Why does energy use feedback not work in workplaces? Insights from social practice theory

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Abstract

The current UK decarbonisation plan requires the application and adoption of smart technologies in buildings to cut down on emissions and encourage demand reduction. However, its success depends on the development of a synergetic relationship between the occupant and the building technologies. While many studies looking at consumption dynamics focus their attention on households, commercial buildings and their users remain a relatively unexplored terrain. This paper investigates thermal comfort practices linked to the use of heating and cooling in a workplace where the provision of real-time consumption feedback is intended to lead to energy savings through behavioural change. Empirical evidence from an office of a university building is used to discuss the key influences that shape thermal comfort preferences and the impact of energy use displays. Given the complex nature of socio-technical elements, the study follows an interdisciplinary methodological approach combining qualitative and quantitative data. Semi-structured interviews and on-site observation are cross-related to environmental conditions monitoring, questionnaire surveys and thermal comfort diaries using insights from social practice theory. Data collection takes place in two phases over the period of a year, aiming to capture winter and summer comfort preferences as well as attitudes before and after the installation of the real-time displays. Initial findings highlight the influence of group dynamics, technological infrastructure and the contextual notion of workplace in shaping thermal comfort preferences. The need for a green organisational identity and feedback through multiple venues are pointed out as key parameters for energy efficiency in a workplace context.

Introduction

The beginning of the twenty-first century has been marked by a significant body of evidence that indicates the urgency of acting on climate change and the CO_2 emission rate on an international scale (Lucon *et al.* 2014). In the UK the built environment accounts for 37 % of total UK greenhouse gas emissions, of which 13 % comes from non-domestic buildings (Committee on Climate Change 2014). A significant part of these emissions is related to space heating, however this can fluctuate year-on-year depending on winter temperatures. In the challenge to reduce carbon and comply with a reduction target of 34 % by 2020 and 80 % by 2050 a series of efficiency measures, policies and technologies have been employed (HM Government 2011). However their effect is undermined by a gap between the 'as designed' and 'actual' building performance and one of the barriers that has been highlighted by recent studies is the influence of occupants' behaviour on a building's energy use (Sunikka-Blank and Galvin 2012, Guerra-Santin 2013). Lifestyle, behaviour and culture have been found to cause up to a fivefold difference on similar buildings (Gram-Hanssen 2010), therefore to achieve a reduction of the overall energy demand societal engagement with awareness of energy issues has a vital role to play.

Policies adopted in the recent years support a change in consumers' consumption behaviour through a range of financial and technological measures. The rollout of smart meters and energy (electricity and gas) utilisation feedback through user displays is one of the technologies aiming to increase aware-

ness and control over energy use and lead to management and reduction of its demand. The mass roll-out of these technologies in the UK is due to take place between 2015 and 2020, with the installation of smart devices in approximately twenty-three million homes and two million businesses (Department of Energy and Climate Change 2013). The increased potential of such a measure has triggered research looking at its implications to energy policy and the consumer-utilities relationship (Darby 2008); smart meters interface and home-owners engagement (Darby 2010, Hargreaves *et al.* 2010); and the impact of feedback on energy use behaviour over the medium and long term (Dam *et al.* 2010). However, there are gaps in knowledge regarding the behavioural processes through which energy savings are achieved over time and in non-domestic settings.

This study attempts to use thermal comfort as the medium to investigate energy use behaviour and in particular the way heating and cooling practices are formed and potentially change through the effect of feedback in a workplace environment. Following the adoptive approach towards comfort, it acknowledges the opportunity of individuals to regulate room temperatures affected by established norms, having a direct but rather unconscious impact on the energy required (Shove 2003). Potential therefore exists to understand the effects of energy use feedback on current comfort standards linked to increased temperature control and energy use. The research questions this study attempts to answer are:

- What key influences shape thermal comfort preferences in a workplace environment?
- What is the impact of energy use feedback on changing energy use and comfort practices?

The paper is structured in five thematic sections. After the introduction, the second section presents the research framework and the use of a methodological approach using insights from Social Practice Theory. The third section discusses the methods used in the empirical study and provides key information on the case study offices, the behavioural change programme this study is based on and the outline of the data collection activities. The fourth section looks at comfort and the four different practice elements in the given context. Finally, the fifth section summarises the primary findings of the study and offers concluding remarks.

