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# The changing landscape of thermal experience and warmth in older people's dwellings

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## HIGHLIGHTS

- Thermal variations across space affect the use of space within a dwelling.
- Older people show interest in and understanding of thermal behavior of dwellings.
- Older people pursue the thermal conditions they desire.
- Older people take actions to modify the quality of the thermal environment in their house.
- Changes made to the house may not be solely motivated by thermal comfort concerns.

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## ABSTRACT

The UK's carbon dioxide reduction policy initiatives often treat environmental conditions in buildings as averaged values of air temperature that flatten spatial variations. This discounts the influence of varying thermal conditions on how people use buildings and the impact this may have on energy consumption. This paper explores the intersection between older people's thermal experience, spatial and temporal variations in thermal conditions in a dwelling and the influence this has on occupants' use of space. The paper reports on qualitative studies in homes with both conventional and newly installed low carbon heating systems. The results suggest that older people are sensitive to and adept at exploiting variations in the dynamic 'landscape' of warmth to achieve desired thermal preferences and that they modify their dwellings to improve the quality of the thermal environment. There is also some evidence of a 'spatial rebound' effect after energy upgrades, when occupants inhabit rooms they previously could not afford to heat. The nature of qualitative research precludes robust recommendations for policy. However, one important avenue to explore further appears to be that householders may be more strongly motivated by interventions offering improvements across a range of aspects rather than on energy savings alone.


## 1. Introduction

The UK's energy policies aimed at reducing carbon dioxide emissions are driven by global and European commitments. Those targeting energy consumption in the domestic sector currently include financial incentives such as the Green Deal[1] (DECC 2010a), through which consumers can secure loans to carry out energy upgrades to their homes, and Feed In Tariffs[2] (DECC 2010b) to promote investment in renewable energy sources, primarily solar photovoltaics. The details of such policy instruments are derived from models of the current state of the country's housing stock and a set of underlying assumptions about how people use their homes, which is often reduced to a representative whole house average temperature (Shorrock et al., 2005). The premise is that if improvements are made to the building fabric and heating systems, predictable energy savings will follow. However, this has proved to be misleading because of "performance gaps" between predicted and actual energy savings (Sunnikka-Blank and Galvin, 2012). Although it is possible to identify various points where performance gaps can be found in the procurement of new and retrofit of existing buildings, the most significant of these appears to be in the differences between assumed and actual occupant behaviour and the impact this has on energy consumption (Milne

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[1] https://www.gov.uk/green-deal-energy-saving-measures/overview
[2] http://www.fitariffs.co.uk/FITs/

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and Boardman, 2000; Marsh et al., 2010). This is evident in retrofit when the predicted savings are often far in excess of what is achieved after the interventions. Much of this is attributed to the behaviour of occupants who, it is argued, operate the upgraded home in ways that negate the energy efficiencies provided by improved insulation levels or better heating systems by choosing higher temperatures rather than reduced energy consumption, for example (Gill et al., 2010; Hamilton et al., 2011). There are many reasons for the discrepancies between predicted, assumed and measured thermal conditions, but perhaps the most discussed is the rebound effect (Sorrell et al., 2009). Rebound normally refers to phenomena such as ‘temperature take-back’ when occupants negate some or all of the energy savings by heating their homes to a higher temperature, thus promoting greater heat losses through a higher temperature difference between outside and inside. However, another form of rebound might be labelled ‘spatial rebound’ in which occupants, because of the cost savings gained through greater energy efficiency, are able to heat more rooms, which again can lead to increase in heat loss from the dwelling (Winther and Wilhite, 2014).

The paper is based on research into how older people respond to the thermal environment in private residences and care homes. The work was carried out as part of a collaborative project across four universities (Manchester, Cardiff, Lancaster and Exeter), with fieldwork in different types of dwellings for older people, from those living in their own homes to those in sheltered accommodation and to those in care settings. The project was concerned with occupants' responses to the introduction of low carbon heating technologies. The research was conducted using qualitative methods with small numbers of participants rather than a larger quantitative study because the team sought to understand the range of responses rather than their frequency. This paper discusses results in relation to one of the themes that emerged from the research across three of the sites: the way in which thermal conditions in the home vary according to space and time and how occupants respond to these variations.

