Winter is Coming: Introducing Climate Sensitive Urban Computing

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ABSTRACT
We propose a novel way to approach the research and design of urban ICT, namely, *climate sensitive urban computing*. This approach considers the climatic patterns, weather conditions and people's adaptations to them on the level of everyday practices. Our theoretical and methodological foundations lay in the fields of cultural anthropology, architecture, and HCI. First, we present a multidisciplinary discussion of prior works relating to technology, weather and climate conditions. Secondly, through two empirical, mostly qualitative data sets, we demonstrate the vast impact weather and climate have on young adults' ICT use at our research site located in Northern Finland. Thirdly, based on the theoretical discussion and findings from the real-world studies, we argue that climate sensitive thinking should be part of the design of urban ICT, and outline some central design challenges.

Author Keywords
urban; ICT; climate; weather; northern; transdisciplinary; theory.

ACM Classification Keywords
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INTRODUCTION
New information and communication technology (ICT) is becoming ever more ubiquitous; it is present wherever people are, including the outdoors. We carry our phones and tablets with us, and they have simply become a part of everyday life. Thus, computers are used everywhere, during all seasons, and in all kinds of conditions. When we go outdoors with technology, weather and climate become an issue. The drastic changes brought about by different seasons inevitably affect people's life spheres and practices, and climate is known to affect human activity and behaviour [28]. Therefore, we hypothesize that these changing conditions and rhythms go hand in hand with designing and using new ICT that has become such an important part of our lives. Although we live in hybrid spaces [36], we are still physical creatures. Using ICT is an embodied [e.g. 7] and emplaced action [30]. Thus, we argue that weather and climate should definitely be considered as design challenges, as illustrated in Figure 1. By the concept of weather we refer to more local and short-term atmospheric conditions, such as heat or rain; while the concept of climate refers to long-term average atmospheric conditions.

Figure 1. Weather poses challenges for urban ICT.

Consequently, this paper lays new ground by raising issues related to the effects of weather and climate conditions on technology use – something that, to the extent of our knowledge, has not been explored in HCI and ubiquitous computing (ubicomp) literature previously. The aim of this paper is to initiate a conversation on the effects of weather and climate on urban technology design and deployment, especially in northern regions where drastic changes in, e.g., temperature during the changing seasons present unique challenges to technology use in outdoor settings. To explore the effects of weather and climate on technology use, we look at the topic from a transdisciplinary [21] perspective; that is, we look at work conducted in both social sciences, and in architecture and urban design to establish a theoretical backbone for developing a new design approach.

Hence, the contribution of the paper is threefold: 1) We present a discussion of prior works relating to technology,

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weather and climate conditions based on a multidisciplinary literature review of anthropological and architectural sources, neither of which have been sufficiently utilized when discussing real-world technology adoption and use. 2) We present unique findings from mainly qualitative real-world studies of ICT usage in Arctic conditions, aimed to uncover practices of people using technology in these conditions in their everyday lives. 3) On the basis of the theoretical discussion and findings from the previously mentioned real-world studies, we discuss how climate sensitive thinking could benefit design.

Approaching Technology Use in Everyday Life

The studies presented in this paper belong to the subcategory of urban computing [18], a branch of ubicomp which considers urban indoor and outdoor environments as a place for computing. In this view, computing artifacts are seen as a being integrated into urban places and their socio-cultural context. In experiments carried out by urban computing researchers, public displays have, for example, been located in the streets [9, 24] and open WiFi networks have been installed to provide easy internet access everywhere [1, 25]. However, Williams *et al.* [43] have argued that many urban computing studies are leaning on essentialist and overly generalized notions of "the city" and its inhabitants, and as a remedy they propose that we should conduct "situated analysis of the urban practice". We agree and, through this study, strive to produce a more nuanced, thorough and situated understanding of everyday practices connected to urban ICT through our expertise in the fields of cultural anthropology and architecture. In order to attain this goal, we emphasize an issue that is not usually present in urban computing studies: we focus on the special northern weather and climate of our research site, the city of Oulu, located in Northern Finland.

In our transdisciplinary effort, we look at technology as a part of everyday life, i.e. on a micro-level. This means in-depth examination of people's everyday life practices, routines and rhythms on an experiential level [e.g. 6, 11]. From our point of view, technological experience does not exist without being entangled with these mundane practices that are profoundly situated. In other words, we see technologies as a part of peoples' lives that always happen somewhere, under certain circumstances. Thus, we have to acknowledge the importance of context if we want to understand technology use from an experiential perspective. The term "context of use" here includes a variety of more or less invisible cultural and social factors, such as cultural norms, but also external physical factors, such as limitations and possibilities posed by climate, geographical features and relations to other locales.

