Designing thermally sensitive public spaces: an analysis through urban design media

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Ignacio Requena-Ruiz[1], Daniel Siret[1], Xenia Stavropulos-Laffaille[1] & Thomas Leduc[1]

Abstract: Urban designers face the challenge of preserving urban life by creating public spaces that are resilient to rising temperatures. This paper studies the dissemination of urban designs specific to summer ("urban coolspots") throughout urban design media. The study of an inventory of urban coolspots (182 references) delineates, firstly, their urban context, the main actors and principal cooling techniques. Secondly, a typological analysis of the projects' spatio-climatic setups highlights four trends as presented in the media. Finally, this article discusses the contributions of the media to an emerging urban design field and establishing an aesthetic of freshness in public space.

Keywords: public space design; urban coolspots; microclimate; thermal comfort; adaptation strategies.

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[1] ENSA Nantes, Ecole Centrale Nantes, Nantes Université, Nantes, France

Introduction

Cities are particularly sensitive to the predicted rise in global temperatures (IPCC 2021). Researchers accept that cities' built environment frequently exacerbates global warming effects by causing a deterioration in outdoor thermal comfort and increasing thermal stress (Stewart and Oke 2012; Santamouris and Kolokotsa 2015). Amongst the multiple negative effects, current research highlights the fact that implementing adaptation measures is a major challenge for cities to avoid public spaces gradually becoming unliveable (Tavares et al. 2020). In preserving the quality of life of public spaces, urban design plays a central role in promoting both (1) mitigation strategies that aim at decreasing air temperature over the whole city (e.g. parks, green roofs, whitening pavements) and (2) adaptation strategies that focus on area-specific cooling techniques and behavioural adaptation (e.g. urban canopies, misting nozzle structures, green surfaces). Knowledge of thermal retrofitting of public spaces nowadays informs urban design practices through various kinds of evidence-based guidelines (Cortesão et al. 2020; Cortesão et al. 2016); however, the contribution of urban design media to popularizing such expertise from a wider perspective remains little studied. Design media can be regarded both as a mirror of public space design practices and as a medium for knowledge dissemination.

Urban design media present recent design practices that intertwine adaptation strategies with design's cultural, social and material inputs to explore attractive and resilient public spaces (Santos Nouri and Costa 2017; Stanislav and Chin 2019). Rather than presenting general transformations of the city with ubiquitous solutions, public space designs are gradually appearing as a form of "tactical heat stress interventions on a street-level scale" (Kluck and Boogard 2020). Such a process leads to the identification of "urban coolspots" (also called "cool urban retreats", or "cool urban oases") within the urban fabric as spaces that locally decrease the perceived temperature and enable public life during hot periods. This paper hypothesizes that urban design media help to promote thermally sensitive public spaces in ways that complement design guidelines. By presenting real designs resulting from a negotiated process with multiple actors and variables, including thermal ones, they influence urban practitioners' inspirational and problem-solving processes (Forty 2000). This study analyzes the main characteristics of urban coolspots as thermally sensitive public spaces from the urban design media perspective.

From specialized periodicals to online design platforms, published photographs of public space designs provide records and interpretative information. Through visual representations of both spatial and climatic dimensions of design, these photographs summarize the phenomenal situation of public space and "help us to clarify forms, processes and conditions engendered" (Morselli 2019). Considering that the editorial process of practitioner-oriented design journals organizes and categorizes the information to guide its interpretation, this paper examines the emerging design approaches for thermally sensitive public spaces as promoted across urban design media.

From urban climate science to urban design media

Thermal retrofitting of public spaces encompasses at least three scientific fields with an extensive body of scientific literature (Lenzholzer, Klemm, and Vasilikou 2018): (1) thermal perception and comfort in outdoor public spaces; (2) urban cooling and mitigation technologies; and (3) public space and public life studies.

From the perspective of thermal perception, various studies analyze the effects of urban spatial characteristics (e.g. shapes of buildings, materials, technical systems, greenery) on human thermal perception (Middel and Krayenhoff 2019; Steane and Steemers 2003). They explore the human body's thermoregulatory responses in outdoor built environments (Johansson et al. 2014), to create thermal sensation indices according to physiological or psychological factors. Other studies have opened up this field by examining factors that affect thermal perception, such as people's culture or climate adaptation (Lenzholzer, Klemm, and Vasilikou 2018).

From the perspective of urban cooling and mitigation technologies, current research addresses the undesired consequences of urban heat island mitigation (Santamouris et al. 2017). Researchers agree on four main approaches for thermal retrofitting of public spaces: reducing solar radiation by shading (Middel et al. 2016), increasing evapotranspiration through green or water-based solutions (Jacobs et al. 2020; Aram et al. 2019), optimizing the materials of surfaces in order to decrease the absorption of solar radiation or enhance heat transfer (Santamouris 2013), and improving the urban form to optimize solar gains and wind effects (Stewart and Oke 2012).

From the perspective of public space and public life studies, pleasant thermal conditions in public space are often linked to the occurrence of optional activities (e.g. standing, sitting, eating, reclining) and social activities (e.g. children playing, group sports, music playing) (Chen and Ng 2012; Gehl 2011; Whyte 1980). Various studies have discussed

the potential of urban forms to create public spaces that modify climate parameters and shape citizens' ordinary experience of urban climates (Heschong 1981; Roesler and Kobbi 2018).