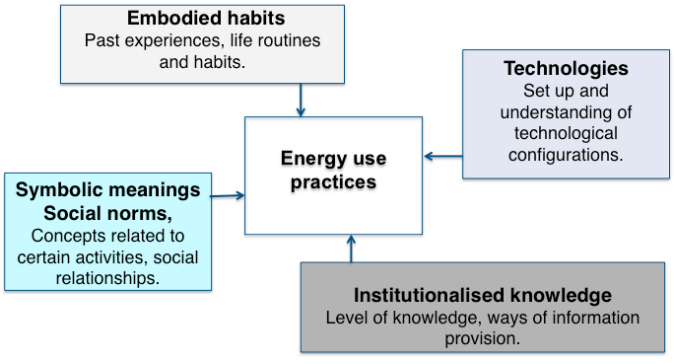

Figure 1. Social Practice Theory elements.

Research framework

There have been several academic disciplines looking at behaviour —and energy use behaviour in particular—through different lenses, spanning from engineering to sociology and economics. A disciplinary bias usually affects the choice of the methodological framework, resulting either in more technical or more sociological approaches (Schweber and Leiringer 2012). The importance of a socio-technical approach in building research is highlighted by a growing body of academic work (Summerfield and Lowe 2012, Foulds *et al.* 2013) and underlines the need to increase understanding of occupants' energy use behaviour and interaction with technology as a way to achieve energy savings (Shove 2003, Tweed 2013).

A relatively new approach from social sciences that has gained academic and policy attention is Social Practice Theory, a theoretical view that aims to understand how people shape their behaviour and in turn are shaped by societal influences (Department of Energy and Climate Change 2011). It diverts the attention away from individuals' decision-making towards wider societal structures, thereby exploring why so many habits are shared by big parts of the population. It suggests that common practices are not shaped by a large number of individuals acting independently but consist of interconnected sets of social norms, infrastructure, embodied habits and understandings. Social Practice Theory has been used as a blueprint for consumption studies that examine how routinized everyday activities are socially structured, both in domestic (Gram-Hanssen 2010, Shove *et al.* 2012) and non-domestic settings (Hargreaves 2011). A framework that has been put forward for looking at energy use behaviour is a four-element model developed by Kirsten Gram-Hanssen (2010) (Figure 1) according to which the elements that hold practices together are habits, social norms, technologies and institutionalised knowledge.

- **Embodied habits** may refer to past experiences and life routines that resulted in unconscious ways of performing actions.
- **Technologies** refer to the physical environment surrounds us including electrical devices, physical objects and infrastructure.
- **Institutionalised knowledge** refers to the level of general knowledge and the way it has been provided to the individuals.
- **Social norms** are concepts that certain actions or behaviours carry which may influence the motivation of individuals. Motivation is a significant parameter for change and its impetus may come from different venues such as social relationships, aspirations and symbolic meanings.

The study presented in this paper is focused on the practice of seeking (thermal) comfort through the use of heating or air-conditioning to achieve specific temperatures that have been established as norms. In this respect, the theoretical framework followed tries to understand practices related to the use of heating and cooling through the investigation of the four Social Practice Theory elements – embodied habits, technologies, knowledge and social norms – and seek the main drivers for behavioural change.

Methodology

A case study research strategy was based on the selection of seven offices within a Cambridge University building in the UK where the data collection activities took place (Table 1). Given the complex nature of socio-technical elements, the study follows a mixed method approach combining both qualitative and quantitative data. The qualitative data include semi-structured interviews of the workplace users while the quantitative include questionnaire surveys, comfort diaries and temperature and humidity measurements of the office spaces. This paper presents results from one of the seven offices, Office A.

BEHAVIOURAL CHANGE PROGRAMME

The university department where the case study office is located consists of several phases, upgrades and extensions with its oldest part dating back to 1924. Every month it consumes an average 300,000 kWh of electricity, equivalent to approximately 165,000 kg of CO_2. When it comes to energy use, the age of the site and the different construction phases are partly a reason for its inefficiency. However, an initial analysis of its electricity consumption during a plug load measurement indicated that 26 % of its baseline consumption in 2011 was due to desktop equipment, research and teaching, directly affected by user behaviour.

Among other efficiency measures, a Behavioural Change Programme was planned by an environmental consultancy to reduce energy consumption and promote behavioural change (where appropriate). It involved the installation of twenty Real Time Displays (RTDs) in different types of sub-metered spaces (offices, research laboratories, workshops, etc.) and the set-up of a competition called the 'Energy Grand Prix' where the selected work areas would race among each other to achieve the most energy savings. It was based on the assumption that individuals are willing to perform an activity they already engage more effectively if the right incentives are provided to them. The approach also resonated with Cialdini's (2003) theory of 'normative messaging' where people tend to save energy when they are told how they are doing compared to others, which can be more effective than financial savings or the idea of saving the environment.