RELATED WORK AND THEORETICAL BACKGROUND

Generally speaking, the fields of computer science and human-computer interaction (HCI) have relied strongly on the positivist paradigm which presents reality as "tangible, static, universal, and driven by immutable natural laws" [40]. Due to universalism, these fields have thought to be culturally neutral and contextualization has not been seen as important. This viewpoint stems from the tradition and even requirement for "replication" — that is, computer scientists attempt to minimize or eliminate external factors that may affect the results of their laboratory-based studies, and thus produce replicable results that can be seen as universal truths. However, as computing moves away from the traditional desktop environments and out into the real world, many researchers highlight the importance of a broader context for technology research and design; this includes both immaterial socio-cultural aspects and material factors, such as built structures and the natural environment, and the dynamic interplay between all these [35, 38].

It is no wonder then that it seems that technology use in northern conditions has not been studied within the fields of computer science and HCI so far. Occasionally, cold weather has been mentioned as one factor that has motivated the design of a certain device or application [e.g. 46], but these are rare examples. Climate and weather are normally not seen as central issues. Perhaps this is due to the fact that computing has moved outdoors quite recently. It is reasonable to assume that the industry and the military have conducted at least some usability testing on the subject, but these studies are not accessible for the broader scientific community.

In the social sciences, on the other hand, cultural, social and physical contexts are understood as crucial factors [e.g. 29]. Without acknowledging their relevance, the field of cultural anthropology, for example, would hardly exist. Thus, the theme of climate and weather appeared early on in the social sciences. Over the years, the impact of climate on the subject(s) of the study has been approached from many viewpoints starting with Hippocrates, who theorized how climate shapes society [28]. Peterson and Broad [28] track the history of climate and weather discourse within anthropology through the centuries. They demonstrate how the anthropological study of climate was based on deterministic assumptions in the 19th century; cultural and physiological variations in human populations were explained by differing climate conditions. From these often racist and imperialist arguments the anthropology of weather and climate has moved towards more nuanced analyses where other influencing factors are highlighted, or "the role of culture in shaping human responses to climate is emphasized". The newest turn in this sub-field has adopted a global scale, focusing on climate change [cf. 33]. Current academic discourse acknowledges that 1) climate is only one factor affecting human behaviour, 2) climate is by no means static (on most timescales), and 3) climate can be influenced and even changed by humans. Overall, Peterson and Broad [28] conclude that climate and weather are drivers that "link all scales of human activity, objects, and ideas".

However, if we narrow the scope heavily, and focus on the theme of this paper, i.e. northern weather, climate and ICT use, it seems that qualitative, micro-level studies are scarce, and their focus is somewhat different from ours. Our literature review indicates that although a number of studies concerning ICT use and everyday life have been conducted in the circumpolar Arctic and in the Nordic countries, restrictions or possibilities posed by climate and outdoor use are usually not considered or analysed in detail; ICT use in the arctic or in Northern countries has been scrutinised, for example, from the point of view of cultural identity [e.g. 4], the digital divide [e.g. 37], infrastructure [e.g. 3] or technology adoption [e.g. 41]. However, these studies have not concentrated on analysing how physical conditions and seasonal variations specific to the north, such as darkness during the winter, might affect everyday use. In our study, neither cultural identity nor lack of access are focal points – actually, in our case the ICT infrastructure in the city where the study was conducted is rich and varied.

From the point of view of architecture and urban design, the augmentation of urban places with technology is a novel phenomenon, and as such, our literature review did not reveal studies that would have adopted issues related to climate and weather as their central interest. It is a theme, then, that has not been properly explored. Yet it is an underlying variable that all builders necessarily have had to grapple with. [34] As opposed to ICT themed studies in various fields, a brief foray into the architectural field reveals a wealth of studies which approach the subject from various angles. For example, climate and weather consciousness had already been introduced formally into architectural theory in 1963 as ”bio-climatic design” [26], with the objective “to fashion architecture in harmony with nature while keeping the comfort needs of the human being as its central concern” [34].