The aforementioned fields of thermal perception and urban cooling techniques contribute to urban design guidelines with evidence-based knowledge (Cortesão et al. 2020). They offer transferable knowledge that "works beyond a specific case to a more generalizable set of situations" (Prominski 2017). Strategies for designing thermally sensitive public spaces nowadays incorporate guidelines for urban planners and designers from a supra-national level (e.g. C40-cities 2021; Georgi et al. 2016) to national and local ones (e.g. Osmond and Sharifi 2017; Ruefenacht and Acero 2017; Mairie de Paris 2018).

When addressed only from the perspective of the problem-solving philosophy of guidelines, the framework of adaptation strategies remains incomplete for the design of a public space. Thus, the inspirational references published in urban design media, presented as a whole, could affect the creative trial-and-error process of design complementary to guidelines.

Urban coolspots: designing the thermal experience of the city

Urban coolspots are public spaces of different scales (from the square to street furniture) in which the design process combines space and climate while creating reciprocal relationships with social activities. They are "thermal places", or places with thermal qualities that "naturally tend to become social places as people gather to take advantage of the comfort to be found there" (Heschong 1979, 60). They modify climate variables (e.g. temperature, humidity, air movement) at the level of the body through ephemeral or permanent strategies (e.g. misting canopies, water mirrors, floor-mounted dry fountains).

A simple review of urban design periodicals shows that the media echo this interest across articles and special issues on urban health, climate change, or urban greening. However, the influence of thermal retrofitting approaches in practitioner-oriented urban design media remains little studied and raises questions such as the following: How do the media delineate, directly or indirectly, a summer-specific approach to public space design? How do media contribute to establishing an aesthetic of freshness in public space by presenting inspiring projects of urban coolspots?

Research method

This paper adopts *observatory science*'s (Miller et al. 2021) inductive approach based on the construction of a multi-source inventory of urban design projects involving urban cooling techniques. A consolidated version of the inventory was examined with two techniques of data analysis for addressing the aforementioned research questions: a descriptive statistical analysis and a constructivist approach to grounded theory (Corbin and Strauss 2008) through qualitative data analysis and variable coding (della Porta 2008).

Data collection procedures

The research work started with compiling an inventory of built projects of public space design. These projects were selected via a four-type systematic review of practitioner-oriented sources of urban design media. The study period was set from 2002 (year of creation of the European Prize for Urban Public Space) to December 2020, although it was reduced for several sources, depending on their publication period or their accessibility. Four categories of research sources were monitored (see Table 1 for further detail):

- Architecture, urban and landscape design periodicals published in paper form.
- Online journals and platforms in architecture, urban design and landscape architecture.
- Design awards in architecture, urban design and landscape architecture.
- Architecture and urban design programmes.

Type of source	Name	Source's scope	Query description
Architecture, urban and landscape design periodicals published on paper	A+T	Spanish/ww	Search period 2005–2020
	Domus	Worldwide	Search period 2002–2020
	Journal of Landscape Architecture	Worldwide	Search period 2006–2020
	L'Architecture d'Aujourd'hui	French/ww	Search period 2002–2020
	Urban Design Journal	Worldwide	Search period 2002–2020
	Revue Urbanisme	French	Search period 2014–2020
Design awards in architecture, urban design and landscape architecture	European Prize for Urban Public Space	European	Search period 2002–2020
	European Union Prize for Contemporary Architecture Mies van der Rohe Award	European	Search period 2005–2020
	LILA – Landezine International Landscape Award	Worldwide	Search period 2016–2020
	Urban Land Institute's Urban Open Space Award	American	Search period 2010–2020

Architecture and urban design programmes	Young Architects Programme MOMA PS1 (New York)	Worldwide	Search period 2002–2019
	Young Architects Programme Maxxi (Rome)	Worldwide	Search period 2011–2020
Online journals & platforms in architecture, urban design and landscape architecture	Archdaily	Worldwide	Boolean query "public space OR urban" AND "cooling OR oasis OR cool spot"
	Dezeen	Worldwide	
	Landezine	Worldwide	
	Metropolis	Worldwide	
	Topos Magazine	Worldwide	
Search engines	Google	Worldwide	Boolean query "public space OR urban" AND "cooling OR oasis OR cool spot"
	DuckDuckGo	Worldwide	
	Pinterest	Worldwide	Reiterative random search starting with previous word chains.
	Google Images	Worldwide	

Table 1. Inventory data sources

Paper periodicals were surveyed via a review of the table of contents, the article title and the project's illustrations. Online sources were analyzed through a Boolean query string in the site's main language. This was followed by a review of titles, introduction and thumbnails.

To capture different dimensions of the same phenomenon and triangulate data, a second method was used for data collection. The documentary research was complemented by identical Boolean queries in multilingual word-based search engines (Google and DuckDuckGo) and image-based search engines (Google Images and Pinterest). This process was conducted in English, French and Spanish.

Three cumulative criteria were needed to include the projects in the inventory:

- The project deals with a design of an outdoor public space already built;
- The project's statement and illustrations reveal the designers' intention of dealing with climate parameters, creating cooling effects or introducing cooling techniques;
- The project's photographs provide visual evidence of climate conditioning by representing cooling effects (e.g. shadows, mist) or citizens potentially enjoying the freshness.

