How cognitive links and decision-making capacity shape sectoral experts' recognition of climate knowledge for adaptation

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Abstract

Scientific climate knowledge is often argued to be a key ingredient in climate adaptation. Focusing on individual sectors and institutions, researchers have given insights as to how climate knowledge is reframed according to institutional cultures and priorities. This study extends such scholarship by comparing how four sectors—greenspace management, building technology, spatial planning, and health—perceive, judge, transfer, and appropriate knowledge on urban heatwaves, and what adaptation options are proposed. Based on semi-structured interviews, documentary materials and observations of two workshops collected in two Swiss cities, I draw on Eviatar Zerubavel and his 'cultural cognitive sociology' whose work emphasises how collectively shared patterns of recognition and thinking guide and facilitate human judgement. I find two factors to influence knowledge appropriation. On the one hand, the *formative* dimension of knowledge underscores that experts understand climate knowledge similarly when a sector shares key concepts with climate science. If such 'cognitive links' are missing, the answers on how heatwaves impact experts' work are more varied. On the other hand, the *performative* dimension of knowledge highlights that experts' eagerness to adapt is influenced by diverging technical, legal, and social possibilities. When experts' decision scope is large, then uptake of climate knowledge is more fluid. With a more explicit understanding of why sectors differ in their appropriation and integration of climate knowledge into their work, this study is a reminder that only fitting knowledge is of value to sectoral experts.

Keywords Urban heatwaves · Sectoral climate adaptation · Climate knowledge appropriation · Understanding of climate science · Climate knowledge transfer · Cultural cognitive sociology · Thought styles

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1 Introduction

Climate adaptation is often portrayed as a knowledge-intensive endeavour (e.g., Willows and Connell 2003; Adaptation Sub-Committee 2016). Knowledge has also been fascinating American sociologist Eviatar Zerubavel (1999, 2015). For over three decades, he has studied how recognition and thinking are exhibited similarly within comparable 'thought styles' (Fleck 1979[1935]), and how cognition structures human interactions and guides collective behaviour. The insights and conceptualisations of the Zerubavelian 'school' of cultural cognitive sociology (Brekhus 2007) have, however, not yet been applied to the question of how scientific climate knowledge gets transformed and potentially appropriated by professional experts working in sectors vulnerable to climatic changes. While some studies have elaborated how prior expertise and institutional cultures influence the way climate change has, literally, been made sense of and appropriated within one sector (e.g., Ryghaug and Solli 2012; Klenk et al. 2017), multi-sectoral comparisons of how such prior thought styles shift the perception of climate change are rare.

In this study, I compare empirically how, and more importantly why, four sectors often described as being vulnerable to urban heatwaves—building technology, greenspace management, spatial planning, and health—have appropriated scientific climate knowledge on heatwaves differently or similarly. In particular, by drawing on the work of Zerubavel, I explain the underlying dynamics of how prior expertise and collectively shared patterns of recognition influence the uptake of, or resistance to, climate knowledge in these sectors. The comparison of four sectors rather than one also allows a more nuanced conceptualisation of the underlying dynamics influencing how sectoral experts perceive and judge the relevance of climate science, and how they link up climate change with other sectoral concerns and aims.

In Sect. 2, I review three distinct areas of scholarship relevant to this study: how actors appropriate climate change and climate knowledge, the Zerubavelian cultural cognitive sociological perspective, and urban adaptation to heatwaves. Section 3 describes the sector selection, the case study cities, and the methodology and type of analysis undertaken. In Sect. 4, I compare how the four sectors differ in recognizing and linking up heatwaves with their work. Section 5 then contrasts the adaptation options proposed by the four sectors. I then discuss how and why some sectors were able to appropriate heatwaves similarly and also give them priority, while others struggled to recognise the impact and importance of heatwaves for their work (Sect. 6).

2 Literature review

2.1 Uptake of scientific climate knowledge informing climate adaptation

Two distinct strands of research studying the uptake of scientific climate knowledge can be distinguished. On the one hand, the dominant discussion around 'climate services' (e.g., Vaughan and Dessai 2014) places a premium on 'co-produced', 'tailored', and 'usable' climate information (Lemos et al. 2012). Aimed at overcoming the mismatch of 'supply and demand' (Sarewitz and Pielke 2007) or the 'usability gap' (Lemos et al. 2012), the underlying conception emphasises that in many instances improved—more usable, more actionable—climate knowledge would lead to an increase in its use for climate adaptation. While various studies have been published on the information needs of so-called users (e.g., Bruno Soares

et al. 2018), more recently there have also been empirical studies on the actual use of such co-produced climate information (e.g., Lorenz et al. 2017; Skelton et al. 2019a).

A second strand of research has elaborated how prior expertise and institutional cultures influence how climate change is, literally, made sense of and appropriated. For instance, drawing on the Public Understanding of Science literature, Ryghaug and Solli (2012) empha-sise how Norwegian road managers perceive and frame climate change predominantly through their experience of past extreme weather events rather than through the statistical conception of climate (cf. Hulme et al. 2009). In contrast to the climate services conception of knowledge uptake, several studies have shown that climate adaptation within organisations is often hampered because climatic changes are not perceived to be salient to an organisation's work (Berkhout 2012). Such attitudes may also be exhibited because 'standardization organizations and public authorities do not take climate change and adaptation needs into account' (Rotter et al. 2016: 618). Weber (2006: 115) has argued that stakeholders' 'finite pool of worry' might lead to exclude climatic concerns. This research thus emphasises that climate knowledge is not inherently of value and might even be 'uncomfortable' (Rayner 2012). Further, Preston et al. (2015) have identified eight 'adaptation heuristics', including 'no regrets adaptation' where win–win situations are sought, and 'predict and respond' framings where scientific assess-ments guide adaptation deliberations. Lastly, while academic debates around the role of 'local' knowledge in adaptation have intensified, the review by Klenk et al. (2017) reveals that many of these studies still focus on 'extractive' practices, comparing local and scientific knowledge, rather than the interplay between the two.