Climate-awareness in building went into steep decline during the Modernist [15] era, which sought to universalize architectural principles. However, this attitude was turned on its head in the 1980’s, which saw the heyday of Critical Regionalism which highlighted local physical and socio-cultural conditions [e.g. 10]. Through regionalism and the subsequent relinquishing of universalist goals in design, then, climate consciousness was re-introduced into architectural thinking. In recent times, Hill [14] has even examined the entire history of architecture through the lens of weather, i.e. architecture as being the product of weather. Having particular relevance for our study, Pressman maintains that “our perpetual summer ‘state of mind’ has been a serious impediment to the development of meaningful solutions for winter living” [20]. Moreover, he maintains that we should not consider winter as merely something to shelter people from, but also expose people to its positive aspects; i.e looking at locale climate and weather as a productive point of view for design. This positioning also serves as the point of departure for our study, and the choice of theoretical concepts we have utilised.

ANALYTICAL FRAMEWORK

The first concept framing our analysis is *emplacement*. The concept is originally derived from Howes [16] and the idea of emplacement and emplaced ethnography has recently been elaborated by Pink [30]. *Embodiment* [e.g. 7] can be seen as its precedent; deconstructing the divide between the mind and the body in the social sciences, and making researchers see the human body as a meaningful site of knowing. Emplacement aims to add environment to this model. Thus, this paradigm emphasizes that knowledge is produced through the entanglement of mind-body-environment [16]. For us this means taking into account the materiality (e.g. the climate) of the environment, and studying situated everyday life practices. Further, the concept of place [5] and the unique and holistic socio-physical quality of each location, often referred to as the genius loci [e.g. 22], are central for us in understanding situated practices. Temperature and the amount of light, for instance, have an impact on how and how much people move around, where they go, and what they do. Physical factors can have a significant effect on how people use and appropriate mobile and situated technologies, as people develop tacit and implicit knowledge about the physical locales they live in or frequent. The changing seasons also strongly change the aesthetics of the environment and our sensory experience of it [27].

Our second central concept is the study of *the rhythms and flows of everyday life*, proposed by Galloway for designing meaningful technologies in the context of ubiquitous computing and the city [11]. These rhythms are connected to the various temporal cycles, such as the time of the day, and how they affect people’s actions. In our case, these mundane rhythms are clearly visible and connected to the seasons, as our analysis shows. This point of view is also in line with the traditions of weather and climate anthropology within which scholars have often examined how seasonal patterns might affect human activities [28].

STUDY

Research Site

Our research site is located in Finland, a sparsely populated but technologically highly developed Nordic country. For example, according to the most recent (2013) statistics, 85 % of citizens between ages 16–89 used the Internet [23], and 61 % of citizens between ages 16–60 owned a smartphone [42]. Information networks cover nearly every corner of the country, which has been one of the leading developers of ICT. The city center of Oulu is exceptional even among other technologically well-equipped cities, as it has been furnished with unusually rich computing infrastructure. In addition to standard networks provided by commercial providers, the city center has been endowed with public WiFi providing open Internet access [25], and

with a network of large interactive public displays deployed at pivotal indoor and outdoor locations [24]. However, it is the severe and changing northern climate that makes this "civic laboratory" a truly unique site for researchers equipped with a context sensitive approach. At our research site, the average temperature is +16.5°C in July and -9.6°C in January [31]. The average annual precipitation is 450 mm [31], and snow covers the ground usually for five months of the year. The growing season is short, approx. 160 days, and drastic changes in temperatures are typical for the area. The length of the day also varies to a large degree over the course of the year: The longest day in June is approx. 22 hours long and the shortest day in December lasts for approx. 3 hours.

Research Design

As ICT is being weaved into the fabric of everyday life and becoming more and more ubiquitous, Sellen *et al.* [35] propose a broader and more multidisciplinary approach for HCI where a new stage is added to a research project's iterative cycle. A typical, although a slightly simplified, approach includes four stages: *study, design, build,* and *evaluate*. Sellen *et al*. propose that we should add a stage called *understand* to this model in order to point out human values that the technology should be serving. We position our study at this stage. Understanding socio-cultural phenomena, also those connected to technology, can actually be seen as the essence of cultural anthropology and its accompanying methodology, ethnography. Although our methodological approach cannot be completely understood as traditional ethnography, we want to emphasize that "thick", detailed and thorough, ethnographic description in the spirit of Geertz [13] can produce important knowledge about the surrounding reality and serve technology design.