Based on grounded theory's data collection protocols, the sample size was determined by three cumulative conditions:

- Informational redundancy on urban cooling techniques: data collection was finished when no new information on the topic was elicited by adding more projects.
- Thematic saturation: data collection was finished when no new thematic codes were found by sampling more projects (Guest, Namey and Chen 2020).

- Temporal limitation of research: data collection was carried out from March 2019 to December 2020.

As a result of this process, 232 references were initially identified. After a detailed review of texts and illustrations, each project in a different urban context was isolated as a single study item. When further information was needed for the analysis, it was collected from the websites of designers, consultants or commissioners. At the end of the process, 182 references constituted the first version of the inventory as presented in the dataset (10.5281/zenodo.4646959).

Each item in the dataset identifies an urban coolspot located in a different environment with spatiotemporal data (GPS coordinates, address, city, country, construction year), design actors (designers, specialist consultants, sponsors), urban context (compact/dense city, suburbs, city, or cultural parks) and the urban cooling technique applied. These facts were complemented by a description of the project and its architectural illustrations: technical drawings (plans and sections), published and descriptive photographs (space, materials, construction, events or ordinary situations).

Data analysis procedures

Descriptive statistical analysis

A statistical analysis aimed at describing the inventory and delineating the definition of an urban coolspot: the urban context, the actors involved, and the cooling techniques applied.

Qualitative data analysis and theory inference

The inventory forms the foundation for a constructivist approach to grounded theory (Corbin and Strauss 2008), through qualitative data analysis and variable coding (della Porta 2008), with the intention of inferring general trends and theories (Charmaz 2001). This procedure was assisted by MaxQDA® and R statistics.

The steps for the qualitative data analysis (QDA) process were as follows:

(1) Open coding: selecting key terms in cooling strategies, spatial layout and potential activities through the projects' textual descriptions and illustrations;
(2) Restating key elements: reviewing selected texts and illustrations to identify repeated characteristics and singularities;
(3) Reducing elements: codes were accumulated and reduced to avoid redundancies.

(4) Generating categories: codes were grouped by themes to develop categories and, where possible, codes were organized in gradual scales;
(5) Linking categories: links were made between the categories, based on theories of urban and architectural design, urban atmospheres and thermal perception, to enhance the strength of the framework.

Steps one to five were conducted by two researchers trained in architecture and urban planning. As a result, the coding scheme explained above was created and implemented consistently throughout the inventory content.

Microclimate coding description. The physical aspects that can be observed in the projects' illustrations and texts are classified according to four categories: (1) urban cooling strategy, (2) heat transfer approach, (3) potential use of resources (energy & water), and (4) area of influence of the microclimatic effect appraised in photographs compared with its surface. Table 2 presents a detailed definition of the coding categories.

Codes	Sub-codes	Description
Urban cooling strategies	Blue	Water-based approaches: stagnant, in storage or circulation.
	Green	Approaches using diverse forms of vegetation integrated with the design.
	White	Approaches based on the formal characteristics of the design favouring shade and wind currents as cooling effects.
	Grey	Material and technology-based approaches: they influence the albedo of surfaces, their ability to absorb water or their surface temperature.
Heat transfer approaches	Conduction	Cooling effect produced by heat transfer when directly in contact with a cooler element.
	Convection	Cool feeling created when the body comes into contact with cooler moving air.
	Evaporation	Cooling effect by reducing surrounding air temperature or surface heat dissipation when a liquid changes its state to a gaseous one.
	Radiation (shading)	Cooling produced by masking shortwave solar radiation transmission.
	Radiation (absorption)	Cooling effect created by heat dissipation through shortwave radiation to a cooler element.
Potential use of resources (energy & water)	Active	Energy-demanding devices.
	Passive	Zero-energy devices.
Area of influence of the microclimate effect (compared with the device surface)	Diffused	Area of influence diffused far from the device's surface.
	Expanded	Area of influence expanded to the device's immediate environment.
	Restricted	Area of influence restricted to the device's surface.
	Localized	Area of influence located at a spot within the device.

Table 2. Microclimate coding structure and description.

Spatial coding description. The climate-relevant spatial aspects of public space design are classified according to four categories (see Table 3). The categorization (1) of the design scale, the (2) spatial identification and the (3) prevailing material appearance for each urban coolspot was achieved through the analysis of illustrations. The project's textual descriptions and plans contributed to characterizing the (4) temporality of the design.

Codes	Sub-codes	Description
Scale of the design	XS	Urban furniture.
	S	Pavilion/installation.
	M	Small public space.
	L	Public space.
	XL	Large-scale open space.
Spatial identification	Unnoticed	Device totally or nearly unnoticed in the space.
	Borders	Device perceptible by the borders.
	Relief	Prominent or topographical device.
	Semi-closed	Devices as an open construction enclosed on at least three sides.
	Closed	Device is in the form of a closed space limiting the area of influence of the microclimatic effect.
Prevailing material appearance	Artificial/Mineral	Mainly traditional manufactured materials: metal, stone, concrete, plastics, wood.
	Vegetation (manufactured)	Artificial space integrating vegetal plantations.
	Vegetation (free)	Vegetal space with free-growing vegetation.
Temporality of the design	Permanent	Long-term design.
	Ephemeral	Reversible device installed in the urban space for a finite time.

