b) (more extreme measured data). Adding up the matches of all results in a chart (tab. 1) reveals that the influence of the extreme microclimate events is clearly stronger.

Tab. 1 overview results of comparisons between experienced situation and measured situation, all three case- study squares

	Spuiplein, Den Haag	Neckerspoel, Eindhov.	Grote M., Groningen	total
Averages	27 %	43%	53%	41 %
Extremes	63%	48%	73 %	61%

These results suggested that people in public squares have the extreme microclimate situations engrained in schemata they have developed about these places. This is in general accordance with results from the studies discussed earlier on psychological schemata. Also the fact that more salient and thus memorable events (in this case the more extreme microclimate situations) constitute the schemata is consistent with psychological theory [23, 24].

The results derived through the application of the cognitive mapping method in this case are more explicit with respect to specific weather circumstances on microclimate perception. They are more space-related than the classical indices for thermal comfort such as PMV, PET and also the more recent ASV and hence more useful for urban design objectives.

3.2 spatial patterns and microclimate perception- reading "spatial cues"

As a second step to get insight into the mechanisms steering people's microclimate-space perception an analysis was conducted that focuses on the reading of "spatial cues" with respect to microclimate (see theoretical framework, fig. 1). The analysis is based on the assumption that certain spatial configurations are

"spatial cues" that get assigned certain microclimate qualities in people's psychological schemata.

To achieve this, the sets of accumulated cognitive maps were analyzed for reoccurring spatial patterns that were assigned with a specific microclimate quality. The sets of maps for the three squares were scanned for areas that got at least 10% of the votes to be thermally comfortable or uncomfortable for a specific microclimate reason (wind comfortable- too windy, shade comfortable- too shady, etc.). From this analysis a range of spatial configurations could be identified that suggest to be read as "spatial cues" for certain microclimate properties by the long- term users of the places (see fig. 6, 7 and 8).

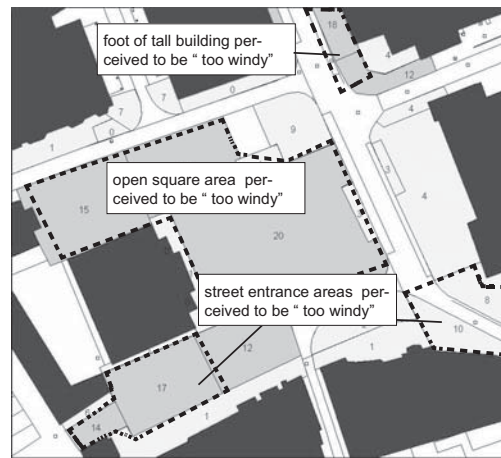


Fig. 6 typical spatial patterns of experienced wind-discomfort derived from cognitive mappings on example Grote Markt, Groningen

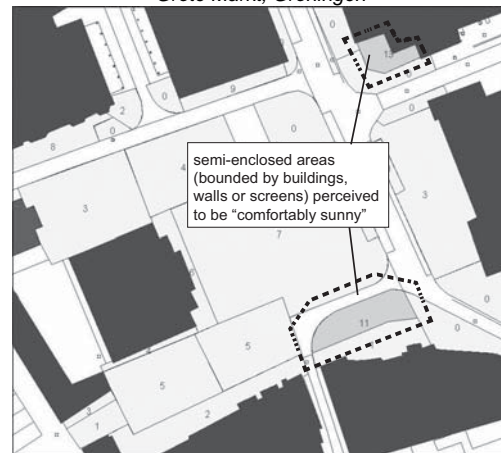


Fig. 7 typical spatial patterns of experienced sun-comfort derived from cognitive mappings on example Grote Markt, Groningen

Comparisons of these spatial configurations (being "spatial cues") with the same places on the sets of maps derived from measurements showed that partly people's perceptions in these places correlate well with data from the more extreme measurements, but to a considerable extent they do not correspond. The fact that, for

example, street canyon entrances were rated to be “windy” could often not be supported by the measurement data. The same goes for semi-enclosed areas that were considered “sunny” places (for all maps see website [20]).