The 'Grand Prix' competition was communicated through an e-mail, the launch event, the department's intranet page and monthly e-bulletins. A grand prize, along with monthly prizes, was available for the best performing team. The RTD was a 15-inch monitor mounted on a wall of the case study offices displaying information on the current energy use compared to the indented reduction target and the ranking of the office in the competition's League Table indicating each space's energy reduction (Figures 2 & 3). This was done using a customised version of the Workplace Footprint Tracker[1], a tool that monitors energy use in real-time and presents this information through different channels such as an energy dashboard, a public screen or the client's website.

The Behavioural Change Programme was launched in July 2014 with the competition starting a week after. The competition run for a 6-month period and was initially planned to coincide with the installation of the screens. However, due delays with the order of the screens and Raspberry Pi's and a series of technical issues related to the installation and connectivity of the smart meters, the RTDs were in use several months after the end of the campaign. The current study started along with the behavioural change campaign. Planned observation took place on key events (e.g. introduction of CO_2 Grand Prix competition in the department; presentation of the Footprint Tracker web tool during the University's Switch-off week; introduction of the web-tool in Office A) and also more informal discussions were made with the participants (e.g. discussions during on-site visits; e-mails with relevant material) and the staff responsible for the behavioural change programme. The detailed phases of the programme and the study are presented in Table 2.

DATA COLLECTION

The collected data included the environmental conditions monitoring (Temperature, Relative Humidity), the semi-structured interviews and the comfort diaries that were filled out by the research participants in Office A. The office was occupied by eight employees working full-time. It featured an L-shaped layout and was located in the mezzanine floor of the building (Figures 4 & 5). The space was not designed to be used as an office, therefore it was not connected to the central heating system and had a relatively low ceiling height (≈2.5 m). It was equipped with four Air Conditioning (A/C) units (three wall and one ceiling mounted) that were used for heating and cooling purposes. In total five individuals took part in the study voluntarily recruited after a short presentation of the research project.

The offices were monitored and participants interviewed and asked to fill a comfort diary over two rounds:

- *February–March 2014.* The first round aimed to understand perceptions and prevailing conditions in the offices prior to the installation of the RTDs. Also it provided an indication of winter comfort patterns and heating regimes. The interviews lasted on average 38 minutes in length (19–60 min range).
- *July 2014.* The second round was conducted a few weeks after the installation of the RTDs. It focused further on the most important findings that came across in the first round, grasped the first impressions from the screens and captured thermal conditions and preferences during the cooling season. An average second interview was approximately 26 minutes (11–43 minutes range).

Each participant filled a thermal comfort diary three times a day for a five-day period marking his thermal sensation, preference and acceptability. Thermal sensation votes were based on a scale from -3 (much too cool) to 3 (much too warm) with 0 being neutral. The interview took place after the end of this 5-day period.

The interview format was structured in categories that covered five main themes: comfort, embodied habits, technological infrastructure, existing knowledge and social norms/motivation. The data from the semi-structured interviews were recorded, transcribed, coded and then meticulously analysed using NVivo software. Following the approach of Bazeley and Jackson (2013) the coding structure was implied by the research methodology and nature of the data that have been gath-

1. http://www.footprinttracker.com

Table 1. Characteristics of case study offices.

Office name	A	B	C	D	E	F	G
Office typology	Shared enclosed	Open plan	Open plan	Shared enclosed	Shared enclosed	Shared enclosed	Shared enclosed
Heating and Cooling system	A/C	Central Heating and A/C	Central Heating and A/C	Central Heating and A/C	Central Heating	Central Heating	Central Heating and A/C
Size	97 m^2	88 m^2	97 m^2	36 m^2	26 m^2	11 m^2	6 m^2
Number of users	8	26	17	6	4	6	3
Research participants	5	6	3	1	4	1	2
Users occupation	Administration staff	PhD and Post Doctoral researchers	PhD and Post Doctoral researchers	PhD and Post Doctoral researchers	PhD and Post Doctoral researchers	PhD and Post Doctoral researchers	Post Doctoral researchers

Figure 2. The screen in Office A displaying the actual and target consumption graph.

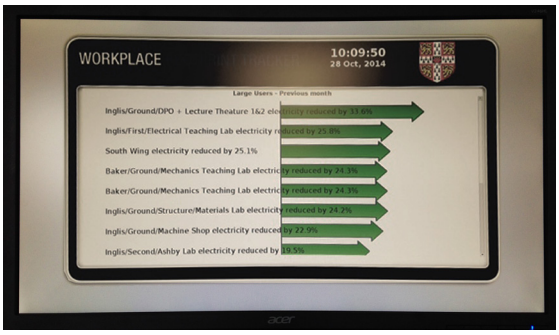

Figure 3. The screen in Office A with the League Table.

