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Occupant Behaviours and Environmental Preferences in Home-Office Environments Versus Conventional Office Environments; Reflections from The Pandemic.

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Abstract: This paper focuses on differences in thermal comfort perceptions and behaviours between home-based and conventional office settings and discusses the consequences of its findings on domestic energy use in the UK in the context of extreme circumstances and beyond. Data were collected using a web-based questionnaire and online follow-up interviews. The 106 responses to the questionnaire captured the frequency of some adaptive behaviours. The in-depth interviews revealed a wide range and diverse adaptation strategies that people exercise when working from home, while these coping strategies were very limited in conventional offices. Moreover, discussions with energy and built environment experts shed light on the potential implications of working from home. The findings of this study indicate that occupants were satisfied with working from home, and the main elements they prefer for a future home office are energy-efficient airtight windows and good ventilation. Further research could usefully propose an energy-efficient home office with the technological and personal behaviours and the upgraded standards revealed in this study.
Keywords: Post-pandemic, home-office, energy consumption, thermal comfort, thermal adaptation

1. Introduction

In 2020, the COVID -19 crisis became a central issue for the world and the pandemic has since changed the way people live, work, and interact (Thapa et al., 2021) (D'alessandro et al., 2020) (Brown, 2020). In response to this pandemic, in March 2020, people in the UK were instructed to stay at home (Menneer et al., 2021), and many companies shifted to home working. According to (Chen et al., 2020), 30% of the population by 2020 had experienced lockdowns and quarantines. Spending more time indoors requires a higher need for heating, and consequently higher energy bills (Menneer et al., 2021). Therefore, significant changes in the energy and electricity consumption load profiles were observed during lockdowns. For instance, a 30% increase in midday consumption was shown in a study by (Chen et al., 2020) focusing on the UK domestic context.

This paper focuses on UK-based office workers and explores the differences in perceptions and behaviours influencing thermal comfort in their home-office and standard office environments. The specific objectives of this study are [to]:

- Review the impact of working from home on households' energy consumption and (space) heating load profiles.
- Evaluate the behaviours involved in coping with cold home-office spaces, and the potential implications of such behaviours on energy consumption.

- Explore the occupants' thermal preferences and willingness for adaptation that may underline these behaviours.

2. Methodology

The primary data for this study was collected through a web-based questionnaire and follow-up interviews. The secondary data is collected from energy experts' reports (Energyrev, Department of Energy and Climate Change of the UK, Department of Business, Energy and Industrial Strategy, office of gas and electricity markets publications Ofgem), books, journal papers, and recent studies.

2.1. Questionnaire:

The questionnaire was built on previous research (Liu et al., 2014) (Ambrose et al., 2021) and was set up on the onlinesurveys platform. It focused on the thermal adaptations strategies: conventional vs home office.

The link of the questionnaire was shared via LinkedIn and an email was also circulated to students and staff of the School of Architecture of Cardiff University. LinkedIn enabled the researcher to contact and target the participants who have shared interests or some shared identity, something in common expanding access to 'hard-to-find' research populations through a process of 'snowballing' (Denscombe, 2017).

2.2. Interviews:

The purpose of the interviews was to obtain information about the heating practices, adaptations and routines while working from home. Some interviews were with selected people who have extended knowledge of the topic, seen as "key informants" (Lazar, 2017). Eight experts in the industry of sustainable buildings and construction and four non-experts were interviewed. The key informants were members of CIBSE, working in academia or the industry. 30-45 minutes of one-to-one Microsoft Teams interviews were performed, audio-recorded and transcribed (appropriate consents obtained). Analysis was carried out using NVivo qualitative analysis software, to code the transcriptions and highlight the thematic analysis of the research.

