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Towards guidelines for designing parks of the future

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ABSTRACT

This study investigated human behaviour in parks in order to develop spatially explicit design guidelines considering future climate conditions in moderate climates. Fieldwork was carried out in two parks (in Utrecht and Wageningen, the Netherlands) during summer and tropical days ($T_{a\,max} > 25\,°C$ and $> 30\,°C$, respectively), the latter representing future climate conditions. Behavioural responses (park attendance, spatio-temporal user patterns) and thermal perception of resting park visitors were studied through unobtrusive observations (N = 11337) and surveys (N = 317). Outcomes were related to air temperature (T_a) of meteorological reference stations and spatial data on the vegetation structures of the parks.

Observational data show that daily park attendance decreased with rising $T_{a\,max}$. Survey results indicate that resting park visitors perceived a high level of thermal comfort during all investigated days. Park visitors chose resting locations predominantly based on solar exposure conditions (sun, half shade, shade). Those solar exposure preferences were significantly related to T_a: with increased T_a the number of park visitors in the shade increased and decreased in the sun ($p < 0.001$) with a tipping point of 26 °C. These results indicate that parks in moderate climates may guarantee a high level of thermal comfort, even on tropical days, if a variety of solar exposure conditions is guaranteed. A ratio of 40% sun, 20% half shade and 40% shade in parks was derived from spatio-temporal user patterns, which appear to accommodate preferences of resting park visitors under summer and tropical thermal conditions and on various daytimes. These results and a spatial typology of tree configurations for microclimatic variety provide direction for designing future parks: they need to offer a wide range of sun-exposed, half shaded and shaded places to accommodate for different user needs and future climate conditions.

1. Introduction

Parks, like many other urban green spaces, provide multiple benefits for city dwellers. They are of importance for recreation and mental restoration (Chiesura, 2004) and relieve environmental challenges such as air quality, water storage and urban heat (Demuzere et al., 2014; Lafortezza et al., 2013; Roy et al., 2012; Tzoulas et al., 2007). During warm summer periods parks are preferred urban outdoor spaces to recreate (Lafortezza et al., 2009) and are even favoured to outdoor spaces with open water (Klemm et al., 2015).

Those behavioural preferences can be ascribed to the well-known fact that urban parks are 'cool spots' in cities during summer periods. Evapotranspiration of the parks' vegetation structures provide lower air temperatures (T_a) compared to the built surroundings (Bowler et al., 2010; Chen and Wong, 2006; Klemm et al., 2015; Norton et al., 2015; Oke, 1989). Tree canopies reduce solar radiation, significantly affecting the mean radiant temperature (T_{mrt}) and thus contributing to the thermal conditions in parks (Brown et al., 2015; Klemm et al., 2015; Yang et al., 2013).

The thermal conditions of a park thus are largely determined by the spatial configuration of its vegetation structure (e.g. size and distribution of tree canopies). As a consequence, the creation of thermally comfortable parks depends on designers' decisions (Brown et al., 2015). To inform climate responsive design decisions spatially explicit information is needed. Quantitative approaches including thermal comfort indices, (e.g. the thermal sensation vote) have been used to investigate thermal conditions in parks (e.g. Yang et al., 2013). Though these indices deliver valuable scientific evidence on thermal variety in parks, they are not explicit in spatial terms to inform park design. For generating design guidelines, additional more qualitative thermo-spatial information is needed

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(Lenzholzer et al., in press). Understanding how people perceive, value and use a park helps to understand the human dimension of planning and design (Meijering et al., 2015).

Designing 'cool- spot' parks will gain importance in the context of global warming. Even in the Netherlands with its moderate climate, the number of summer and tropical days (T_{amax} > 25 °C and > 30 °C, respectively) has increased in the last 50 years and future projections feature more 'tropical days'(IPCC, 2014; KNMI, 2015). This will have negative impacts on human thermal comfort and health (Daanen et al., 2013; Huynen and van Vliet, 2009; Kovats and Hajat, 2008). Additionally, it may influence city-dwellers' use of parks and their behaviour in parks and thus pose challenges for future park design.