2.2 Zerubavel's cultural cognitive school of sociology

The academic interest of sociologist Eviatar Zerubavel has focused on the surprising similar-ities of how people recognise patterns around them, how they focus their attention, what knowledge gets appropriated and remembered, how perceptions are classified, and how knowledge remains unspoken (Zerubavel 1991, 1999, 2015). He argues that recognition and thinking are much influenced by people's social and professional surroundings. A shared way of attending to and judging things thus allows an exchange of shared interests and commit-ments. As such, there are certain 'socio-attentional patterns' which are exhibited by more than a single individual, but not by all. This is similar to the concept of 'thought styles' (Fleck 1979[1935]). From the perspective of the 'Zerubavelian culturalist cognitive school of sociol-ogy' (Brekhus 2007), experts in the field of greenspace management or building technology are likely to exhibit different sets of knowledge which is 'collectively memorised'. Central to Zerubavel's study are both a *formative* and *performative* dimension of knowledge, explaining how and why knowledge gets appropriated successfully.

Formative Knowledge and its distinct way of being thought about and reasoned with creates groups of people which collectively share similar perceptions of the world and create similar relevance. As such, knowledge can structure human interactions and guide collective behav-iour. However, for Zerubavel it is clear that these culturally and socially mediated forms of recognition and thinking are not universal, and that the continued existence of such a 'thought style' requires new members who learn to perceive, judge, classify, think, and know similarly. This can be seen, for example, in university education which not only ensures the continued existence of thought styles but enables knowledge to be shared and memorised. What is

known, and how it is thought about, thus enables individuals to connect up with other people sharing the particular way of thinking and form distinct thought collectives.

Performative Knowledge and thinking also allow fulfilment of a designated role. Experts, for instance, can perform their advisory or constructive functions legitimately because they exhibit more specialist knowledge and a deeper understanding of a particular subject area. The socio-attentional pattern embedded within a thought style allows them not only to notice but also to deliberate on and judge certain information more competently. This facilitates carrying out a particular task or responsibility well. However, not all knowledge is necessarily performative and might thus not be considered relevant.

Overall, Zerubavel's work can help explain why knowledge and groups of experts are similarly organised. Not only can shared knowledge and socio-attentional patterns form a common group identity, they also allow people to perform a designated role. Both attributes thus emphasise the social underpinnings of knowledge and play an important role which knowledge is transferred between two thought styles. In a similar vein, Mary Douglas (1986: 71) finds that '[anthropologists] are less inclined to ask why people forget. For them, remembering is the peculiar thing that needs to be explained'. Her own work has illustrated that the solutions proposed by thought styles often mirror their activities. Successful appropriation of scientific climate knowledge into sectors' thinking is thus not a random process, but one that is influenced by the *formative* and *performative* dimension of knowledge. Still, as the concept of 'hypocognition' illustrates, various (sub) cultures may fail to recognise and describe something adequately and similarly (Wu and Dunning 2018).

2.3 Urban adaptation to heatwaves

Studies on climate adaptation taking place within cities have proliferated, in particular those relating to spatial planning. While German cities as an exception have a legacy of accounting for urban climate (Hebbert and Webb 2012), elsewhere climate-aware planning is rarely prioritised (Eliasson 2000). Scholars have also called for more explicit discussions of justice issues around how urban climate adaptation impacts marginalised groups (Shi et al. 2016). Klinenberg (2002) has unearthed how mortality rates during the 1995 Chicago heatwave were accentuated by socio-political factors. This concern is shared by Leitner et al. (2018) analysing how the concept of 'urban resilience' has brought together powerful international actors to influence cities' adaptation action, but excludes more vulnerable actors. Other researchers have been interested in the prominence of ecosystem-based adaptation options—such as the promotion of 'green' walls and roofs—within European cities' adaptation plans (Geneletti and Zardo 2016). Lastly, some studies have focused on the knowledge requirements of local governments, finding that enough science is available for the assessment of vulnerabilities, yet not for the implementation of adaptation options (Nordgren et al. 2016). While the proliferation of studies indicates closer academic attention to urban adaptation, many studies have often focused on multiple climate impacts.

A limited range of studies have specifically been published on adaptation to urban heatwaves. For instance, Heaphy (2018) has analysed five transdisciplinary research projects producing knowledge on urban climate change. Taking climate models as a starting point for changing urban policies (cf. Heaphy 2015), cities learned about the climatic changes which then fed into 'evidence-based approaches underwriting policies on green infrastructure and

urban design' (Heaphy 2018: 622). Further, Reischl et al. (2018) evaluated the adaptation efforts of Graz (Austria) and found that risk perception of heatwaves among decision-makers is high, assisted by adaptation networks and recent heatwaves. Despite this recognition, adaptation efforts need to take into account that an expert's knowledge is always only partial and fragmented, as the study by Olazabal et al. (2018) emphasises. By mapping the knowledge of individual actors as a proportion of the collectively available knowledge, they find that the diversity of knowledge on heatwave adaptation is so large that no single 'super-stakeholder' is able to possess—and thus integrate—it all. Thus, there is a need for continued interactions between policy-makers and scientists to exchange their respective knowledge. Still, climate awareness does not necessarily lead to prioritising heatwaves in planning (Eliasson 2000).

Lastly, papers on how heatwaves impact ecological and human livelihoods and available adaptation options have been published for all four compared sectors. For building technology, heatwaves affect the thermal comfort within buildings adversely, leading to overheating (e.g., Roaf et al. 2009). Spatial planning has to deal with larger and intensified urban heat islands, in particular during the night(e.g., Roaf et al. 2009). Calls to public health officials for more awareness on heatwaves have been made (Winkler et al. 2015), while health warning systems (WMO and WHO 2015) have been developed to reduce the observed excess mortality during heatwaves (Ragettli et al. 2017). Lastly, trees in cities are also being impacted by heatwaves, with species resistant to heat and drought now being preferred (Blaser et al. 2017).