Fig. 8 example of semi-enclosed typology: café-terraces, Grote Markt, Groningen

This indicates a rather generic reading of “spatial cues” by people- the interpretation of spatial configurations that is based on long- term learning mechanisms. These mechanisms also rely on experiences made in other places with similar spatial configurations where possibly the microclimate was indeed “too windy”, or “comfortably sunny”, etc.. These mechanisms lead to the development of psychological schemata. The use of schemata helps to quickly evaluate circumstances and places, risking that certain circumstances and places can be misinterpreted.

Apart from that it seems that these probabilistic judgments of spatial configurations can be rather well supported by general scientific microclimate knowledge. When the spatial configurations derived from the accumulated cognitive maps are compared to their general, not place-specific microclimate properties, for example in the case of “windy” street entrances, the probability of increased wind speeds is quite high due to wind-channel effects of the street canyons plus often occurring higher wind- speeds at the building corners. The semi-enclosed areas (like café-terraces) are indeed often sun-oriented, only in the case-study areas this is not always the case.

This analysis indicated a generally quite well-developed ability of people to predict microclimate in certain spatial configurations, or to interpret “spatial” cues in relation to microclimate. In this case the method of cognitive mapping has proven very useful to reveal this space - related microclimate perception.

4. Conclusions

People’s schemata about microclimate in urban squares are often quite congruent with the real local situation, especially when the more salient, extreme microclimate situations are considered. But also their possible misinterpretations of the local microclimate situations and spatial cues are

to be taken serious, because these often rely on experiences made elsewhere and are often congruent with physical microclimate laws. And in the end, as stated earlier, people’s perceptions and “schemata” steer behavior such as preference or avoidance of a place, and to a lesser degree the factual situations.

These issues together suggest that the classical purely physical approach with a focus on the “factual” microclimate is not sufficient and that the psychological parameters need more attention. This is of special importance in the inventory phase of urban design projects where design for thermal comfort is an issue. Here, people’s long-term perceptions of the local microclimate should always be taken into account. In public space design projects where an existing situation is to be refitted or refurbished the inventory of people’s long-term perception patterns can give very useful hints about the experienced microclimate. This in the end is what influences people’s acceptance or avoidance of a place and - amongst other influences- the sojourn quality of a place.

For projects where a completely new environment is created the method is, of course, not viable because people have no place-related experiences to communicate. Here only the design guidelines derived from this project (and hopefully more similar projects in the future) on spatial configurations can be applied.

But actually many public design projects deal with the refurbishment, embellishment and refitting of existing urban places and here the cognitive mapping method used in this project can be helpful to acquire knowledge on people’s correlated microclimate and space perception in the inventory phase of an urban design project.

Yet, the duration of the inventory phase of an urban design project as well as the financial possibilities in practice are rather limited. This requires a more time- and cost efficient method than the one used in the scientific research project described where between 220 and 250 persons were interviewed per case-study. For a practical purpose such as the inventory for an urban design project the amount of data for analysis does not have to be as extensive as for a scientific research project. An estimated number of around 50 individual cognitive maps might already yield sufficient information. From this amount of cognitive maps the main areas of preference or avoidance can be derived and accumulated into overviews. It has to be taken into account, however, that this will probably bring about some more “white spots” or places in the accumulated cognitive maps that get mentioned less than 5 %. In this case the places that are mentioned only in small percentages still should be taken into consideration and not be seen as variances.

Nevertheless, in order to calibrate people’s assessments and possible misinterpretations

(that might have dangerous consequences) of microclimate it is still advisable to also include a more “factual” view on local microclimatic circumstances which is best be derived from measurements. But since conducting measurement series prior to urban redevelopment projects is generally too costly and time consuming data derived from microclimate simulations could also be sufficient.

A balanced view on local microclimate including the physical and especially perceptual issues should be included in all public re- design projects. To achieve this, the method of cognitive microclimate mapping has proven very useful.

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