Table 3. Spatial coding structure and description.

Citizens' experience coding description. The activity range and the bodily engagement presented in photographs is classified according to four categories: the definition of the (1) diversity of activities, (2) the spatial kinetics, and (3) the responsiveness through design as observed in architectural illustrations. A theory-driven approach contributed to hypothesizing (4) citizens' perceptual gradient and the apparent conditions of the designed climate in the public space. The typology applied in this paper was inspired by Torgue's (2005) morphological principles for urban atmospheres (backgrounds, located sequences and signals) and Popovic's (2017) typology of climate stimuli at body level (microclimate islands, bands of climate atmospheres and thermally striking climates). A detailed definition of these coding categories is presented in Table 4.

Codes	Sub-codes	Description
Diversity of activities	Mono-functional	Device photographs show people in only one activity.
	Multifunctional	Device photographs present people in a variety of uses without showing fully reversible situation.
	Flexible	Device photographs present a fully reversible situation in which the device can appear and disappear from the space.
Spatial kinetics	Seating	Device photographs show people sitting.

	Strolling	Device photographs show people strolling.
	Passing through	Device photographs show people walking.
Responsiveness through design	Transiting	Device offering a basic form of interaction based on the simple crossing of space. It involves a movement of the city dweller to get closer to the device rather than conscious physical interaction.
	Entering	Device needing pedestrians to move into its area of influence. It involves immersion of the pedestrians within the device.
	Acting	Device requiring a simple action by the city dwellers to cool themselves down – e.g. sitting down or standing up in a place.
	Operating	Device requiring a conscious gesture by the city dwellers to cool themselves down – e.g. pressing a button, operating a control handle.
Perceptual gradient	Background	Gradient characterized by the presence of constant climatic conditions in an area with blurred limits. It emerges gradually, going almost unnoticed until the immersion is accomplished. Once immersed, it creates a stable climatic state, without intense variations, that can pass to a second level of attention.
	Sequences	Gradient composed of different climatic conditions that are considered and perceived as a whole. It is composed through sequences or superpositions of climatic effects stored as multiple cumulative layers in the area. As a single perceived entity, sequences play the role of spatial markers in the public space, and as a heterogeneous climatic compound, they act as temporal markers.
	Events	Gradient occurring in small areas and appearing prominently in a context. It modifies the pedestrians' feelings and behaviours through stimulation at specific points. Events emerge clearly from their context by both the contrast in intensity and the change in body/climate interaction or sensory stimulation.

Table 4. Coding structure and description for citizens' experience.

Typology Construction Process

This paper presents a typological approach that aims to elucidate how the singular characteristics of each project can be related to the global picture of public space design in the face of rising temperatures. Frequently adopted in social sciences when no theoretical model explains the parameters of each possible type (Henry et al. 2015), a typological approach contributes to knowledge in public space design. This has been achieved by defining the set of common attributes that characterizes ongoing design trends, as shown in urban design media.

A typology is the result of a clustering process in which all elements within a type or cluster are as similar as possible, while the differences between the latter must be as strong as possible. Based on the analysis of occurrences of qualitative attributes in the same project, MaxQDA® was used to infer an early typology through unsupervised learning –

also called clustering in statistics. The measure of similarity between the coded projects was analyzed by applying the coefficient of Kuckartz & Rädikers (2019): codes in two or more documents were counted twice, whereas the non-repetition of the same codes was counted once. The early results were evaluated and discussed by analysis of a tree diagram and visual inspection of the projects' thumbnails of each category. This allowed the sensitivity of the model to the qualitative attributes to be refined. In other words, the attributes avoiding a clear differentiation between types were filtered – mostly because they did not contribute to differentiation of types.

Delineating urban coolspots through urban design media

Urban context analysis

The inventory consists of 182 references from 33 countries around the world. As Table 5 reveals, the research method has led to a geographic distribution in which 161 out of 182 coolspots are in Western Europe, North America and Southern Europe. Half of the projects are located between latitude 40.5° and 49.0° – from Madrid or New York (southern limit) to Paris or Nuremberg (northern limit). The use of languages of Indo-European origin for research (English, French, Spanish) introduces a significant bias that needs further research to refine a global picture. For instance, the presence of only 16 references in Eastern and South-eastern Asia, a region heavily urbanized and with high-income populations, could be underestimated.

In the context of Europe and North America, this finding provides evidence for the hypothesis that urban coolspots, as presented in urban design media, are relatively specific to mid-latitude cities in wealthy countries.

World region	No. of projects
Western Europe	96
Northern America	27
Southern Europe	25
Eastern Asia	12
Northern Europe	7
South-eastern Asia	4
Eastern Europe	4
Western Asia	3
Oceania	3
Latin America	1

Table 5. Project distribution across world regions.

Analysis of the published projects' cities shows that this phenomenon tends to be limited to big cities and metropolises. Table 6 shows that 101 projects appear in urban agglomerations, with populations between 500,000 and 10 million people. Influenced by the global competition in urban attractiveness, big cities seem to allocate more resources to creating attractive public spaces that are more resilient to rising temperatures. This finding could also be explained by a general bias of urban design literature towards big-city projects.