3 Case description and methods

3.1 Sector selection and description

I adopted a case study approach to analyse how a range of relevant experts perceive, frame and appropriate knowledge on urban heatwaves, and importantly, why integration of urban heat into experts' thinking differs from sector to sector. The four sectors *greenspace management*, *building technology*, *spatial planning*, and *health* were selected because they are not only portrayed as being vulnerable to heatwaves (e.g., Akademien der Wissenschaften Schweiz 2016), but have also been identified as key sectors in Switzerland's national climate adaptation strategy (FOEN 2012; BAFU 2018). Climate change affects cities in particular through an exacerbated urban heat island effect, increasing cities' temperature further compared with its surroundings (BAFU 2018). This is because cities exhibit proportionally more sealed surfaces and fewer greenspaces, as well as reduced air circulation capacity between buildings. As much of the population and economic activity is in cities, the consideration of heatwaves by greenspace managers, building technicians, spatial planners, and health specialists is becoming increasingly important.

The four selected sectors exhibit similarities as well as differences. For instance, all four sectoral specialists work in public administration departments, for which an academic degree is a prerequisite. However, while the education and range of work of greenspace managers, building technicians, and spatial planners were similar within their sectors, the health specialists interviewed had more diverse academic backgrounds, including medicine, epidemiology, health promotion, and health economics. Further, health specialists' work focus is more diverse too, ranging from emergency management in the event of a pandemic, overseeing medical doctors, and arranging medical check-ups in schools. Thus, all four sectors have their

designated and politically legitimated area of work and expertise, and are guided and assisted by formal academic training and knowledge when carrying out their duties.

The case study was conducted in Switzerland, whose governance is described as the archetypical 'consensus model of democracy', a term applicable also to the European Union (Lijphart 2012). *Not* a synonym for harmony, 'consensus' denotes a politics of bridging societies divided by religion, ideology, language, culture, or ethnicity. Characteristically, Swiss policy-making includes both the proportionally represented parties as well as a public consultation where well-organised interest groups react to policy proposals. Compared with its majoritarian antagonist—the 'Westminster model' found in the UK and in many of its former colonies—national executive power in Switzerland is comparably low (Lijphart 2012). Further, similar to other federal states such as Germany or the USA, Switzerland places a high premium on governing at subnational tiers, a principle termed 'subsidiarity' (Ritaine and Papeil 2014). Overall, studying Swiss cities' action is thus particularly insightful as they retain governmental, legislation, and implementation power over services such as schooling, social security, health care, spatial planning, and taxation. Compared with centralized nations such as the UK or France, Swiss cities need to resolve many tense issues and contested policies themselves. This might also explain why Swiss climate scientists are at the forefront of customising global climate science into local climate information (cf. Skelton et al. 2019b). Intriguingly, the political culture on 'consensus' also influenced how and what climate science was tailored to Switzerland, similar to how the British and Dutch political cultures influenced their national climate information (Skelton et al. 2017).

3.2 Data and methods

To obtain a detailed picture of how the four sectors appropriate knowledge on heatwaves into their thinking and work, I collected and triangulated three data sources from the two Swiss cities of Schaffhausen and Zurich. *First*, a desk-based web search identified relevant documentary materials, such as briefing reports or municipal strategies of the two case cities. Being a public record and guideline for action, these documents reflect discussions within the administrations and sectors. Thirtythree documents were obtained from the two case sites, complemented by 26 relevant national reports.

Second, I conducted semi-structured interviews with 20 sectoral experts working in the local governments of Schaffhausen and Zurich, as well as one expert per sector working in an applied university department. The semi-structured interviews, conducted in German, included questions such as 'what distinguishes a 'good' sectoral expert?', 'what are the implications of 'urban heat' for your work?', and 'what type of action could be taken to lessen the impact of heatwaves?' (full interview protocol in Supplementary Materials). With six and five interviewees respectively, greenspace managers and building technicians were relatively accessible for interviews.[1] Spatial planners were more difficult to motivate, often stating time pressure as a reason. Four planners could be interviewed in person and one answered key interview questions in writing. Lastly, it proved particularly difficult to recruit the four health specialists with any work experience concerning heatwaves at a local level.

Third, following up from the interviews, I organised two transdisciplinary workshops with 29 experts from all four sectors together with four Swiss climate scientists. Aided by an

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[1] I aimed for $n = 5$ interviewees per sector. However, a pair of greenspace specialists wanted to be interviewed together.

external and professional facilitator, the participants discussed past and future impacts of urban heatwaves as well as fruitful adaptation options. These workshops also explored potential uses of the Swiss climate change scenarios CH2018 (cf. Bresch et al. 2018). While the participants recorded the results themselves, two social scientists also observed the group discussions. Both data sources were then circulated in a workshop report for approval by the participants.

All three data sources—the documentary materials, the semi-structured interviews and the workshop report—were imported into the qualitative coding software MAXQDA and manually coded during two cycles to identify emergent themes. Based on the central research question, the questionnaire, and initial reflections after the interviews, I first sketched out recurrent themes, topics, emotions, and experiences. With these designated codes, I assigned similar text passages with the same code. I then paraphrased each code according to sectors to find key similarities and differences. In the second cycle of coding I double-checked the original material to see whether in my paraphrasing I had overlooked any contradictory statements, or whether my summary over-simplified key aspects of the sectors' work. If this was the case, I changed the summaries accordingly. The key quotes in this manuscript have been translated by the author from German into English.