In order to explore issues related to the effect of northern winter climate on technology use, we examine two separate studies. First, we conducted a "Diary study", complemented with group interviews, which mapped participants' ICT related practices broadly, concentrating mostly on mobile devices and computers. Second, we conducted a more focused "Notebook study", tracing how participants experienced the use of one specific situated technology, namely interactive public displays. We decided to concentrate on studying young adults' (between ages 20–30) perceptions and experiences about ICT, mostly because we wanted to break down some essentialist notions connected to them. This particular age group is often favoured by urban computing researchers because they are thought to be the early adopters of technological innovations, and expected to have good skills and knowledge about new technology [6, 39, 43]. However, as we have argued previously [45], the typical attributes, such as "technologically-savvy" often attached to young adults do not apply to the whole age group. Age is not the only category defining people, and it does not necessarily say anything about a person's ability or willingness to use new technology. Thus, our two sets of research materials reflect the varying technological experiences and perceptions of young adults. The participants of both studies were mostly contacted through mailing lists of different academies located in the city, but we also used the so-called snowball method and asked recruited participants to forward our call to their friends and spouses.

Diary Study and Notebook Study

The Diary study was carried out in a traditional ethnographic manner: it covered a wide range of themes that have been analyzed in separate articles from different theoretical perspectives [19, 44, 45]. The overall aim of this data collection was to gain a thorough yet broad outlook on the experiences, perceptions, attitudes and values related to ICT and everyday life, within this particular age group living in this particular city. The study was realized in late 2011 and early 2012, and it involved 48 participants; 37 women and 11 men. The material consists of written "ICT diaries", accompanied by drawings and clippings, and hundreds of pages of transcribed interviews. First, the participants performed self-documentation about their mobile phone and computer use with a diary that resembled a small, colourful scrapbook; it was designed in the spirit of the cultural probe methodology [12]. It included ten playful tasks with open questions that supported out-of-the-box thinking and helped participants observe and think about their own ICT practices. Later, the young adults involved were invited to participate in semi-structured group interviews where they elaborated on the themes of the diary. One of the tasks of the diary addressed, in a very open manner, *ICT and northern conditions*, and these thoughts were further discussed in the interviews. Within this theme climate and weather surfaced repeatedly as central issues.

The Notebook study was more strictly defined: it focused on the interactive public outdoor displays located in the city center. To complement the Diary study, we used this data to explore how climate and seasons affect the use of this different type of technology. The collection of the material was conducted in two parts: in winter and in autumn. The first set of participants tried out the displays and filled in their notebooks during a period of two weeks in late February and early March. During these two weeks the climate conditions were typical winter weather conditions for the research site, with temperatures ranging between -5,5°C and -7°C, and the precipitation (in the form of snow) from 20–30 mm in February [31]. The second set of participants filled out the notebooks in late September and early October, with temperatures ranging from +4°C–6°C. Precipitation was between 60–70 mm. The first set included 20 participants (12 females, 8 males); and the second, 21 participants (12 females, 9 males). We used a simple but carefully designed notebook to capture young adults' thoughts and attitudes about the public displays deployed in the city. Participants were asked to use an outdoor display

and then carefully write down their thoughts. The notebooks included ten different questions concerning the overall experience, the appearance of the display and its position in the surrounding city space. For the purposes of this paper, we analysed these results through a climate sensitive point of view. Through this approach, we were able to explore two different kinds of use experiences in real-world settings.

Within the chosen age group, participants of both the Diary study and the Notebook study formed a diverse group with a broad spectrum of opinions and lifestyles. Most of the participants were studying at universities, with only a few of them working full-time. They represented different areas of expertise, from the humanities to industrial engineering, visual communication and health care. The vast majority of them had lived in the city for several years; however, only a few were originally from the city. Most of them had moved there in their early twenties and late teens from eastern or even more northern parts: from nearby smaller townships, from rural areas or from further north. The data sets, then, reflect (1) both genders, (2) the varied areas of expertise in young adults (3) the role of our research site, which is the most popular student city of the northern part of the country. We must take into account here that the Diary study mapped mainly experiences related to small and portable mobile devices; on the other hand, notebooks gauged opinions and experiences related to a situated technology [38]. Large public displays cannot be taken out of the wind or the rain; As such, they are the exact opposite of the lightweight and portable mobile technologies. Together these sets of research materials complement each other.

ANALYSIS

The following analysis, composed on the basis of the Diary and Notebook studies, is divided into two main parts, according to our theoretical concepts. Consequently, we examine the material through: 1) emplacement and 2) rhythms of everyday life. These chapters also roughly correspond with the concepts of weather and climate, respectively. We also briefly refer to quantitative user data.

Emplacement

Diary Study

The Diary study revealed interesting experiences, practices and attitudes that our participants had regarding weather and technology use. Overall, the participants recounted in the interviews that the task related to ICT and northern conditions had been slightly difficult for them. On the other hand, many considered it simultaneously as a very fascinating task; it required them to combine two issues that are not usually discussed together, namely, ICT, and weather and climate, and ponder how they are interrelated.