Urban fabric	No. of projects
> 10 million: megalopolis	24
1–10 million: metropolis	74
500 k to 1 million: regional city	22
50 k to 500 k: city	36
20 k to 50 k: mid-size town	17
< 20 k: small town	9

Table 6. Distribution of the projects' city size

Amongst the three categories proposed in Table 7

Urban context	No. of projects
Compact/dense urban fabric	121
Dispersed urban fabric	12
Large-scale parks (city or cultural parks)	49

Table 7, 120 out of 182 projects are located in compact/dense urban fabric, mostly close to the city centre. Less often, they are located in cultural parks or commercial activity areas in which the urban coolspot helps to diversify cooling situations and amenities. This result confirms three main trends: (1) urban coolspots appear as activity attractors in the city, to strengthen existing nodes or create new ones; (2) urban coolspots appear as design solutions in areas where plant growth conditions are limited due to soil compaction or limited space for root growth (Czaja, Kołton, and Muras 2020); (3) decision-makers and designers' awareness of the necessity of prioritizing urban coolspots in densely urbanized areas more sensitive to urban heat islands (Stewart and Oke 2012).

Urban context	No. of projects
Compact/dense urban fabric	121
Dispersed urban fabric	12
Large-scale parks (city or cultural parks)	49

Table 7. Distribution of the projects' urban contexts.

Main actors in urban cooling

The diversity of designers of urban coolspots

In accordance with the inherently interdisciplinary nature of urban design (Carmona

2014), the inventory shows nine types of designer profiles working alone or in collaboration in the design of urban coolspots; still, as Table 8 presents, 143 out of 182 projects were designed by architects or landscape architects. In 61 cases, the designers operated in interdisciplinary teams, combining architects and landscape architects (20 out of 182), engineers and designers (7 out of 182), architects and artists, or designers (10 out of 182), architects and urban planners (6 out of 182), or urban planners and landscape architects (6 out of 182).

Type of professional	No. of projects[2]
Architects	88
Landscape architects	55
Engineers	20
Artists	19
Designers	17
Urban planners	8
Fountain designers	8
Researchers	5
Stage designers	2

Table 8. Distribution of project designers.

For generalist urban practitioners such as architects, landscape architects or engineers, urban cooling has become a prerequisite for dealing with climate change adaptation strategies. Only 79 projects out of 182 report the contribution of specialist consultants in outdoor space comfort or urban cooling; amongst them, just 6 consultants/designers appear in 38 projects. Urban cooling skills are handled by a few professionals specializing in outdoor space comfort (e.g. Transolar KlimaEngineering, Breathe Earth Collective, Philippe Rahm Architects) or urban cooling techniques, such as fountain design (e.g. Diluvial, JML, The Fountain Workshop). Although these 6 specialist firms emerge as leaders in the field as presented in urban design media, another 25 specialists have been identified through the inventory references, so the high visibility of the 6 outstanding firms could also be explained by self-promotion.

Commissioners of Urban Coolspots

The results presented in Table 9 show that 124 out 182 commissions come from public developers or cultural institutions. Private companies or semi-public companies, in charge of 41 projects, concentrate their activities on the scale of temporary installations

[2] Note that projects can involve several type of professionals recognized as principal designers.

or pavilions, occasionally moving towards permanent intervention in public space, depending on urban development policies in each country.

Type of commissioner	No. of projects
Public planners	92
Cultural organization	32
Private companies	28
Mixed economy companies	13
N/A	17

Table 9. Distribution of project commissioners.

A wide range of urban cooling techniques

Throughout the data collection process, 54 different combinations of urban cooling techniques were found. Although they are not always specified in design magazines, additional documentary research provided this study with at least the range of techniques used for further categorization. Table 10 presents the independent use of the 20 techniques that were identified.

The blue approach (water-based), using water for cooling, whether or not combined with other approaches, was applied in 143 out of 182 projects. The white approach, referring to the formal characteristics of the design, is also widely employed (56 out of 182 projects), specifically regarding shadow creation. The grey approach, concerning the properties of the materials or systems, applies to 31 projects. Lastly, the green approach, utilizing plants in various forms, watered or not, applies to 29 projects.

Type of approach	No. of projects[3]	Urban cooling technique	Times used
blue	143	Pop-jet fountains	63
		Misting nozzles	59
		Body of water	54
		Fogging nozzles	11
		Dry fountain	10
		Waterfall	8
		Watercourse	3
		Fountain	2
		Water immersion	1
white	56	Canopy	49
		Passive stack ventilation	6
		Ultraviolet filtering	1
grey	31	HVLS fans	12
		Cooled surface	9
		Forced-air ventilation	7
		Moistened fabric	1

[3] Note that projects can combine several approaches, using various urban cooling techniques.

		Thermal insulation	1
green	29	Vegetation (manufactured)	23
		Tree growing (ground or containers)	16
		Vegetation (traditional gardening)	4

Table 10. Urban cooling approaches and techniques implemented in the inventory.