4 Formative knowledge: How experts linked up heatwaves to their sectoral concerns and aims

Using the interviewees' responses and the descriptions of their sectors' vulnerability in the documentary brochures, this section analyses how experts in the four sectors differ in recognising heatwaves as a legitimate concern for their work, and how far this concern is shared within each sector. Two aspects crystallised as being dissimilar: how differently the impacts of heatwaves were described by the four sectors and how specific examples and technical vocabulary employed in such descriptions were. Both elements pinpoint the importance of the *formative* dimension of knowledge as a social activity: the shared knowledge together with the encompassing shared goals and aims demonstrated how 'collective' and 'social' knowledge can form the basis for organising and distinguishing groups.

Greenspace managers were keen to emphasise two issues. First, several interviewees mentioned that heatwaves have negative impacts on trees and other plants. While intensified watering schemes are too costly as an adaptation strategy, many specialists stated that they are currently reconsidering which tree species to plant in cities, focusing on those species with greater heat tolerance and drought resistance (#GM1, #GM4, #GM5). Second, many interviewees emphasised how public greenspaces can bring about cooler temperatures during hot spells. 'Urban greenspace is of enormous importance to the respite quality of public spaces when it is getting hotter' (#GM4). There was widespread agreement among the interviewees that trees in particular can lower the surrounding temperatures by providing shade and through evapotranspiration (#GM1, #GM2, #GM4, #GM5), as the following exchange indicates:

[Considering climate change in greenspace management] started with selecting different plants. A forest tree [species] has a limited survival expectancy in a city. The urban climate is just different. Now we plant other [heat-resistant] species. This just started further action against the overheating of cities. Exactly. And another topic which has been on the agenda for a long time are green roofs. Now façade greening is trending

since a few years. But how [tree] shading, evaporation, and greenspace influences the urban climate [and not vice versa] is a newer topic (#GM1, #GM5).

Questions on heatwaves quickly triggered discussion of another area of concern for greenspace managers, namely, biodiversity. Not only the positive effects of plants on urban climate, but also the larger 'loss of vegetation mass' (#GM4) due to new developments have led experts to call for more greenspaces in cities, including space out of reach of humans (#GM2, #GM3). 'Green roofs' (#GM2, #GM3) have been described as one of the few areas in cities left where diverse habitats for both plants and birds can be created, and heatwaves are reinforcing the imagination of the public and ecologists of greening cities (Grün Stadt Zürich 2018). One specialist was, however, doubtful whether such roofs can provide significant cooling benefits during heatwaves, as the rainfall would quickly evaporate (#GM3). Overall, greenspace managers similarly recognised heatwaves, describing the impacts on their work with many professional examples.

Building technicians perceived heat as a 'key topic' (#BT4). Widely and primarily under-stood as a problem of 'overheating of buildings' (#BT4), heatwaves lead to a reduction in thermal comfort which building technicians see as their responsibility to avoid (#BT1, #BT2, #BT5, cf. AFC et al. 2016). With key terms such as 'cooling', 'indoor climate', 'energy', 'heat pumps', and 'free cooling' frequently being used in the interviews, building technicians shared a considerable number of terms with climate scientists. However, technicians were clear that these were themes in their work independently of heatwaves, as 'building users have rising expectations on thermal comfort' (#BT2). Intriguingly, sustainable building norms managed to create a win–win situation:

> We know that houses which are... really well built have a high [thermal] comfort. Even have a low energy consumption. This is no contradiction! … The decisive thing we managed to show with the Minergie label [sustainable building norm] is to show that better houses have higher security, better preservation of value, more ancillary benefits. … And that is widely desirable – everyone wants a higher comfort. And thermal insulation is an important aspect of that comfort (#BT5).

While all profit from indoor thermal comfort, many of the interviewees nuanced priority areas: '[heat protection] is a topic in particular in the municipalities' schools and homes for the elderly. There are fewer discussions concerning apartments and offices, as these have less vulnerable uses [and users]' (#BT4). In banks and insurances, however, 'it is also a matter of prestige to have 23°C indoors when it is 30°C outside' (#BT2, also #BT1. #BT5). Overall, building technicians had similar views to those of greenspace specialists and they also described heatwave impacts consistently using similar vocabulary. The details provided—in one case even sketching a complete energy-efficient cooling system (#BT1)—demonstrated that these experts are highly aware of how heatwaves affect their work. This climatic knowledge has thus already altered the work focus of building technicians, thereby changing the infrastructure underlying each city.

Spatial planners' descriptions of how heatwave impacts their work were generally more diverse, with fewer common technical terms than those of greenspace specialists or building technicians. For instance, only a single interviewee mentioned the term 'urban heat islands' (#SP3), despite sealed surfaces and dense building designs being widely recognised as exacerbating local temperatures (#SP1, #SP2, #SP4). Planners were also less favourable towards increasing the amount of greenspace in cities compared with greenspace managers.

While spatial planners acknowledged the positive effect of greenspace lowering the surround-ing temperature, some planners also took the position that a rise of a few degrees in inner cities is tolerable in order to ensure city aesthetics and qualities (#SP2, #SP4).

> I tell [greenspace manager] again and again: We want to have different urban spaces... Citizens and visitors should be able to enjoy the urban space from façade to façade. That is a trademark of cities. For instance, Zurich's [main shopping street] is typical, it does not have front yards. I am in an urban space – in which one can plant trees – but what we [spatial planners] do not want is that we start creating greenspaces, allotments, because of climatic considerations. I think we need to think twice where we add greenspace, and where we have urban spaces which have higher temperatures during some weeks in summer (#SP4).

Similar tensions were raised concerning public spaces with few trees (#SP1, #SP3, #SP4, #SP5). In both Zurich and Schaffhausen some large sealed squares have been criticised in the local media by residents and local restaurants with outdoor seating for being so hot that people could no longer enjoy them. Spatial planners saw heatwaves as leading to a goal conflict between greenspace managers' biodiversity goal and cultural events: planting trees would provide shade and cooler temperatures, but would make it impossible to host cultural events such as music festivals, which require open space. Thus, the appropriation of climatic knowledge into spatial planners' thought style is less pronounced and more ambivalent, triggering active discussions also with greenspace managers.