Table 2. Behavioural change programme and data collection rounds.

Behavioural Change Programme timeframe	
Event	**Date**
Energy Grand Prix competition launch	June 2013
Installation of RTDs (order, installation, commissioning and configuration of smart meters, screens and Raspberry Pi's)	August 2013–December 2013 (intended) April 2014–October 2014 (actual) July 2014–October 2014 (Office A)
Run competition with monthly communications and prizes	July 2013–December 2013
Winning teams announced	December 2013
Data collection – Round 1	February 2014–March 2014
Data collection – Round 2	June 2014–July 2014
Presentation of the Workplace Footprint Tracker tool in the department	November 2014
Introduction of the web-tool in Office A	November 2014

Figure 4. The layout of Office A and its location within the building.

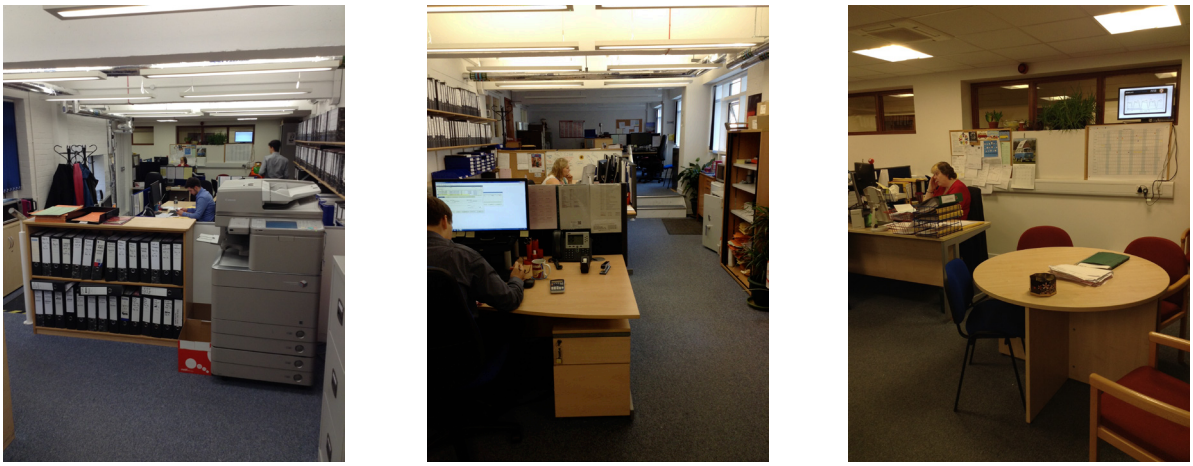

Figure 5. Three internal views of Office A (1, 2, 3).

ered. For the analysis, the ideas expressed by the participants in response to the different questions were placed in 'classifying nodes' based on the main theme and content of each question. At a second level, 'case nodes' were created in association with each participant's office and the interview round. Quotations in text are referenced as '1A_1', where '1' represents the participant, 'A' the office space and '1' the interview round.

Investigating comfort and practice elements

COMFORT

Thermal comfort preferences are highly related to decisions regarding the use of heating and cooling of a space. Understand how people conceptualise and value comfort and how their preferences may be subjected to the social and material environment, was the starting point in the investigation of heating and cooling practices and their subjectivity to change. Interview questions focused on the different adoptive actions taken by the participants (behavioural, psychological or technological) and their thermal expectations while diaries mapped their sensation and acceptability of the existing conditions.

A variety of comfort preferences emerged between the staff members, both during winter and summer time, based on their perceptions of the environment—mainly temperature and humidity. In the winter months, some noted that the space could get really cold, especially in the mornings, while others complained that it was too hot and dry. Comments on the office thermal conditions were also verified by the environmental monitoring conducted place in the office during both research rounds. Figure 6 gives an indication of the temperature and relative humidity levels during five weekdays in February 2014 coinciding with the days the comfort diaries were filled. The temperature fluctuated mainly between 21 °C and 23 °C which

is considered normal for offices in winter according to CIBSE[2] standards, with some peaks during the evenings and low early morning temperatures dropping down to 18 °C. Humidity was found to be low, approximately 35 % during the whole week, slightly below the recommended CIBSE levels of 40 % to 70 % for office spaces. This was an indication of a dry environment and lack of a proper ventilation strategy, something verified by the users' comments.