The predominance of water-based techniques for local public space cooling is consistent with other studies analysing their cooling potential (Santamouris et al. 2017). Blue approaches, when the local climate is dry, lead to a mean peak air temperature drop of 4.5 °C, whereas grey, green and white approaches remain less efficient (air temperature drop by 1.3-1.7 °C). This study also highlights the fact that the combination of approaches, as it prevails in the inventory content, leads to a higher cooling potential.

From the wider perspective of carbon-free public space design, urban cooling globally remains an energy-dependent or water-dependent design practice. A total of 143 out of 182 projects in the inventory consume energy or water resources in different ways and intensities. Specifically, blue and grey techniques are the most resource-dependent. Only 38 devices are described as passive during the occupancy phase, and they are primarily based on green and white techniques. An alternative explanation for the reduced number of projects using green techniques could be found in the difficulties for plant growth in dense urban areas, as previously explained (see Urban context analysis).

An early typology of urban coolspots as spatio-climatic configurations through urban design media

The typological study of the inventory produces an early typology structured into 4 types and covers 165 projects out of 182 (see Figure 1). The remaining 17 projects were judged as too singular for integration into other categories. Typologies can be consulted in the dataset (10.5281/zenodo.4646959).

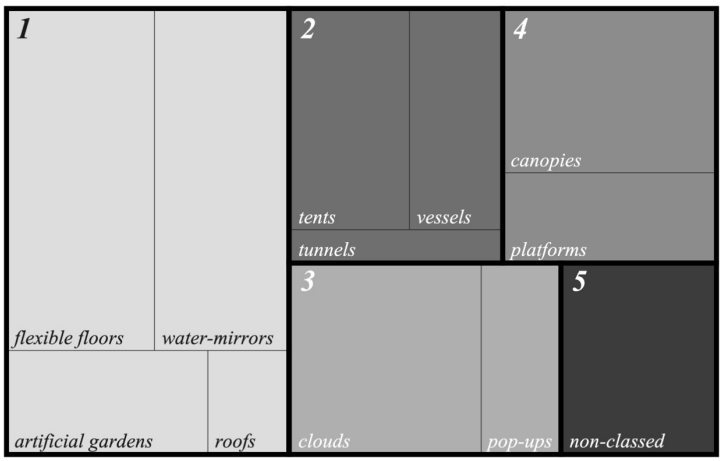

Figure 1. Distribution of the inventory's reference types and subtypes: (1) Microclimatic plazas; (2) Climatic capsules; (3) Climatic stage settings; (4) Cooling street furniture; and (5) Non-classed items.

Type	Subtype	No. of items
Microclimatic plazas	Flexible floors	29
	Water mirrors	27
	Artificial gardens	12
	Roofs	5
Climatic capsules	Tents	15
	Vessels	12
	Tunnels	4
Climatic stage settings	Clouds	21
	Pop-ups	9
Cooling street furniture	Canopies	20
	Platforms	11
Non-classed items		17
Total		182

Table 11. Distribution of the inventory's reference types and subtypes.

Microclimatic plazas

A major part of the inventory's references lies in this category (73 projects). From the perspective of the spatio-climatic configuration, microclimatic plazas are public open spaces of medium or large size in which the presence of cooling techniques remains visually discreet. The technical systems integrate the spatial layout of the public space that reveals their presence through subtle changes in flooring textures or materials. In this regard, plazas are mainly permanent public spaces (64 cases), with the exception of a few ephemeral approaches (9 cases) that involve mineral and massive materials combined with dynamic water elements. Occasionally they involve shading from trees or canopies. From the perspective of the microclimate experience, plazas create background effects disseminated throughout the space. The imbrication of space and climate seems to be indissoluble from the atmosphere of the public space that is presented. Design magazines show plazas as multifunctional or flexible areas that host different everyday activities (e.g. sitting, strolling, passing through) and events.

In more general terms, microclimatic plazas enhance the thermal regulation purpose of traditional plazas and pocket squares (Heschong 1979). As a complement to them, the emergence of microclimatic plazas can be explained by both environmental and socioeconomic factors, such as the climate constraints imposed by inherited urban forms originally designed for sunlight accessibility (Foshag et al. 2020), the difficulty of planting

trees, or the intensification of the urban experience through multifunctional open public spaces (Stanislav and Chin 2019).

Figure 2. Distribution of the inventory's reference types and subtypes: (1) Microclimatic plazas; (2) Climatic capsules; (3) Climatic stage settings; (4) Cooling street furniture; and (5) Non-classed items.

Four major setups have been identified within this category:

- Flexible floors (29 cases) integrate the cooling sources in the floor of the public space. The horizontal surface is designed as a continuous topography in which cooling sources can be positioned at individual points or distributed throughout the space. Through the use of techniques such as dry fountains, misting nozzles, or waterjets, they appear to be designed for functional reversibility.
- Water mirrors (27 cases) are presented as horizontal surfaces with a subtle ground socket of a few centimetres' depth, allowing the presence of water. Water characterizes the space both visually, with the effect of reflection on the water, and thermally, with the presence of fresh water, jets and misting. Although their uses and activities are flexible, the device seems designed with an almost permanent presence of water.
- Artificial gardens (12 cases) develop varied climate zones by combining water with other cooling techniques – frequently shading with greening. They also combine permanent and temporal approaches that transform the space throughout the seasons – for instance, integrating collapsible structures for shading.
- Roofs (5 cases) appear, such as canopies covering a high proportion of the surface of the public space. Shading is their main thermal effect, even if some cases also include water-based strategies. They involve major interventions achieved through ephemeral or permanent approaches.