Health specialists' descriptions of heatwave impacts were the most diverse of all four sectors, but there was still unity in the way they talked about them, being hesitant to see heatwaves as a legitimate public health issue. As one interviewee put it, 'the negative effects of heat on health were a prominent theme in the newspapers, but I had the feeling that this was so because of the summer slump' (#HS4). Another health official added that 'there weren't any information requests by politicians or media outlets' (#HS2). A third said: 'Heat is often not really an issue. I mean, half of the Swiss population go on holidays in hotter areas… Some people love it, others hate it' (#HS3). This hesitance was, however, only for those people 'who can sweat and who can drink... Those who cannot look after themselves, such as infants, or those with reduced heat and thirst sensitivity, the elderly, are at risk' (#HS1; also #HS2, #HS3, #HS4).

While the majority of answers were about dehydration and sweating, the indirect effects of heatwaves on human health were rarely mentioned. For instance, when one health specialist mentioned prolonged asthma suffering due to the longer pollen season and the spread of new illnesses, the interviewer enquired why in prior mail exchanges she had written that 'heat is not a topic in the area of health promotion' (#HS4). She responded that 'at that moment, I didn't think that heat was a health issue', but in preparation for the interview she had done some research, and realised that there are various indirect effects, such as increased skin cancer risk. This illustrates that heatwaves elude the causal illness framings such as bacteria or toxic substances. The additional effort required to understand how heat affects people's behaviours or how new diseases can spread could be an explanation why the various indirect effects of heatwaves were only mentioned by a single health official. Thus, knowledge on heatwaves lacks formative character for health specialists, and as such has not altered their recognition and work priorities.

To sum up, this comparison of the four sectors has shown not only that they understood heatwaves differently as an issue but also that within the sectors the examples given by the

experts could diverge. For instance, greenspace managers and building technicians described heatwave impacts similarly, giving first-hand examples. These two sectors not only used similar concepts to describe how heatwaves influence their work, but many of their technical terms correlate closely with climatologists' descriptions of heatwaves. Among spatial planners and health officials, however, knowledge on heatwave impacts was more fragmented. Not only were there fewer shared concepts and examples within these sectors, but the used terms linked much less with physics-based notions of heatwaves, such as temperature and energy. However, there was still some common ground between spatial planners and health officials: both sectors were hesitant in recognising and legitimising heatwaves as a significant issue and a priority for their work. For health officials this critical interaction with the issue of heatwaves resulted partly out of scepticism grounded in the way heatwaves have been characterised as a health issue in the media. For spatial planners the problem arose from goal conflicts when designing public spaces. As such, while knowledge on heatwave impacts was not always shared within a sector, experts within their sectors largely agreed on how relevant, or not, heatwaves are for their work.

5 Performative knowledge: How a sector's decision-making capabilities influenced its style of adaptation

Experts of all four sectors gave examples of adaptation options to lessen the impacts of heatwaves on their cities' inhabitants. While knowledge about the impacts of heatwaves on their work guides which adaptation measures the experts proposed, this section emphasises that the experts' adaptation options are much influenced by the physical properties of their areas of work: plants, machines, space, and humans. As such, how keen the different sectors are on taking adaptation to heatwaves depends not only on their knowledge of the phenomenon but on their ability to take meaningful action.

When greenspace managers plan greenspace accessible to the public, they 'consider three core claims: use, design, and ecology' (#GM4, #GM5, #GM6) and 'try to find the intersection between these [three claims]' (#GM6; also #GM4). Their general aim is to have 'more greenspace' as a synonym for 'more quality of life' (Grün Stadt Zürich 2018: 2), an aim also politically mandated in Zurich's long-term 'greening strategy' (Grün Stadt Zürich 2019). While this is also supported by planning and health (e.g., #SP2, #SP3, #HS2, #HS3, BAFU 2018), greenspace managers still 'need to lobby for our work and need to receive political legitimation' (#GM4) to manage the parks, cemeteries, sports grounds, and playgrounds entrusted to them. With heatwaves becoming more frequent, greenspace specialists are reconsidering which trees to plant, opting for species offering more heat and drought tolerance (Blaser et al. 2017). They are also experimenting with different soil substrates to ensure optimal conditions for growing the trees (Heinrich and Saluz 2017).

The choice and depth of substrate matter are also of crucial importance when greening roofs: 'you do not even need to tend it [the green roof], because you have already botched it up if you select the wrong substrate … such as a cheap recycled clay brick' (#GM3, cf. Stadt Zürich 2013). After intensively deliberating and finding agreement with building technicians among others, greenspace managers working in administration and research institutions updated an official (though voluntary) building norm for green roofs (Brenneisen 2015), while both case cities have defined their own 'native' seed mixtures (Stadt Schaffhausen 2006; Stadt Zürich 2013). Both ensure that green roofs are a practical and eco-friendly adaptation option,

forming 'wildlife corridors' between eco-habitats (Grün Stadt Zürich 2019). Thus, greenspace managers saw heatwaves as a legitimate means to promote action they are concerned with anyway: more high-quality and biodiverse greenspaces in cities.

Building technicians' adaptation options to heatwaves were widely known and shared among the experts, revolving around the cornerstones of 'thermal protection, mass, and efficient cooling' (#BT5; cf. AFC et al. 2016). *Thermal protection* includes 'renovating windows' (#BT2) with an appropriate '*g*-value' (#BT4) indicating energy transmittance. While external shading options provide some thermal protection, they 'are quickly exhausted' (#BT2) and trigger 'architectural discussions' (#BT2). One architectural way of preventing buildings from overheating is through the increased use of mass, as mass can absorb thermal energy fluctuations, thus 'letting rooms warm up only slowly' (#BT5). 'Solid buildings are like bunkers, they never get really hot' (#BT2). Interestingly, green roofs were seen as possible adaptation options when buildings were not adequately insulated:

> For a concrete roof [without insulation], having a green roof in summer would be extremely influential. But if I have a roof with a good, modern heat insulation then I do not feel inside what is on top [of the insulation]… But green roofs have the benefit of retaining rain, important against flash floods… Then it also reduces the urban heat islands effect minimally… And then it is also pleasant for insects and plants. I support green roofs, but for indoor temperature they hardly matter (#BT1).