From the point of view of emplacement, ICT in northern conditions must be understood in terms of situated and embodied use. Especially the winter was experienced as a season when outdoors technology use is difficult, if not totally impossible. In the Diary study, only the most necessary devices, i.e. mobile phones and smartphones, were reportedly used outside, and participants even avoided carrying laptops with them during wet and cold seasons. One participant commented in her diary: “Using a mobile phone in the winter: zero compatibility” (F23[1]). The participants gave colorful accounts of how mobile phones, and especially smart phones with touch screens, slow down and freeze. Using these devices without having any gloves on had been experienced as painful and irritating. The difficulties confronted especially during the winter awoke strong reactions in the participants: “How can this be possible? It’s totally normal that it’s -20 degrees!” (F25). On the other hand, most of them were, of course, aware that the northern climate is harsh, and that it poses many challenges to electronic devices. Roughly, the attitudes of the participants reflected either anger and frustration or submission. Mobile communication technology was unanimously experienced as an important security factor in winter conditions, and many felt that it is a shame that it cannot be trusted when it is needed the most.

However, many of the participants described practical ways to cope with the difficulties posed by winter: they kept their phones close to their body, under their outerwear or buried inside their mittens to keep devices warm and functional. One young woman recounted how she is in the habit of tapping her smartphone with her nose sometimes to avoid getting frostbitten fingers [cf. 46]. The usefulness of the screens’ bright light was brought up by a couple of participants. One of them (F24) recounted how she is in the habit of staring at the screen of her mobile phone in the morning in order to wake up (as there is no sunlight in the winter before 9-10:30 am); another one (F24) recounted how light can help in cases of emergency during dark seasons.

Participants’ past and current experiences concerning weather, climate and technology coloured also their perceptions of different mobile phone brands. Many of them wondered why the Finnish company Nokia does not make phones that would adapt better to Nordic conditions. A few participants reminisced nostalgically how their old Nokia phones had worked so well in all conditions; a man (M30) who normally used a smartphone, recounted how he takes his old Nokia phone with him when he goes hiking; “the battery lasts for a week, and I can call and text”. Here we actually clearly see how different time layers intersect in the experiences of the participants. The other brand that came up in discussions was the Apple iPhone and its

[1]Participants have been coded as follows: F=female, M=male, age. In the notebook data set we use W to denote winter time participants and A to denote autumn time participants, e.g. W-F29, A-M21.

sensitiveness to cold, which was highlighted in the media at the time of the interviews. Although the iPhone was used by some participants, its fragility was considered ridiculous. Overall, mobiles and smartphones were considered to be more compatible with the summer. However, participants had numerous stories about phones getting destroyed or damaged by rain, heat or dirt. Some of them had forgotten phones in their pocket when going for a swim (e.g. M22). As one participant summarized, "a phone needs cloudy, windless, rainless and warm weather" (F23).

Notebook Study

When examining the notebooks on public displays, we noticed that, unsurprisingly, our participants mentioned climate-related issues more frequently in the winter-time notebooks; yet, there were plenty of climate-related challenges also found in the autumn data set. A common issue here was the difficulty of keeping hands protected from the elements while using a large touch screen, a theme which resonates with the diary study findings. This was found both in the autumn and winter data, although there was a significant difference in prevailing temperatures. A notable exception, however, was one participant (W-M24) who had used the device's excess heat, emitted through the screen, to warm his fingers in the sub-zero outdoor conditions. Most participants, however, had found the cold problematic, and some had opted to use the screen with gloves on. This had had an adverse effect on the responsiveness of the touch screen of the display. During episodes of more unfavorable weather, such as in the rain, participants had often opted to use screens that were more sheltered from the weather, such as one that was located in an arcade structure (e.g. A-F21). However, even some of those who had used the device in good conditions noted that sleet, snow or icy conditions would make it more unpleasant to use the device. Shelter, then, is a central design challenge that involves the environment, the body and the device, all of which are engaged in dynamic relationships.

Understanding technology through emplacement means also that the orientation and location of the devices should be carefully considered; weather and climate affect use, and orientation and location can either hamper or support it. Situated technology also creates maintenance-related issues – these can be seen as being connected to location – that were mentioned by several participants. These largely dealt with perceived cleanliness and access. A device which is exposed to the elements was seen by several participants as hygienically problematic. Notably, only one autumn participant complained of dirtiness, whereas six winter participants had severe hygienic concerns. Snow is a clear maintenance issue that was mentioned by several participants, most memorably by one (W-F29) who drew a picture of a personified urban display calling for help from amidst piles of snow. Surprisingly, a seemingly badly maintained display clearly created a feeling of pity or sympathy towards the device in this participant.