Climatic capsules

A small part of the inventory's references lies in this category (31 projects). From the perspective of the spatio-climatic configuration, climatic capsules are mostly small spaces

that envelop the pedestrians and immerse them in a microclimate effect circumscribed by the limits of the space. They are ephemeral installations (24 projects) rather than permanent ones (7 projects). Built with light materials, climatic capsules appear as covered spaces with a perimetric enclosure, sometimes even façades, which pedestrians can access only through entrances. They combine diverse cooling strategies: blue (misting nozzles), green (green walls, suspended plants), grey (fans, cooling surfaces, insulation materials) and white (canopies, wind towers).

From the perspective of the microclimate experience, climatic capsules create situations of contrast between the surrounding environment and the interior of the space, like a fresh break in the public space. They create microclimate events, possibly as part of large microclimate sequences of an urban path, that create a sensory disruption in the citizens' experience of the public space. Climatic capsules are specialized structures for individuals or small groups, often for a finite time. They seem to enhance experiences of the public space at various points, which can be either activity-oriented (e.g. cultural, commercial) or non-functional experiences (e.g. urban rest areas).

In more general terms, climatic capsules recall the landscaping perspective of the pavilion or garden "follies" and introduce a climatic dimension to it, sometimes to create pleasant situations, sometimes shelter. This type contributes to the construction of the thermal representation of the city structured in nodes, paths and edges, which enrich to the visual structure of the city (Lynch 1960).

Figure 3. Examples of climatic capsules: (a) tents; (b) vessels; and (c) tunnels.

Three major subgroups have been identified within this type:

- Tents (15 cases) create local climate conditions while preserving a visual link with the surroundings. Citizens access the device through various entrances and can move about inside as part of their regular urban walks. Through their partial openness, designers use cooling techniques in the form of localized action targeted at the pedestrians' bodies, to produce the climate experience within.

- Vessels (12 cases) are ephemeral installations effecting a total disconnection from the outdoor environment. They are light constructions that envelop the pedestrians, isolating them and simultaneously promoting a fresher atmosphere inside. Entrances to the device are at various points.
- Tunnels (4 cases) are a variation of the previous group. They emerge as linear tents allowing routes through the urban space with regulated climate conditions.

Climatic stage settings

Only 30 projects out of 182 references of the inventory lie in this category. From the perspective of the spatio-climatic configuration, climatic stage settings create dynamic visual and thermal setups that appear as theatrical effects in the public space depending on temporal or activity patterns. They are usually materialized by small sources, or sources at various points, integrated into the shape or materials of the public space, but they can also be created by more prominent temporary structures. Their flexibility is further enhanced by the exclusive use of water-based techniques (e.g. misting nozzles, pop-jet fountains, dripping water features). Climatic stage settings are mainly ephemeral installations (25 projects) even if few permanent designs also coexist in the inventory content (7 projects).

From the perspective of the microclimate experience, climatic stage settings can produce two kinds of perceptual gradients: background microclimates covering a large area or event microclimates targeted at the citizen's body. Photographs present them as flexible public spaces for mainly dynamic activities.

In more general terms, climatic stage settings appear as an urban staging approach to the public space, in which climate effects prevail over material ones. The space becomes the canvas for collective or individual intangible climatic effects that are spontaneously recognizable by citizens.

Figure 4. Examples of climatic stage settings: (a) clouds; and (b) pop-ups.

Two subgroups have been identified within this type:

- Clouds (21 projects) link climate and visual effects through the creation of a mist moving along a surface larger than the urban coolspot itself. Integrated into floors, roofs or other structures, they involve expansive climate effects created through water-misting techniques. The devices' formal presence, limits and temporality vary according to the weather (wind, relative humidity, air temperature) and the neighbouring urban forms. Clouds mainly involve ephemeral installations in the public space, yet some permanent ones also adopt this approach.
- Pop-ups (9 projects) introduce urban surprises in which technical devices are built within other regular urban objects; thus, they go almost unnoticed from a visual perspective. They create a localized climate event directly applied to the citizen's body, like a "bit of freshness". They act on the citizen's thermal perception by using individual and focused techniques such as misting nozzles or waterjets. Pop-ups can involve both automatic activation or a direct form of interaction, including activation by the pedestrian's action or presence.

Cooling street furniture

A total of 31 projects out of 182 lie in this category. From the perspective of the spatio-climatic configuration, cooling street furniture involves the engagement of pedestrians' bodies with the device. They appear as micro or small interventions, presented as open or semi-closed structures, with remarkable visual presence in the public space. They can be either permanent or ephemeral installations, materialized by hybridizing greenery with construction materials. Cooling street furniture modifies pedestrians' thermal perceptions by combining the use of white techniques for reducing solar radiation (canopies, vegetal structures) or water-based techniques (misting) with grey (cooled surfaces, moistened fabrics, forced-air ventilation) or green (green walls) techniques.

From the perspective of the microclimate experience, cooling street furniture creates event gradients that contrast with their environment and whose area of influence is limited to the device's footprint. Their presence in the public space creates an opportunity for interaction that attracts individuals and concentrates people around them. Designed mainly for sitting or standing postures, most of these designs propose an almost mono-functional use.