Cooling of buildings was seen as a major adaptation option and likely to increase in future (e.g., BFE 2017), but all interviewees and brochures were in agreement that conventional air-conditioning units are not a desirable or viable solution. While 'night time air circulation' is one way of cooling buildings (#BT2, #BT3), 'free cooling' is the widely preferred technique, transporting heat out of a building to a cooler source using energy-efficient circulation pumps (#BT1, #BT4, #BT5; Rohrer et al. 2018). Cooling sources include lakes, larger rivers, and near-surface geothermal units (#BT1). However, to work efficiently, such technologies need to be combined with adequate thermal protection: 'Already with these [double-glazed] windows building technicians can install systems with which one can both heat or cool a building' (#BT1). This has the benefit that the thermal source is regenerated in summer, thus acting as a seasonal energy reservoir. Overall, building technicians exhibited a strong commitment to implement adaptation options, potentially using a 'simple simulation tool to calculate how warm a room can get' (#BT4; cf. AFC et al. 2016). Knowledge on heatwaves thus changes building technicians' practice by adding different ways of keeping buildings cool, often requiring in-depth and long-term interactions with heritage conservationists, building users and house owners.

Spatial planners described their work using many more verbs indicating interaction and communication than the other sectors. 'One needs to communicate very well' (#SP3), 'reconciling, coordinating as well as getting through all the commissions' (#SP1), 'being open-ended in the beginning, listening at the start' (#SP5), 'integrate what is happening outside of this city' (#SP4), and 'not always showing solutions top-down, but stating that this is the problem to be addressed' (#SP3). Likewise, a 'good' spatial planner needs to 'adjust well to one's counterparts and know what their interests are' (#SP3), to be able to 'mediate' (#SP3) and be 'cooperative and diplomatic' (#SP5). Examples of 'goal conflicts' (#SP4, #SP1) triggered by heatwaves include sealed squares getting so hot that staying on them during heatwaves is uncomfortable. Two adaptation options were mentioned: choosing a surface

which is brighter and reflects more sunlight (#SP4, also #GM2) and the installation of temporary shading and artistic awnings (#SP1, #SP4; Stadt Zürich 2017).

Two legal tools are available to spatial planners to guide adaptation to heatwaves (#SP1, #SP3, #SP4; ARE 2013; BAFU 2018). Some are only legally binding for public authorities, such as the 'structure plan' or thematic strategies (e.g., ARE and AWEL 2015; Stadt Zürich 2016), which define which issues and actors have to be considered in the planning process. In addition, there are instruments which also private actors need to adhere to, such as the municipal 'building and zoning regulations'. Defining the use of plots and associated building sizes, Zurich's recent regulation revision now includes legally binding obligations on green roofs (Stadt Zürich 2013) and the reduction of sealed surfaces wherever possible (BAFU 2018). Although building and zoning regulations are open to intense scrutiny, sometimes also accompanied by judicial appeals, there are efforts underway to 'prescribe climate adaptation as binding for landowners, so that we can demand adaptation measures' (#SP4) even if developers oppose them. In other words, the success of spatial planners' adaptation options is conditional on the support of other actors, but is nonetheless assisted by certain legal tools. Certainly, climatic knowledge acts as a legitimate concern for intersectoral interactions, accentuating discussions on the design and function of urban landscapes.

Health specialists' style of adaptation is an intriguing mixture of resistance to and avoidance of responsibility for adaptation measures. A common take among the interviewed specialists was that 'we assume that they [the healthy and adult population] know about them [heat impacts] themselves' (#HS2). As such, 'the wider public has not so far been targeted by any particular measures' (#HS3). The interviewed health specialists were overall reluctant to describe the majority of the population as being at risk from heatwaves, wanting to treat people as being responsible for themselves. Underlying such reasoning is the question whether.

> this [prevention measure] is really justified…? Or shouldn't everyone decide on their own? Yes, that is the challenge [in our work]: where is one too patronising, just provoking an attitude of total defiance to all prevention measures? And where is [it] justified to look after the general public, to ensure that individuals do not go over the top? (#HS3).

The elderly and infants were, however, not judged as self-reliant, but as vulnerable. The dangers of heatwaves for these groups are addressed by raising awareness among their caretakers, for example, through home care organisations (#HS3), pharmacies (Städtische Gesundheitsdienste 2019), and schools (Schulgesundheitsdienste Stadt Zürich 2017). Health officials were, however, quick to shift the responsibility for ensuring that people have options to avoid heat stress on to other specialists. This includes insisting on building technicians being responsible for indoor climate (#HS1), greenspace managers for shading (#HS2), and those who promote cultural festivals for the provision of free drinking water (#HS3). Overall, health specialists' approach to heatwave adaptation is to see themselves not as responsible for implementing any measures, but for communicating with specialists, vulnerable people and their caretakers. But with health largely perceived to be a matter of private responsibility, health specialists were hesitant to propose health promotion measures which to most people might be seen as patronising. Thus, the work of health specialists has not really changed because of climatic knowledge, and intersectoral interactions remained low.