### 1.1. Occupant behaviour and energy consumption in the home

Despite a number of monitoring studies that show variations in thermal conditions within dwellings both time and space (Hong et al., 2009; Kavgic et al. 2012; Tweed et al., 2014; Chiu et al., 2014), most of the discussions around potential reductions in carbon dioxide emissions assume a whole house average temperature (Shipworth, 2011). This approach may be useful for generalised prediction, but is not so good for understanding the detailed variations that occur and, most importantly, why they occur. Most studies addressing energy efficiency tend to focus on quantitative aspects of thermal comfort[3], such as measurements of air and mean radiant temperatures, relative humidity, air velocity and $CO_2$ levels (Summerfield et al., 2007; Gupta and Chandiwala, 2010). These indicators are used to calculate various indices and determine the indoor air quality. In non-domestic spaces, the Predicted Mean Vote (PMV) is used to indicate the likely satisfaction across a typical population with the thermal environment. The PMV works reasonably well for homogenous environments, such as offices, though Humphreys and Nicol (2002) note that in specific buildings it can differ significantly from actual mean vote. Its use is less reliable in domestic settings, where there is often a large variation in the thermal conditions from room to room (Hong et al., 2009; Oseland, 1994; Feriadi et al., 2003). Field studies have shown that building occupants can be thermally satisfied with conditions outside the boundaries predicted by current theory (Humphreys, 1976; Sharma and Ali, 1986; Busch, 1992; Baker and Standeven, 1995). Becker and Paciuk suggest this is particularly so in residential settings (Becker and Paciuk, 2009). Proposals for a new approach to thermal comfort based on empirical studies emerged in the 1990s (Nicol and Humphreys, 2002). The adaptive comfort[4] hypothesis argues that contextual factors and past thermal history influence building occupants' thermal expectations and preferences. One of the key postulates of the adaptive comfort theory is that satisfaction with a given thermal environment is not solely a matter of physics and physiology. It recognises three categories of adaptation: physiological adaptation, psychological adaptation and behavioural adaptation.[5] Behavioural adaptation comprises a range of actions occupants may undertake to create and maintain their own comfort. Typically this refers to changing the levels of clothing or activity, but it can include other forms of adaptive behaviour—opening and closing windows, switching on fans, adjusting thermostats, consuming hot drinks, etc. According to Nicol and Humphreys, the adaptive principle is “if a change occurs such as to produce discomfort, people react in ways which tend to restore their comfort” (Nicol and Humphreys, 2002).

As actions are determined by available opportunities, the variety of adaptive opportunities present in the home is generally much greater than in other settings.[6] The key difference between the home and other environments is that householders are usually in charge of their own comfort. They have agency at home that they would not enjoy in ‘managed’ environments. Occupants are usually free to turn heating on and off, open windows and doors and, most importantly in the context of this paper, move around a dwelling and spend time in places that meet their preferences. It is rare to have these options in a more regulated environment such as the workplace. They may also be freed from feeling the need to conform to social norms about clothing and other aspects of their behaviour that may restrict the availability of these adaptive opportunities elsewhere. Our interpretation of ‘available’ in this case is akin to how social influences determine the perceived availability of affordances as highlighted by Dreyfus (1996).

More recent discussions about comfort introduce social practices as a way of understanding how notions of comfort are constructed and evolve within a broad social and cultural context. The work by Shove Shove (2003), Shove et al. (2008) and Chappells and Shove (2005) has brought a fresh perspective to a field that previously has been dominated by building science and offers a useful reminder that the perception of comfort is neither stable nor predictable.

Adaptive thermal comfort theories recognise there is a variety of thermal preferences and expectations, and that people exert actions to achieve comfort. In addition to these aspects, there are specific issues that emerge when considering the thermal experience[7] of the older population: (1) physiological changes

[3] It should be noted that studies addressing quantitative aspects of thermal comfort are likely to build upon theories that focus on the physiological responses of people to thermal stimuli (Fanger, 1970; Markus et al., 1980)

[4] A useful summary of the current position on different approaches to thermal comfort and the models that are in use is provided by Yau and Chew (2014), and Nicol's introduction to a special issue (Nicol, 2011) describes recent developments in adaptive comfort theory.

[5] The research reported here is mainly interested in the behavioural opportunities for adaptation.

[6] Although the lack of research on psychological and cultural aspects of thermal comfort is significant, perhaps the greatest gaps arise from too much emphasis on non-domestic environments (Humphreys et al., 2005; Wagner et al., 2007; Brager and Baker, 2009). As a result, there is a dearth of information about comfort in the home. The primary purpose of this study is to investigate how people create and maintain thermal conditions at home.

[7] We use the term “thermal experience” rather than the more common place “thermal comfort” as a recognition that people sometimes express preferences for thermal conditions that lie outside comfort zones, even if temporarily.