> First thing in the morning when I come in I find the office very cold. […] The only heating that we have is the A/C. […] I do occasionally have a fan heater that I would literally put on just for 30 seconds just to take —what I feel like— the little chill off me.
>
> (Participant 1A_1)

> I find it stuffy and I wish that these top windows had been done so that we could open them. […] It is hot at times, I can stand it being too hot because I can take off a cardigan but I do find it stuffy.
>
> (Participant 3A_1)

Despite the complaints about the conditions, when the participants were asked to state their thermal preference, the majority said that they would not like any change. They also appeared sympathetic of their colleagues' comfort expectations and stated that they would compromise their comfort in order to avoid conflicts. They also acknowledged the temperature variations that occur in an open-plan layout equipped with A/C's.

> I am aware that I feel the cold more than other people so I show more understanding. […] I wouldn't expect the rest of them to suffer with the heat.
>
> (Participant 1A_1)

The data from the comfort diaries were correlated with the actual room temperatures from the environmental monitoring in order to gain a clear view of the comfort preferences within the workplace. Of the 75 thermal sensation responses, 26 were on the cool side (-2 to -1), 34 were neutral (0) and 17 were on the warm side. There were no -3 or +3 votes cast. The relationship between thermal sensation and temperature was displayed on a scatterplot indicating a weak positive correlation between the two variables meaning that as the temperature increases, people feel warmer as one would expect (Figure 7). What is striking is the diversity of individual comfort profiles, which becomes further apart when feeling cold and more uniform when feeling comfortable and comfortably warm.

The distribution of temperatures for each thermal sensation vote was analysed using a box-and-whisker plot (Figure 8). The varied concepts of comfort were once more highlighted and two main trends were noted. A comparatively wider distribution in the temperature range for 'Too cool' and 'Comfortably cool' thermal sensation votes ranging between 19–24 °C and a narrower range of temperature for feeling 'Comfortable' and 'Warm' at an average of 22.5 °C.

The findings confirmed the notion that comfort can significantly vary between individuals sharing the same space and can be achieved in a wide range of temperatures. One interesting observation was that heating and cooling preferences within the office were subject to social influences and group dynamics; therefore comfort preferences were not only individually but also collectively shaped.

KNOW-HOW AND EMBODIED HABITS

Habits, unconscious ways of performing certain actions and the build-up of learning by doing experiences can influence heating and cooling patterns and the use of devices. In order to understand their impact, participants were asked to reflect on their childhood experiences and everyday habits in relation to comfort preferences and interaction with the heating system and appliances both at their home and office.

One of the interviewees claimed to always put appliances on standby mode instead of turning them off despite knowing that they still consume energy. Although he is aware of the rational choice this is the way he has always been doing. Similarly, others commented on the difficulty to turn-off computers during lunch breaks because of laziness and perceived time-wasting. In this case, however, technologies are also relevant since the time to restart a computer might vary significantly depending on the computer model.

> I've never actually turned a computer fully off, neither at home or at work. Or even at College when we used computers there. […] It's partial habit partial laziness I would say from my part. I'd rather say more habit than laziness.
>
> (Participant 5A)

Thermal preferences as a result of family influences were also identified among the interviewees. The gradual build-up of comfort preferences and the development of a pro-environmental attitude as a result of the prevailing thermal conditions and behaviours at home were mentioned in two of the cases. Although participants had similar comfort preferences at home and at work they felt to have less control of the thermal environment in their office, something that affected their comfort and adaptation preferences.

> We were not poor but we were not a particularly rich family so we were always trying to save on energy, save money basically so we were conscious. I suppose its been a habit of mine ever since.
>
> (Participant 2A_1)

Although the influence of embodied habits in shaping behaviours cannot be ignored what is interesting to note is the impact that social, technological and contextual aspects may have in their expression and possible change. In the studied office, these aspects included colleagues' preferences, the type of heating and cooling system and the notion of the workplace compared to that of the home environment.

TECHNOLOGIES

Existing technological infrastructure, devices and physical objects can be strong components that hold practices together. In the context of this study, the office layout, the electrical equipment as well as the heating and cooling system consisted of material components that are able to prefigure certain comfort practices and energy use attitudes. To investigate these elements participants were asked to comment on the existing