Rhythms

Diary Study

The northern climate, with its radical seasonal changes seems to create a phenomenon which one of our participants aptly called "technological seasons". It highlights how the ways ICT is used is connected with the natural rhythms of the year. This aspect was extremely consistent in the diary material; almost all participants expressed opinions that indicated how the use of technology changes over seasons. Most of the participants recounted how they spent more time at home and inside buildings during the dark and cold time of the year, and how this increases the use of a computer or laptop. Overall, ICT and virtual networks became more meaningful during the winter. "During the winter I tend to curl up indoors where it's warm, and spend more time alone" (F26); "Going out takes a lot more effort, so I just kinda get stuck on my computer" (F21). The participants described how virtual life becomes more attractive than going anywhere, and how nice it is just to have adventures on the Internet.

On the other hand, the diary material indicated that towards the summer the meaning of laptops or computers decreases; people start to move outside more, and the mobile phone or the smartphone becomes the most important device. "Summer and the mobile phone go together hand-in-hand" (M29). "I use the mobile phone more during the summertime to keep in touch; the people of the city come alive during this time" (F26). The northern summer was thought to be so short that it is extremely important to enjoy it as much as you can, and spent as much time outside as possible. The phone's main function was to enable social navigation, i.e. finding friends [19]. On the other hand, the meaning of ICT was experienced to decrease overall. Some young adults described how they restrain their ICT use consciously. Some explained how they are more active, want to meet friends face-to-face, and have many other things to do, and as a consequence, ICT is forgotten, sometimes even concretely, when a mobile phone is accidentally left at home. A few participants – some quite active ICT users overall – said that they use laptops also outside, for example to study or work at beach or summer cottage.

Notebook Study

We could also find themes connected to "technological seasons" when analysing the notebooks on public displays. In addition to the previously mentioned bodily comfort issues, these were connected to, for example, visual aspects. Seasonal variation changes the appearance of the urban landscape and produces aesthetic rhythms; during the winter the dark colour of the screen was found to be more visible, described as "protruding from the snow" (W-F29, W-M24 image). In the autumn, more participants described

the screens as meshing with their surroundings, resembling the box-shaped buildings nearby, or due to their material, looking like other urban furniture, such as lamps and trash cans. Seasonal variation can produce unexpected visual results. Variations in weather can, naturally, have a similar effect. Darkness is also a rhythmically alternating condition that can have unexpected effects on the design. For example, striking a good balance between dynamic lighting conditions and the brightness of the display can be difficult. "In the dusk, the glow of the screen can lure people to take a closer look" (A-F26), one participant felt; in the daytime, however, the screens were "not bright enough (A-F23), to be either visible enough or to prevent glare in all conditions.

However, the theme of experiencing sympathy for a situated device emerges not only in the case of a seemingly badly maintained device, as was previously mentioned, but also in the case of the display being caught in bad weather. Remarkably, one participant illustrated this point with a haiku (N.B translated): 'Proudly the display stands / Alone in the rain / "I wish someone would touch me!"' It is highly interesting to think why a situated display would rouse such sympathies in an observer. After all, there are many other things in the streetscape that are similarly exposed to the elements year-round. Furthermore, one participant noted that the display "looks lonely when the marketplace is empty" (A-F26), and similar feelings were echoed by another participant (A-F23). The use of the marketplace varies heavily with the seasons, as well as daily rhythms; this is a contextual issue that is beyond the control of technology designers, as people tend to stay indoors during colder seasons.

Quantitative Usage Data on Displays

To validate the findings of our qualitative studies, we briefly analyze the quantitative usage data collected from the aforementioned outdoor display installed at the market place with respect to daily weather and seasonal climate. The usage data was collected during the 43 month period from June 1, 2010 till December 31, 2013, excluding two months in September-October 2011 when the display was broken as a result of vandalism, and the month of April 2012 when the display was out of use to due to a hardware failure. During the remaining 1202 days the control buttons of the interface were clicked 59578 times in total (~50 clicks/day), in most cases to launch a service from the menu. Clicks taking place 'within' a particular service were not included.

Daily weather measurement	*r*
Average temperature	0.33
Average wind speed	-0.12
Precipitation sum	-0.77

Table 1. Pearson correlation coefficient between the daily number of clicks and weather measurements.