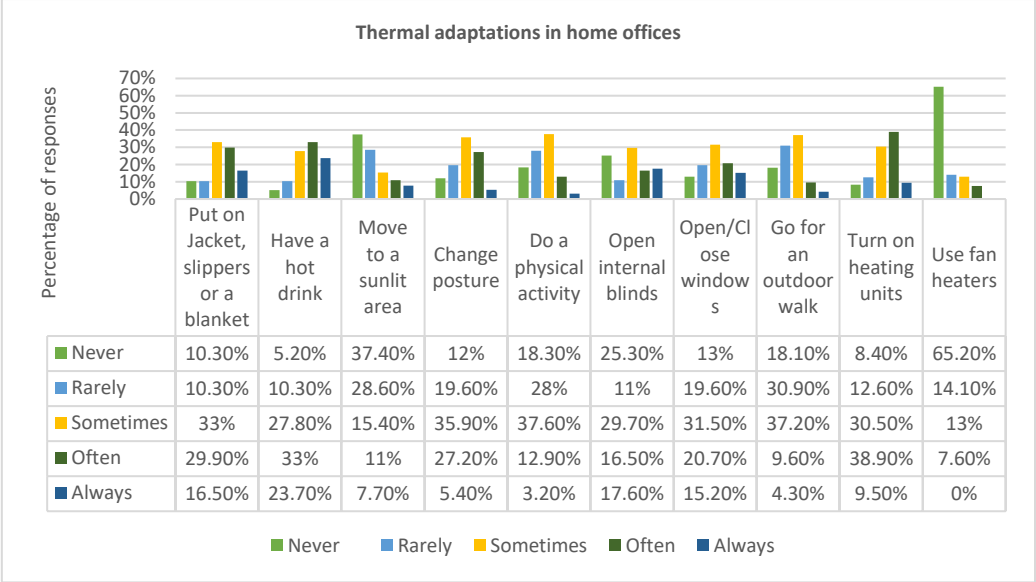
3. Data Analysis

3.1. Findings of the questionnaire

The questionnaire was sent to a total of 729 people on LinkedIn and a total of 106 responses were received, with a proportion of 60% female and 40% male. The response rate was 14.5% and potentially impacted by the call being circulated during the holiday break (December 2021 – January 2022).

- **Thermal adaptations strategies: conventional vs home office**

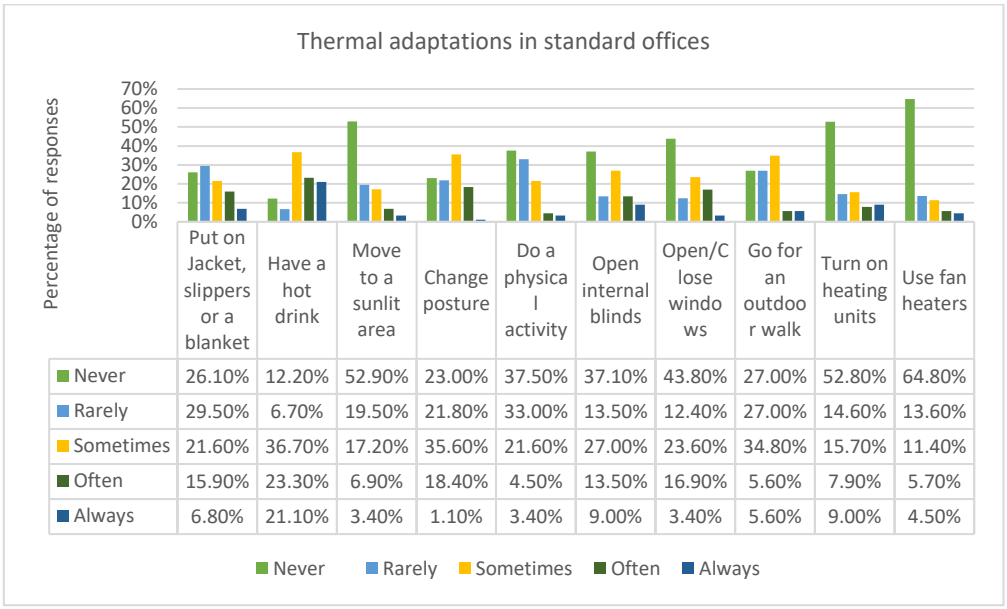
The findings of the key question "How regularly do you adopt these behaviours to keep yourself warm in the home office/standard office environment?" provided insights into the differences in types of thermal adaptations and frequency of use between the two office environments. The most adopted (highest 33% for 'often' and 23.7% 'always') action in home offices is "have a hot drink", followed by "open internal blinds" 16.5% for often and 17.6% for always and 15.2% "open/close windows". However, 38.9% of the respondents tend to often "turn on heating units" 29.9% "put on a jacket, blanket or slippers" and 27.2% "change posture", figure 1.