To sum up, while the four sectors differed in the specific adaptation measures they proposed, certain characteristics were shared between certain sectors. For instance, the three sectors greenspace management, building technology and spatial planning proposed mainly

physical measures. However, many of these experts also brought up individual or social adaptation measures (#GM1, #GM4, #GM5, #BT2, #BT4, #SP1, #SP3, #SP5), such as shifting work hours during heatwaves or selecting leisure options which cool one down. Meanwhile, health specialists focused more on *socio-cognitive* measures such as campaigns to raise awareness, as well as insisting on physical measures being undertaken by the three other sectors (#HS1, #HS2, #HS3). Another key difference is the degree to which the experts themselves have decision-making power over implementation. While the scope of action is relatively large for greenspace management and building technology, spatial planners and health specialists rely on the approval of, even implementation by, other actors for fostering climate adaptation. Lastly, climatic knowledge was highly *performative* for greenspace managers and building technicians, whose sectoral aims were reinforced by heatwaves. Spatial planning and health experts, on the other hand, consider the implementation of heatwave measures more often as a complication, critically reflecting and questioning such options.

6 Discussion: Cognitive links and high sectoral decision scope co-constitute appropriation of heatwave knowledge

This comparative analysis emphasises that the degree to which sectoral experts appropriate knowledge on urban heatwaves is mutually influenced by two factors: (a) availability of *cognitive links*, that is, whether concepts and vocabulary are shared with climate scientists' descriptions of heatwaves; and (b) the different decision scope experts have in implementing adaptation options. The distinction between these two factors is similar to Zerubavel's description of knowledge having *formative* and *performative* dimensions in structuring human collectives and action (Zerubavel 2015).

(a). The two sectors *greenspace management* and *building technology* exhibited most clearly what Zerubavel (1999) dubs a 'collective memory': similar descriptions and recognition of heatwaves (see Table 1). Characteristically, these two sectors used similar terminology to describe the impacts of heatwaves on their work. Terms, moreover, which are also used by climate scientists, such as 'climate', 'heat', or 'energy'. Both green specialists and building technicians thus share what I dub *cognitive links* with climate science, allowing the sectoral experts to recognise relatively uniformly the relevance of more intense and frequent heatwaves. Such cognitive links between sectors reveal that both communities share certain 'socio-attentional patterns' which mark elements to be foregrounded against those which remain largely unnoticed (Zerubavel 2015). Such 'socio-attentional patterns' guide and facilitate knowledge appropriation while also ensuring that heatwaves are similarly understood, memorised and described within the sector. Overall, in both sectors knowledge on heatwaves has been successfully integrated, adding and updating a shared set of knowledge and concern. Successfully appropriated climatic knowledge can thus be *formative* to a sector's work aim and focus.

Within *planning* and *health*, the interviewees in both cities were less able to describe the impacts of heatwaves consistently and similarly, evidenced in particular by a variety of terms. While together they mentioned almost all the issues discussed in the academic literature, individually they covered only parts of the entire corpus of knowledge. Such a situation was also described by Olazabal et al. (2018), mapping individual expert's knowledge as a proportion of the total knowledge on heatwaves in Madrid. As such, this study finds that many of the interviewees are still trying to find adequate sectoral concepts to, literally, make

Table 1 Key results of how experts appropriate and frame knowledge on heatwaves as relevant for their work

	Greenspace management	Building technology	Spatial planning	Health
Formative				
Cognitive links with climate science	'Micro climate', 'bioclimate'	'Indoor climate', 'energy', 'heat', 'temperature', 'cooling'	'Urban heat islands'	–
Similarity of responses among experts	High, with specific examples from professional contexts	High, with many specific examples from professional contexts	Intermediate, some examples given. Descriptions based on both personal and professional experiences.	Intermediate, with few concrete examples. Descriptions mainly based on personal experiences (e.g., guided holiday tours, festival visits).
Performative				
Proposed adaptation options	Green roofs and green facades; more greenspace; different types of trees; different soil substrates	Thermal insulation; sun radiation protection; building with more mass; free cooling	Adjusting building and zoning regulations for improved air circulation; adequate greenspaces; prevention of sealed surfaces; reflective surfaces	Awareness campaigns for vulnerable groups (elderly, children) and their caretakers; urge other sectors to provide greenspaces and free drinking water
Style of adaptation	instrumental	instrumental	participative	persuasive

sense of heatwaves for their work. Echoing the finding of Eliasson (2000), interviewees *knew about* what intensifies heatwaves in cities, but descriptions of the *relevance* of heatwaves for their work were ambiguous. Planners' and health officials' 'socio-attentional pattern' (Zerubavel 2015) is more geared towards social, epidemiological, or aesthetic concerns, into which climatic knowledge cannot be so easily integrated. Thus, the unavailability of dominant and shared concepts with climate science—or cognitive links—made it difficult for planners and health specialists alike to appropriate heatwave knowledge similarly. Wu and Dunning (2018) write that such 'hypocognition' also impairs what gets memorised. Compared with greenspace management and building technology, knowledge on heatwaves does not resonate with prior concerns and aims and is unable to form a common understanding among planners and health specialists. Other concerns and worries seem to have priority over heatwaves (cf. Weber 2006). According to the Zerubavel, however, a shared set of assumptions and recognition patterns are necessary in order for climatic knowledge to have *formative* character of expert communities.

   (b). My comparative analysis further revealed three different *styles of adaptation*, largely determined by experts' scope for deciding to implement a measure or experts' reliance on external support (see Table 1). For example, the *instrumental* style of adaptation exhibited by greenspace managers and building technicians is largely due to the fact that these two sectors can deliberately employ—or manipulate—material and matter to provide the desired services and amenities. That is, both plants and cooling devices have only a limited ability to resist the expert, allowing these experts to exhibit what Gillard et al. (2016) dub a 'managerial' approach. Those two sectors whose experts enjoy greater decision scope were also keener to

actively integrate urban heat into their core work. They not only had the means and *performative* knowledge to implement adaptation options, but heatwaves legitimised their *prior* work aims further, gaining approval from a wide range of actors. Thus, climatic knowledge has shifted intersectoral discussions on public spaces and indoor climate in favour of greenspace managers and building technicians' *instrumental* adaptation.