Table 1 shows the Pearson correlation coefficient between the daily number of clicks and selected daily weather measurements collected by a nearby weather station. As expected, rain and snowfall were particularly strong repellants to use the display located out in the open. Seasonal rhythms are illustrated in Figure 2 that shows the 30 day moving averages of daily clicks and daily average temperatures over the data collection period.

DISCUSSION

In anthropology and architecture, climate and weather have been considered important drivers of human activity and design for centuries. On the other hand, as we pointed out, these factors have not played an important role in HCI and urban computing research. In this paper we have attempted to merge theoretical accounts from anthropology and architecture with newest approaches in HCI, and demonstrate through our empirical studies the importance of climate and weather for technology use and design.

Climate as Cultural Variable in Urban Computing Design

When analysing our empirical material through aspects of emplacement and rhythms of everyday life, we discovered the enormous impact weather and climate actually have on people's possibilities and willingness to use ICT. In other words, climate and weather, understood as cultural variables, affect peoples' meaning making processes and their whole way of life. Even though design solutions must always be context specific and require designers' creative input, we can point to some design implications and strategies that were derived from our studies.

Studying technology use through the lens of emplacement

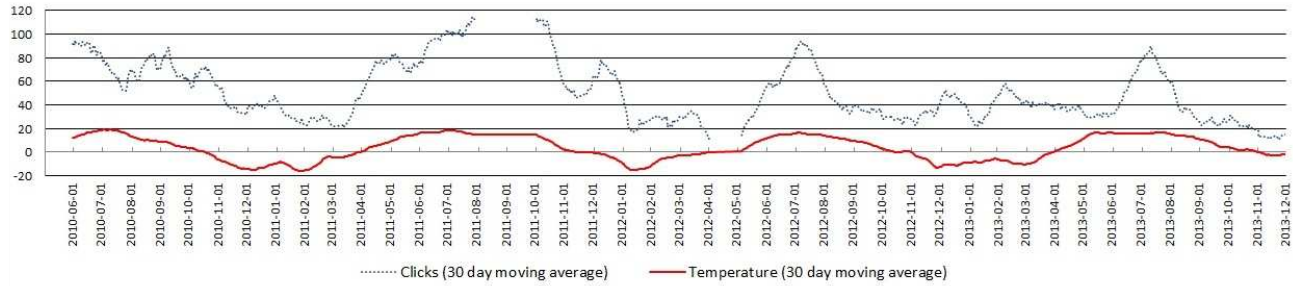
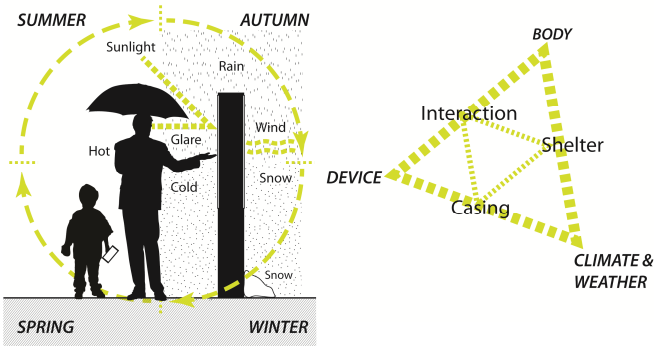


Figure 2. Clicks versus average temperatures.

revealed ***weather-related tactics of ICT use***. Our analysis did not just underline the obstacles of outdoor use, but it shed light on the multiple ways that people use to cope with these inconveniences: for instance, body heat was used to keep devices functional, and some people owned two phones, simple mobile phones for hiking or hunting trips and versatile, fancy smartphones for urban use. However, these tactics are never based on just functionality. To understand peoples' behavior, we need to take also into account values and everyday objects' role in identity work [17]. We can, for example, ask why people chose to protect fragile devices or own two devices instead of simply acquiring one "weather proof" mobile device. We argue that an even more detailed ethnography could be helpful in understanding these tactics of use and related values, and they could inform the design of future ICT. Overall, mobile technologies are relatively easy for users to adapt into various conditions. It becomes imperative for designers, then, to think for their part what, for instance, closeness to the body (and other emplaced user tactics) means for their designer strategies on the level of materiality, form and function. For example, could the device be made of materials which are designed to absorb body heat? Should it be made of slightly flexible materials, and be shaped overall to neatly align with users' body contours when placed in different pockets? However, there is an interesting conflict here; the devices are known to radiate somewhat, and yet many deem them so useful they choose keep them close to their bodies anyway. This contradiction should be addressed by designers and engineers. Situated technologies, on the other hand, face a host of unique climate-related and emplaced design challenges, as there is not such a wide array of tactics available; i.e. users are not able to adapt them to prevailing conditions as easily as with mobile technologies. Outdoor public displays are not as flexible as mobile devices, and their adoption process has been slow, as we have argued elsewhere [44]. Designers, then, would do well to strive towards understanding and designing for emplaced tactics. After all, ignoring these problems might lead into total disuse of technology. We argue that more research is needed to reveal effective designer strategies in this regard.