	Put on Jacket, slippers or a blanket	Have a hot drink	Move to a sunlit area	Change posture	Do a physical activity	Open internal blinds	Open/Close windows	Go for an outdoor walk	Turn on heating units	Use fan heaters
Never	10.30%	5.20%	37.40%	12%	18.30%	25.30%	13%	18.10%	8.40%	65.20%
Rarely	10.30%	10.30%	28.60%	19.60%	28%	11%	19.60%	30.90%	12.60%	14.10%
Sometimes	33%	27.80%	15.40%	35.90%	37.60%	29.70%	31.50%	37.20%	30.50%	13%
Often	29.90%	33%	11%	27.20%	12.90%	16.50%	20.70%	9.60%	38.90%	7.60%
Always	16.50%	23.70%	7.70%	5.40%	3.20%	17.60%	15.20%	4.30%	9.50%	0%

Figure 1 Thermal adaptations in home offices

In contrast, in the standard workplace environments, respondents tend to adopt mostly personal adjustments, for example, 21.1% always have a hot drink. Sometimes 35.6% change posture and 34.8% sometimes go for an outdoor walk. What stands out in the standard office behaviours responses is that the frequency of choosing "never" as answer is higher than in the home office. For example, 64.8% never use fan heaters, 52.9% never "move to the sunlit area", 52.8% never turn on heating, and around half 43.8% never open or close windows (details seen in figure 2).



	Put on Jacket, slippers or a blanket	Have a hot drink	Move to a sunlit area	Change posture	Do a physical activity	Open internal blinds	Open/Close windows	Go for an outdoor walk	Turn on heating units	Use fan heaters
Never	26.10%	12.20%	52.90%	23.00%	37.50%	37.10%	43.80%	27.00%	52.80%	64.80%
Rarely	29.50%	6.70%	19.50%	21.80%	33.00%	13.50%	12.40%	27.00%	14.60%	13.60%
Sometimes	21.60%	36.70%	17.20%	35.60%	21.60%	27.00%	23.60%	34.80%	15.70%	11.40%
Often	15.90%	23.30%	6.90%	18.40%	4.50%	13.50%	16.90%	5.60%	7.90%	5.70%
Always	6.80%	21.10%	3.40%	1.10%	3.40%	9.00%	3.40%	5.60%	9.00%	4.50%

Figure 2 Thermal adaptations in standard offices

3.2. **Findings of the Interview**

- **Home office vs. conventional office:**

Similarly, with the results coming out of the questionnaire analysis, the results from the interviews indicate a difference between the home office and conventional office, on types

of thermal adaptations exercised. The result summary is presented in table 1 categorised according to the classification presented by (Liu et al., 2014).

Table 1 Categorization of thermal adaptations reported in the interviews

	Conventional office	Home office
Technological responses	• Rolling down internal blinds • Electric heating mat • Opening window • Electric heater • Turn on heating	• Heating mat • Electric heater • Reduce heating temperature • Reduce heating duration • Heat the house partially
Personal adjustments	• Wear cardigan • Changing position • Thermal underwear	• Wear a cardigan • Put a blanket on legs • Clothes • Socks • Woolly jumper and scarf • Standing desk • Physical activity • Hot drink

As can be seen from table 1, some occupants adopt a range of thermal adaptive actions to obtain thermal satisfaction. Interviewees reported both behaviours to adjust the environment to their needs and behaviours to adapt themselves to the environment (Hong et al., 2017). Interviewees also reported effective approaches to feel warm while working from home that would allow them to lower their temperature heating setpoint or decrease the number of hours when heating runs on a working day. These approaches are likely to be related to economic consequences since lower heating temperatures will result in lower energy bills (Luo et al., 2014).