However, dealing with human actors rather than materials, spatial planners and health specialists do not enjoy such possibilities. Planners' *participative* style of adaptation restricts the treatment of single topics, such as heatwaves, from dominating urban design decisions, as the diverse set of actors scrutinise and possibly resist adaptation measures. Thus, the conclusion of Eliasson (2000) that 'climate knowledge had low impact on planning process' seems still to be valid 20 years on. But this does not need to be the case, with Hebbert and Webb (2012) describing Stuttgart (Germany) as an exception to the rule that 'city planning became less climate-aware in the decades after 1950.' Lastly, health officials exhibit a *persuasive* style of adaptation, raising awareness of options to lessen the impacts of heatwaves. But, with conscious and self-responsible people possibly adhering or overreacting to health promotion, health officials often need to strike a delicate balance between patronising or neglecting people. As such, the decision scope by spatial planners and health specialists is smaller than for the other two sectors, as conscious humans need to support planning and health officials' work. This can explain why planners and health specialists exhibited a more questioning and resistant attitude towards heatwaves and their adaptation: heatwaves complicate – rather than legitimise – their work further. While spatial planners' *participative* style led them to discuss climatic impacts with greenspace managers, health specialists' *persuasive* style did not lead to significant intersectoral exchanges.

This result pinpoints an important finding: that knowledge is *not inherently* of value, as discussions revolving around climate services implicitly suggest (e.g., Willows and Connell 2003; Lemos et al. 2012). The *formative* value of knowledge emphasises that its integration— or its refusal—into a thought style reassures and updates how a peer community of experts understands itself and positions its tasks against other actors and discourses. The *performative* aspect of knowledge highlights how knowledge can change expert practices as well expert interactions with other sectors. In practice, expert discussions on heatwaves within the administrations of both Zurich and Schaffhausen have increased substantially. While in more centralised and higher regulated countries such local discussions are likely to be of different legal character than in Switzerland (cf. Lorenz et al. 2017), this comparison revealed sectoral differences in climate knowledge transfer likely applicable in other political contexts where experts shape adaptation action, as sectoral thought styles and work foci are largely similar across civic cultures and governance forms.

Further, the present study serves as a useful illustration just how different appropriating heatwaves into sectoral thinking and work can take place beyond Switzerland too: while it might yield rewards for some experts, it might trigger frustration for others. This situation is similar to that which Rayner (2012) dubs 'uncomfortable' knowledge. For planners and health officials heatwaves are clearly more 'uncomfortable' than for green specialists and building technicians. Not only do they lack cognitive links with climate scientists, but knowledge on heatwaves is perceived more as a complication than as a further legitimisation of their work, for instance as another issue which needs to be deliberated and balanced against other legitimate interests (cf. Eliasson 2000). Lastly, the effectiveness of health promotion is not controlled by health specialists but depends on people's willingness and ability to change their behaviour during heatwaves. This indicates that even if climate scientists communicate their

findings in language more familiar to planners and health officials—thereby establishing cognitive links—the comparatively low agency will still restrict how effectively this knowledge can be used in these two sectors. Bearing this in mind increases the awareness of how complicated narratives can get about which 'evidence-based approaches' are favoured by whom (cf. Heaphy 2018).

This comparative study extends current academic discussions on scientific climate knowledge uptake and urban climate adaptation in various important ways. By drawing on Zerubavel's cultural cognitive conception of knowledge as a *formative* and *performative* guide and structure to human activity, it makes explicit how actors asked to appropriate scientific climate knowledge make use of their particular thought style and prior experiences in making sense and producing relevance for their work. However, this is trickier for some sectors. This confirms the findings of other studies which have shown that climate adaptation options are primarily accepted or resisted due to underlying values, priorities, and institutional cultures (e.g., Ryghaug and Solli 2012; Rotter et al. 2016). By comparing four sectors rather than one, this study has, however, been better able to conceptualise how knowledge transfer between different sectors takes place, and to describe under what circumstances the integration of climate science into adaptation occurs or not. This also bears upon the academic discussions focused on climate information, such as its usability (Lemos et al. 2012). Making sure that climate information builds upon 'cognitive links' allows experts with different socio-attentional patterns to recognise the importance of climate change better and more alike. The UK, for instance, as a centralised country with a more science-informed governance form, early on aimed to foster sectoral appropriation of heatwaves through heatwave plans assisting, among others, health professionals with set actions to take. However, this research also highlights that not all sectors are able to implement adaptation action similarly. Thus, while we ought to applaud those instances in which spatial planners and health officials have managed to implement adaptation measures, a more critical stance towards building technicians and greenspace managers is warranted when they fail to do so.

7 Conclusion

In this study, I compared the transfer and appropriation of heatwave knowledge into four sectors' style of thinking and adapting. On the one hand, with the concept of *cognitive links* I emphasise the profound importance of shared concepts in recognising the relevance of knowledge on urban heatwaves for four sectors' area of responsibility. On the other hand, experts' ability to implement a particular adaptation action is largely directed by the degree of expert authority in implementation. While some sectors can act upon heatwaves more *instrumentally* through materials, others interact with human actors through *participative* or *persuasive* approaches to adaptation. Both these findings have far-reaching implications for envisaging the knowledge transfer between climate scientists and various sectoral expert communities. For scientists looking at evidence-based policies, closer attention ought to be paid to how knowledge legitimises or complicates experts' work. For communication specialists, forging cognitive links between climate science and thought styles with different 'socio-attentional patterns' (Zerubavel 2015) might well lead to a greater shared understanding. And lastly, the cognitive–practical duality influencing knowledge appropriation allows a clearer articulation and critique of the lack of adaptation options: my research shows that for

greenspace managers and building technicians acting on heatwaves is easier, while planners' and health specialists' inaction is if not entirely excusable, at least understandable.

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