In more general terms, this type emerges as a renewal of street furniture in the context of rising temperatures. Based on the consideration of the city as a whole, street furniture

contributes to the thermal experience of the city with a body-scale climatic approach. Urban cooling techniques integrate street furniture in meeting the challenge of increasing comfort whilst creating a strong identity and a qualitative perception of the public space.

Figure 5. Examples of cooling street furniture: (a) canopies; and (b) platforms.

Two subgroups have been identified within this type:

- Canopies (20 cases) are stand-alone structures that cover a small area in the public space. They can emerge from the ground or be superimposed on it. The shaded zone can be a covered free-use space, in which the visual and thermal qualities of the zone act as an attractor for pedestrians' dynamic activities; it can also be partially occupied by a platform that allows more calm and static activities. Both vegetal and artificial canopies can enhance the shading and cooling effect with other complementary approaches – e.g. misting, contact cooling, forced-air ventilation. Canopies are usually presented as sculptural lightweight structures in the public space.
- Platforms (11 cases) are devices placed on the floor of the public space used. Integrated in the general design, they emerge either as salient artefacts or as delicately posed objects. In other cases, they appear as a superimposed structure contrasting with the initial design of the public space. They combine the visual and haptic dimensions intrinsic to urban cooling furniture with the production of climate conditions that influence the activities nearby or on the device. Most platforms use water-based techniques (misting, watercourses and bodies of water) to cool down the atmosphere. Therefore, their effects can be slightly diffused around the device itself.

Conclusions

In the context of adaptation strategies for rising temperatures, the design of thermally sensitive public spaces becomes crucial to preserving their liveability in hot periods. This paper puts the focus on urban coolspots, considered here as spatio-climatic devices specific to summer that intertwine both the spatial and the climatic dimensions of public spaces in the design process. Through the study of an inventory of urban coolspots as presented in urban design media, this paper explores the hypothesis that the media contribute to disseminating knowledge on adaptation strategies, and by doing so they delineate a subfield of climatic urban design. This process can be a complementary approach to design guidelines for inspiring the design of thermally sensitive climatic public spaces. According to the descriptive statistical analysis of the inventory's content, design media provide a distinctive perspective on urban coolspots. Four main features compose this image:

- Urban coolspots appear as adaptation strategies suitable for mid-latitude cities and their socioeconomic contexts (Foshag et al. 2020), in which urban coolspots become tactical interventions to mitigate pedestrians' heat stress (Kluck and Boogard 2020). The design media present them as public facilities, funded by public or semi-public institutions, usually located in city centres or activity districts, to help urban attractiveness policies.
- Urban coolspot design appears as an emerging specialist field for a small group of designers, who can be principal designers or consultants collaborating with a large panel of generalist designers (e.g. architects, urbanists, landscape designers). Their increasing prominence in a field of overlapping disciplines like urban design (Cozzolino et al. 2020) reveals a process of skill renewal in design practice.
- Urban coolspot design combines a diversity of approaches to urban cooling techniques. While guidelines present a material categorization of urban cooling techniques in which vegetation-based techniques are central, the inventory analysis shows 54 strategies merging 20 cooling techniques, with a prevalence of water-based techniques. This result echoes previous work on the necessity of mixing techniques to achieve a more efficient and resilient strategy (Santamouris et al. 2017).
- Urban coolspots are strongly dependent on urban accessibility to resources for locally cooling down the public space. Mainly located in dense urban fabric with

difficult conditions for vegetation-based strategies (Czaja, Kołton, and Muras 2020), urban coolspots appear as "soft adaptation strategies" (Martinez-Juarez et al. 2019), creating intermediate scenarios towards the ideal of green and sustainable cities.

The study of the inventory presented in this paper reveals that urban coolspots are presented in media from a panoramic perspective that syntheses the complexity of the design process and contextualizes climate adaptation strategies. They complete the approach of climate design guidelines which, from a structured approach, present the parts and criteria that are helpful for the design process, including visual guidelines that implement the spatial translation of the scientific information (Cortesão et al. 2020). This paper develops an inductive typological approach to characterizing the spatio-climatic approaches promoted by the media when publishing urban coolspot projects. By moving beyond the case-by-case approach media, this typology contributes to understanding the design trends of urban coolspots and, more specifically, clarifies the constructs of a contemporary "aesthetic of freshness" in public space as presented in the media.

A typology of four types of urban coolspots results from the inductive approach of this paper. Two of these types (microclimatic plazas and cooling street furniture) appear as a thermally sensitive renewal of already existing urban devices. The third type (climatic capsules) recalls the landscape approach of pavilions and garden "follies" to produce a fresh area to take a break from the urban heat islands. The fourth type (climatic stage settings) concerns urban climate staging techniques to modify the perception of the public space.

Directions for future research involve opening up this first version of the inventory to external contributions. On the one hand, the inventory research should be expanded to other geographical areas (e.g. Asia, South America) or professional media underrepresented here (e.g. fountain design, engineering). Alternatively, by addressing the collection and the qualitative coding processes through the perspective of a participative network, the evaluations could be enriched by various experts: a process that could minimize analytical biases and structure a new survey of urban cooling design practices.

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