2. Chartered Institution of Building Services Engineers.

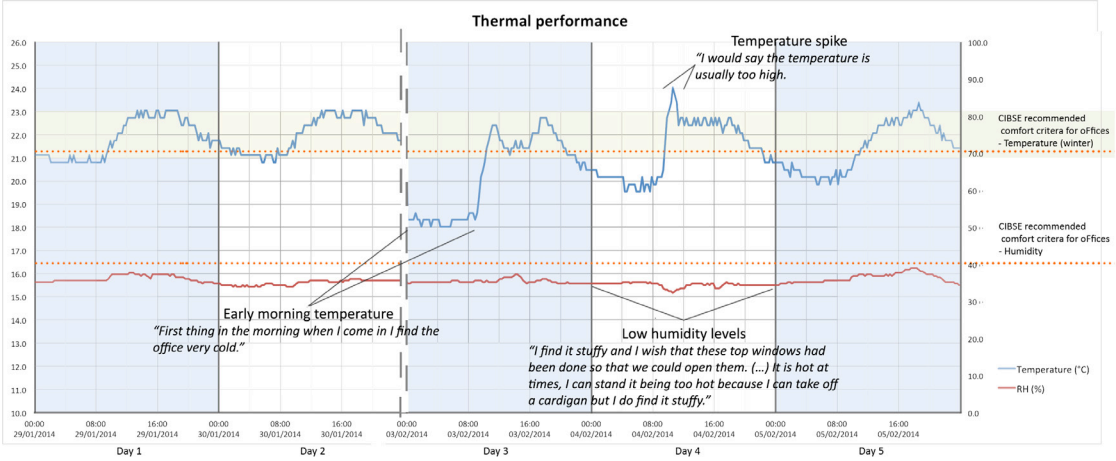

Figure 6. Monitoring of environmental conditions (Temp, RH) in Office A over a period of five days during winter (February 2014).

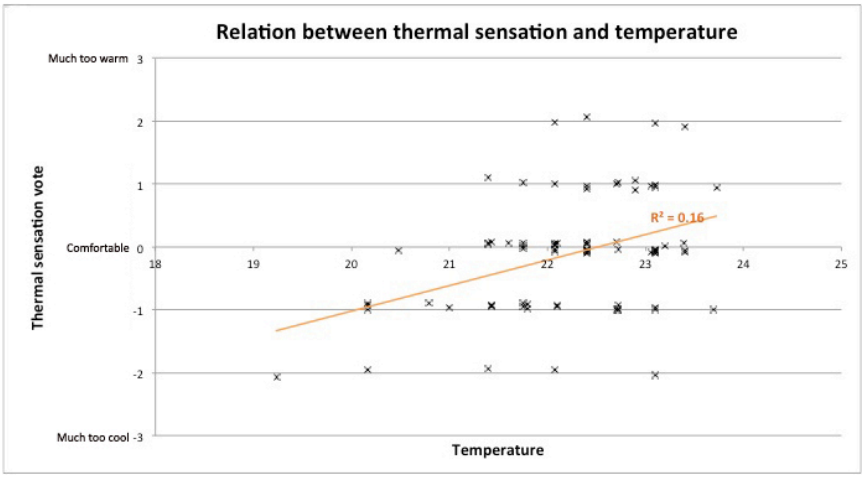

Figure 7. Scatterplot indicating the relationship between thermal sensation and temperature (February 2014).

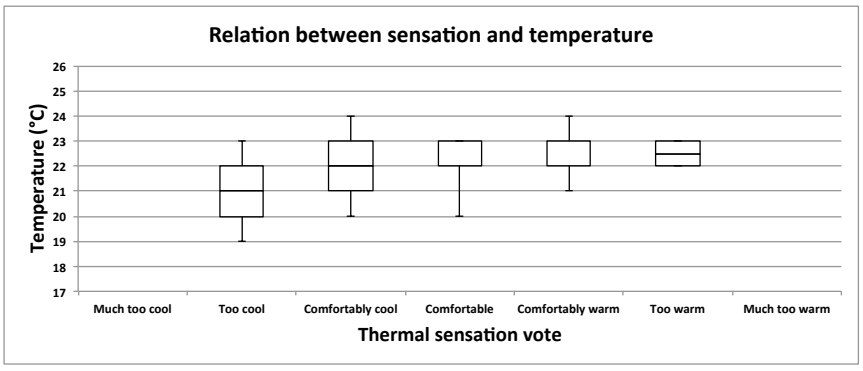

Figure 8. Box-and-whisker plot indicating the relationship between thermal sensation and temperature (February 2014).

heating and cooling system, the office appliances and finally the RTD installed in their office.

The office infrastructure and appliances were found to actually impede energy saving due to them being set-up in complicated networks that in and many cases shutting them off would waste workers' time. The example of the photocopier was used, indicating that if it was turned off at the mains the users were automatically disconnected from the server and had to call the Computer Officer to restore the connection.

> I think the workload on some people, you know, they don't bother, it's too much, you know, you take some time out if you think 'Oh, I've got to go and turn that off', again it's just taking the time out to do it, which given the amount of workload you just haven't got the time to stop them, I think that's the main reason.
>
> (Participant 1A_2)

When asked whether they understand how to use the A/C system, the office users highlighted the lack of control and full understanding of its settings. Most were only aware of the basic settings e.g. how to turn the system on/off and set the temperature. One of the collected comments was about one of the units that seemed not to have a thermostat break and was constantly on. The inability to set a timer, turn it from winter to summer setting and the lack of an instruction were obstacles impeding the efficient use of the heating system. As a result the A/Cs were always used on a default mode, not leaving much space for change.