On the other hand, studying technology with respect to the rhythms unfolded ***continuity-discontinuity patterns of use.*** Seasonal variation was inscribed into peoples' everyday life rhythms and practices, and technology use followed these patterns. Differing seasonal conditions affected young adults' behaviour and this, in turn, had an impact on *the role* of different devices. However, although different seasons placed emphasis on different devices, depending on how and where young adults spent most of their time, the main functions of the ICT remained the same: sociality and information seeking. The flexible shifts between indoor and outdoor use of different mobile technologies depending on the season, ensures the adequate bodily comfort and continuity of use; from this point of view the device itself does not matter but its meaning for everyday life. Situated technologies become problematic in this aspect as users are not able to incorporate them into their lives according to cyclical patterns and resulting practices, as these aspects have not been taken into account in their design. Designers, then, should try and get as detailed an understanding of the rhythms of their design context as possible, including seasonal variations. The mapping of pedestrian flows and use patterns in urban places should be, if at all possible, extended to include the various temporal rhythms of daily, weekly, and seasonal cycles. Combined with other rhythms of everyday life, which change from season to season, a much fuller picture of what it means to design situated interactions can then begin to emerge, as designers would be better able to understand users' sociality and information seeking practices at different times.



(a) (b)

Figure 3. (a) The Body, the Device and the Climate all interact with each other. (b) Framing subsequent design challenges (Interaction, Casing, Shelter) and their relationships in a model. © Anna Luusua 2014.

Framing the Central Design Challenges

We now take the first steps towards framing the central design challenges of designing urban computing with climate and weather in mind, and draw some outlines for future research in this area. Concerning both technologies, participants reported glare, cold, wind, rain and snow as challenges in using mobile and situated devices on their own "in the wild". Through a climate sensitive approach we can see that these "emplaced challenges" are inherently connected to seasonal cycles, as represented in Figure 3(a). In lieu of these findings, we present a model which frames the central design challenges that are brought about by the relationships between the human body, device, and climate and weather. In this model, climate is an issue that affects all aspects of designing technologies for human use in urban settings. Figure 3(b) illustrates the relationships between body, device, and climate and weather, and the design challenges each of them raises, namely interaction, casing and shelter. For example, interaction occurs between the body and the device, as famously put forth by Dourish [7]. Adding climate and weather into this mix, we can see

what an important and challenging part weather and climate play in interaction design.

However, our literature review on architecture showed that climate and weather should not be seen merely in negative terms, but as a productive point of departure, and we deem this a central design strategy of a climate and weather sensitive approach to urban computing. For example, organizing the maintenance of a whole network of displays is a vast challenge that may make even the most advanced technology either inaccessible or undesirable. However, if we take the physical aspects of place, such as rain, as a point of departure for the design of a situated technology, a display that is subjected to the elements should, naturally, use those elements (i.e. rain) to clean itself. Furthermore, the visual aspects of different seasons could easily be used as inspiration in content production, or in making situated technologies mesh better with their surroundings. Another key design strategy that we can derive from our study and the concept of emplacement, is that a designer should also try to attract potential users as embodied beings in a locational context (by offering comfort) rather than simply trying to attract their minds (by offering services and entertainment). In this spirit, a designer might approach the design of situated urban computing as if they were designing urban furniture, which is meant to offer physical comfort and protection to enable people to spend time outdoors. A designer could then design an urban display in a wholly new way; the whole object might be designed mainly as a place to sit down, simultaneously sheltering the user against prevailing winds. Or the designer might simply integrate the display into existing sheltered resting places.

CONCLUSION

Due to the clear resonance between weather, climate and technology use, we propose that *climate sensitive thinking should be an integral part of the design of urban ICT*. Local climate and weather conditions should not be seen only as obstacles or something to shelter people and devices from, but also as a productive point of departure for design. As technology moves outside, in the form of situated installations, becomes part of the built environment and travels with us everywhere, the aspects posed by weather and climate become more and more relevant. Most importantly, through examining ICT use as emplaced action, it becomes apparent that ubicomp is not as ubiquitous as it seems, as the limits of the human body are also necessarily the limits of all HCI.

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