The present study therefore aimed at generating spatially explicit design guidelines for parks that are based on human behaviour and that take warmer future climate conditions into account. Early behavioural studies (Gehl, 1987; Whyte, 1980) revealed strong relationships between microclimatic conditions: especially solar exposure degrees appeared critical for the attendance of outdoor spaces in moderate climates. Recent studies demonstrated that the number of park visitors increased with rising temperatures. In a University park in Szeged (Hungary) Kántor and Unger. (2010) observed a relatively large proportion of people in the sun despite hot thermal conditions during summer. However, for a square in Rome (Italy) Martinelli et al. (2015) observed that square visitors had a consistent preference for shaded areas throughout summer days. For a park in Stockholm (Sweden), Thorsson et al. (2004) demonstrated that during summer and autumn people visit outdoor places mainly to enjoy the sun. Likewise, Katzschner (2004) showed that sunny spaces on a square in Kassel (Germany) were preferred almost all throughout the year. In the latter two studies, it was observed that people moved from sunny to shady places under extreme hot conditions. Yet, none of these studies derived clear guidelines for park design, neither for current climatic situations nor for future situations.

This study therefore investigated preferred solar exposure of resting park visitors on summer and tropical days at various daytimes in the Netherlands through studying visitors' behavioural response (park attendance, spatio-temporal user patterns) and thermal perception. This way, we obtained evidence-based climate-responsive design guidelines for future park design in moderate climates (Brown and Corry, 2011; Brown et al., 2015). To inform design scientific evidence should be translated into design guidelines in an accessible and understandable way (Prominski, 2017) so that design professionals are encouraged to take microclimate aspects into account when shaping outdoor spaces (Nassauer and Opdam, 2008; Ward Thompson, 2013).

Consequently, the main research question was: *What are evidence-based design guidelines for thermally comfortable future parks in moderate climates?* To answer this main question, the following sub-questions were formulated:

1 *What is the importance of microclimate on the spatial preferences of resting park visitors?*
2 *What is the thermal perception of resting park visitors on summer and tropical days?*
3 *How does extreme air temperature in summer influence daily park attendance?*
4 *What are the user patterns related to solar exposure of resting park on summer and tropical days?*
5 *What are spatial typologies for optimal park use on summer and tropical days?*

2. Methods and materials

A combination of quantitative and qualitative methods delivered an empirical database to inform design guidelines for future parks. By combining surveys, unobtrusive observations and spatial analysis we related park visitors' behaviour and thermal perception to meteorological reference data and spatial characteristics of the parks. The conceptual framework of this study is shown in Fig. 1.

2.1. Pre-conditions

2.1.1. Study sites

Since the study aimed at investigating spatial configurations for optimal park use during summer and tropical periods we chose two parks for our multiple case study (Deming and Swaffield, 2011). Both are situated in the moderate/mild mid-latitude climate of the Netherlands: one in the city of Utrecht and one in the city of Wageningen. Utrecht is the fourth largest city of the country with a population and a population density of 330.000 and 3.300/km^2 respectively. In contrast, Wageningen is a relatively small town, with a population and a population density of 37.500 and 1.200/km^2 respectively (CBS, 2014). Size and function of the two parks differ considerably. The Wilhelminapark in the city of Utrecht is 10.9 ha large and a popular city park with a public playground, restaurant and terrace in the centre. The Torckpark

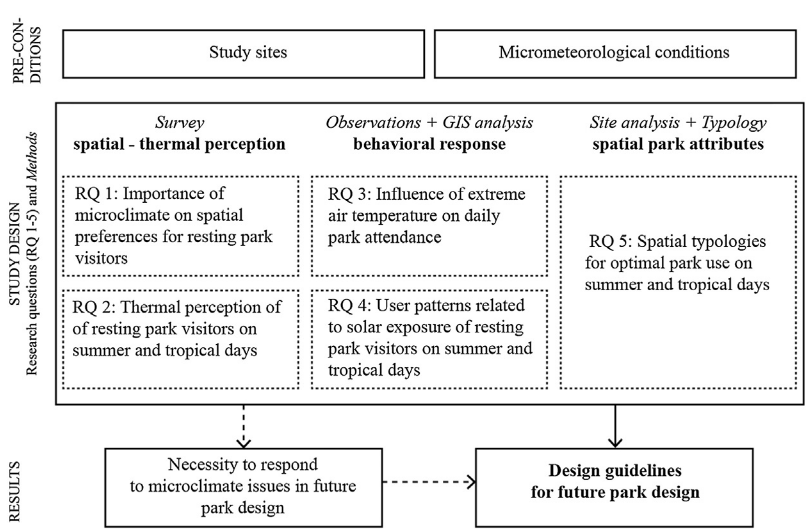

Fig. 1. Conceptual framework of this study.