> These A/C units are a bit hard to figure out I think. Sometimes when I get in first thing in the morning at eight sometimes I put them on and then it just seems it never warms up. I think they have a summer or winter setting on them but we've never been shown how to use them probably correctly.
>
> (Participant 1A_1)

> Ever since we moved into here we have got no instruction manual for those control panels so we tend to leave it how it is been originally set […] Other than that we have never been able to work how to set the timers on them.
>
> (Participant 3A_1)

In terms of the RTD and real-time consumption feedback, it was not found particularly useful by the office users. The feedback screen was on for the first time in early July 2014, after a significant 10-month delay of the initial plan due to various technical issues. Once the screen was on, another problem with the meter had resulted in data distortion, and therefore the office users turned it off after a couple of days. A few days afterwards, the screen was turned on again once the content was valid. Participants said that they lost interest in it quickly, and claimed that the graph was too technical, the reason for having a League Table was not clearly explained and the screen was rather consuming additional energy rather than promoting energy savings. The criticism on the RTD was related mainly to three issues: the difficulty to understand the graphs and tables that were displayed, the lack of an induction to the purpose and right use of the energy saving tool and its location that did not allow most of the users to have a clear view from their desks.

> I am the only person that can see it and I cannot read it from here. I am sure that the screen should be bigger but we've had it on for a few days then it broke and we just turned it off because we were getting sick of the message and all I could see from here was the title of the newsfeed and that was it. I can't read it from here and I've got perfect vision.
>
> (Participant 2A_2)

Technological infrastructure was found to play a key role in the formation of energy use practices and decisions regarding the thermal conditions of the office. The difficulty to control and understand aspects related to the configuration of the A/Cs had resulted in sticking to the default settings and having passive attitudes towards the use of heating in the office. Similarly, the position and interface of the RTDs did not allow for feedback to be effectively conveyed and absorbed by the users.

KNOWLEDGE

The level of understanding of the energy concept is important for examining the ability of energy saving. In this case, the research questions focused on the knowledge of the participants on energy saving options in their workplace, their ability to act accordingly and the source of their knowledge.

The interviewees had a basic level of knowledge of energy use issues, coming mainly from media and magazines, while one commented on the influential role of his energy supplier. In terms of the information coming through the CO_2 Grand Prix only three out of five had actually heard of the competition, but were not aware of any details or looked into it further as they claimed that the information was not easily accessible.

> I've heard something about it but I can't tell you what it is. Probably in an e-mail somewhere but also probably put it in a folder somewhere and never got back to it.
>
> (Participant 5A_1)

When they were asked whether they agreed with the concept of saving energy in their workplace, participants appeared very positive. They claimed to be aware of how to save energy and were open to further guidance on more specific rather than general advice on how to achieve those savings. A critical comment related to the existing heating and cooling infrastructure, pointing out that four independently controlled A/C units in a space that has not been originally designed as an office might actually block any saving intentions. The usefulness of weekly nudges and a display with comparative energy figures was also mentioned in the first interview phase.

> I think the (heating) system we have might impede it (energy saving) because you got the different (A/C) units, there is all these different units on the wall, and people can put them on, turn them off as they want and you might have somewhere 28 °C somewhere 21 °C so you have a big range of temperature across one office.
>
> (Participant 6A_2)

> I think I am more aware now (of how to save energy) than I probably would have been, say four or five years ago, but I would like at home and here, I would like something that actually it shows you what you are using. To make you perhaps a bit more aware I think.
>
> (Participant 3A_1)

In relation to behavioural change and the ability to add upon existing knowledge, the office users could not actually understand the information projected to them by the RTDs, because they found it too technical. This raises the point that the type of users (administration staff or researchers) and their level of knowledge on energy and environmental issues should be taken into account in the design process of a behavioural change scheme.

SOCIAL NORMS AND SYMBOLIC MEANINGS

Engagement towards the practice of certain activities emerges from concepts associated with them. Indoor comfort preferences and energy saving practices can be coming from social, environmental, financial, technical or other motives. Participants were asked to self-assess their lifestyle on a scale of one to five based on how green they think it is and comment on the importance of being energy-conscious. In addition, there were discussions about individuals' attachment to their office and the influence of their colleagues in their comfort preferences.