Within the sample, one of the interviewees uses a 60-Watt heating mat to heat up her study space to the required comfort level and reduce the heating of the entire house which sits under her desk (figure 3). The participant also reported that if she feels her knees, ankles, or chin cold, she will add an extra layer on the top part of her body.
Another interviewee switched from the sitting down position while working to a standing position using a special harmoni desk (Harmoni, 2021) as shown in figure 4. This standing desk increased his physical activity while working, thus allowing him to stay warm at a wider range of temperatures. Interestingly, this participant also discussed another adaptive action, that of doing work-life balance. In other words, he managed to break his day up more than in the standard office. He turns the heating on in the early morning and starts doing the cognitive work while the heating is turned on for 3-4 hours. After that, he would take a break for an hour or two and do a physical activity (go for a walk, or gardening), then work another 4 hours.
Increasing clothing insulation was the most commonly reported coping strategy among the interviewees (7 out of 12). Figure 5 is from the home office of an interviewee who mentioned the presence of a collection of jumpers in her study space.

Figure 3 Electric heating mat under a desk of the interviewees

Figure 4 Standing desk used by one of the interviewees

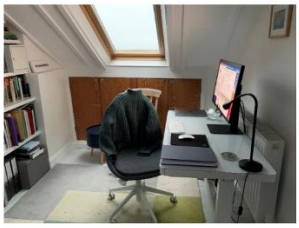


Figure 5 A study space for one of the interviewees, and a jumper shown

- **New home office image**

All the respondents revealed a general satisfaction with the home-office environment. However, respondents were asked, “If you had the chance to have a new home office, what would be the considerations that you take into account, to have a warm and comfortable home office?”. Using NVivo software, a word cloud was generated from the transcripts of the answers to this question at interview. As shown in figure 6, it is notable that windows and light are the most frequent words and were widely reported in conversations by the interviewees.

Figure 3 Word-cloud generated of the elements and considerations the interviewees have identified to have a new home office

The vast majority of the participants had expectations of a new space with energy-efficient windows. Several participants described a future image of their home office with lots of natural light. The findings of this question have emphasized that light and windows are the main elements for a future home office, followed by natural ventilation. Overall, participants showed a range of adaptive and coping strategies while working from home. These strategies varied from sewing thick curtains to installing heat pumps and PV cells.

4. Conclusion

The overall aim of this research was to examine the impact of working from home on thermal adaptations and household energy consumption. Spending more time at houses has caused changes in the residential sector, in terms of energy consumption, thermal comfort and occupants’ behaviours (Jaimes Torres et al., 2021).

This study has identified the coping strategies of occupants in winter while working from home. Respondents tended to apply low-cost strategies, related to the heating routine and control practices. For example, reducing thermostat temperature or the duration of heating staying ON during a typical working day.

The questionnaire provided insights into the most adopted coping strategy in home offices. The highest adopted action that respondents 33 % 'often' adopt is "have a hot drink" followed by "open internal blinds" and "open/close windows". On the other hand, in the conventional work offices, respondents favour adopting personal adjustments. Surprisingly, the frequency of choosing "never' as an option is higher in standard offices than in home offices.

One of the more significant findings to emerge from this study is that the future image for the interviewees for new home offices is daylit spaces with energy-efficient sealed windows and good ventilation.

A key limitation of this study is the small sample size and the fact that most of the participants are from Wales and postgraduates. It is unfortunate that the study does not seem to have received data from energy-poor households as one would expect a set of different viewpoints expressed by that group to the questions asked. Notwithstanding these limitations, the findings of this research provide insights into the interaction of teleworkers with their home office's environments and revealed the preferred adaptations.

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