Most of the participants claimed to have and support a green lifestyle. Energy consciousness was mainly related to home rather than office practices. Participants found it easier to understand and save energy at home because of the information provided with the monthly bills and the associated economic benefits. One of the participants also said that he would prefer making changes that would have an impact at his home, but he would at best welcome the knowledge coming from his work environment.

> I just treat it as a workplace really, so my home is different to my workplace which is for normal people but I'd rather construct more in my house than I would in my workplace but if I learn things at work I could put into practice at my home.
>
> (Participant 4A_1)

> I don't know if there is anything at work that would do the same but for instance at home saving energy would mean saving money, wouldn't it? But that's not technically the same (at work) because it's not technically your money.
>
> (Participant 5A_2)

In order for feedback to be effective and actionable, the need for structured motivational campaigns and specific and measurable targets rather than general advice was stated essential. The image of the company both in terms of sustainability related activity and style [e.g. modern infrastructure and architecture] could also act as a lever towards a pro-environmental behaviour.

> I think if the company has an image, if the staff are sort of encouraged by the company. […] You 'd like to think that the image out there is that 'We are conscious of what we do into the environment, etc., etc.' so I think if that image is there actually the people that work there would think 'Oh, actually I am quite proud to be working in this building'.
>
> (Participant 3A_2)

The concept of energy savings was found to be stronger at home than at work. Although the interviewees commented that they feel their office to be their territory they would not put much effort on changing their habits unless there was certain economic, technical and informational incentive to do so. A green organisational image would also make people more eager to appreciate feedback and commit into change.

Discussion and conclusions

The aim of this paper was to look at how comfort practices were shaped in a workplace environment and to investigate the effectiveness of a feedback mechanism into changing these practices. In addition, it suggested an interdisciplinary methodological approach to studying comfort practices with both qualitative and quantitative data. Social Practice Theory provided insights into identifying key factors that affect thermal comfort preferences. It also offered a way to unfold the interrelationships between these key factors enhancing the understanding of how changes can be achieved and what are possible obstacles to overcome.

In terms of the influences that shape comfort practices in a workplace environment, three key parameters emerged from the empirical data: social dynamics, existing technological infrastructure and the notion of the workplace as opposed to the domestic environment. Thermal comfort preferences were collectively shaped in the workplace in order to avoid conflicts between the office users. The configuration of the existing heating and cooling system was identified as another parameter establishing decisions on the thermal environment. The inability to set a timer and the lack of a thermostat break in the A/Cs promoted a passive comfort approach and preference towards the default settings. Finally, the context of the study seemed to play a significant role in participants' preferences. Their adoptive actions and willingness to change were found to be different between their home and work environment. Regulating the thermal conditions and trying to save energy seemed to be a natural and easier process at home than at work. This was due to the greater control over the heating system and the direct financial incentive. At the workplace there seemed to be no incentive to make changing thermal settings a priority.

Looking at the feedback coming from the CO_2 Grand Prix competition and the RTDs in the context of the case study office, it was found that it did not have a particular effect in changing energy use and comfort practices. It must be noted, that this study has focused on the first impressions after the installation of the feedback screens. The intention has been to understand the reasons why the impact of the feedback mechanism was negligible and to identify the lessons that can be incorporated in the next steps of the on-going project. The social, technological and contextual aspects that came across as the main influences in shaping comfort preferences provided useful hints and direction for recommendations.

The target audience – in the case of Office A the administration staff – found the feedback too technical to understand and the lack of informational support discouraged any further engagement with the scheme. Users also differentiated the domestic with the work setting in terms of the ability and motivation to change. In this case, the expectation of a green organisational identity to motivate change appears to be a possible future direction. The engagement from the workplace management, showing that energy saving is prioritised along with the provision of the right incentives based on the type of users, could act

as a lever towards a collective pro-environmental attitude and staff engagement towards behavioural change.

Regarding the material infrastructure related to energy use and feedback, it is important that the existing heating and cooling system and the set-up of the RTDs allows a certain level of control in order for savings to be achieved through behavioural change. The ability of the office users to choose the way to access the information, through the public screen or their personal computer monitor is another point for consideration. This would engage users with limited visual access to the screens or those who are interested to view more detailed information that the feedback tool can provide (e.g. raw data, energy saving tips, energy use facts).

The potential of energy use feedback as a driver for change has been verified by recent policies and research. Findings from this study suggested that social dynamics, existing infrastructure and the notion of the workplace were key factors to shape thermal comfort preferences in an office and the ones to be considered if change is intended. Using a Social Practice approach in the understanding of practices enabled not only to identify which factors shape preferences in a specific context but also target the most promising levers for change. The future lies in developing a deeper understanding of the everyday energy use practices. This understanding will allow the development of effective feedback approaches to raise awareness and drive behavioural change.

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