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His, hers or both's? The role of male and female's attitudes in explaining their home energy use behaviours

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ABSTRACT

Building energy research has historically overlooked the role of attitudes, instead focusing on building and socio-demographic influences. Even when attitudes are measured, usually, the attitudes of just one household member are measured even though household energy consumption is the result of actions of all household members. This research explored first whether attitudes could help explain heating usage and second whether the attitudes of a *couple* could explain more of the variability in heating behaviour than the attitudes of one partner. The attitudes towards home heating energy use (i.e. attitudes towards *thermal comfort*, *economical with energy*, *industry and technology's role and individual's role*) of 128 English couples were used in this study. Together with building and socio-demographics, attitudes were examined to explain heating temperatures and durations, which were derived from temperature sensors placed in the homes in 2007–2008. The results showed that attitudes helped explain heating temperatures and durations, even when building and socio-demographic variables were controlled. *Economical with energy* was the most highly identified influence on heating behaviours, with *thermal comfort* a close second. In households that included a couple, combined attitudes of both partners explained heating usage behaviours more accurately than the attitudes of either male or female only.

1. Introduction

Home energy use accounts for nearly a third of energy use in Britain and approximately 61% of home energy use is attributable to space heating [1]. Clearly, reducing heating energy use is imperative if the UK is to cut carbon emissions from housing. Historically, building energy research has focused on the influences of building-demographics and socio-demographics on heating energy use. Tenure [2,3], household size [4,5], age [6,7], building age [8], dwelling type [9], and energy-efficiency variables [6] have all been shown to affect home energy consumption and heating use.

However, *attitudes* also influence home energy use, as found by research in the 1980s–1990s. Attitudes to personal comfort were frequently found to be an important influence [10–12]. Other attitudinal influences were: environment and energy concerns [10–12], personal responsibility to save energy [10–12] and price concerns [10]. However, no recent UK study explores whether these attitudes are related to home heating. This analysis sought to explain home heating temperatures and durations derived from internal temperatures measured over a winter period. It was tested whether home heating energy use attitudes helped to explain heating temperatures and durations over and above the explanatory power of building characteristics and socio-demographics. Home heating energy use attitude was defined as people's attitude and perception towards four aspects of heating energy use in this study, i.e. *thermal comfort, economical with energy, industry and technology's role and individual's role.* Temperatures in the living room were measured in the winter of 2007–2008, over a 92-day period. These temperature measurements were used to estimate heating hours and maximum temperatures, and heating durations were estimated heating hours per day over this period.

Most previous home energy use attitude studies focused on the attitudes of one person from the household, taking their views to represent those of the entire household. However, one person's attitudes may not be representative of everyone's attitudes in households with more than one person [13]. Consequently measuring just one person's attitudes could be one cause of the poor explanatory power of attitudes in some research [13,14]. In 2008,

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70% of all households in the UK had more than one person and 85% of those households included a couple [15]. This study explored the effects of home heating attitudes of male and female partners on home heating usage in those households that included a couple. Exploring couple's attitudes is essential also because that research in the field of psychology has found that environmental values and attitudes are generally higher in females than males [16,17]. This would lead to a misrepresentation of household attitudes if only one occupant was studied (e.g. when males were asked, the positive attitudes would generally be underestimated in the whole population). However, very little empirical research has tested whether couple's attitudes explain household energy consumption better than an individual's attitudes do. Although some research was done in the 1980s to examine the correlations between attitudes of husbands and wives with home energy consumption [10,18,19], finding that the combined attitudes of husbands and wives had a slightly higher correlation with the household energy consumption than individual attitudes, the research was far from recent and was not based in the UK. Moreover, there may be a possibility that couple's attitudes are so similar that we only need to measure attitudes of one person to express attitudes of both. Previous research did not explore the relationship between the couples' attitudes, and did not verify whether the combined couple's attitudes explained energy consumption better than the attitudes of a single partner did. Recognizing this gap in knowledge, this empirical study compared the attitudes of the male partner and the female partner and explored whether the attitudes of *both* partners influenced home heating temperatures and durations more than the attitudes of one person. In the next sections, to compare home heating attitudes of couples, correlation coefficients of both male and female partners were calculated for home heating energy use attitudes using correlation analysis. Second, to compare attitudes' influences, home heating temperatures and durations were regressed on combined attitudes of couples as well as one partner's attitudes, using multiple linear regression method.

2. Methods

2.1. Data collection and measures

2.1.1. Sampling

The Carbon Reduction in Buildings (CaRB) project commenced the Home Energy Use Survey in England, in winter early in 2007 (for more details, see Ref. [20]). Stratified random sampling was used to select households from the Postcode Address file, to ensure a good geographic and demographic spread; 427 households participated, yielding an eligible response rate of 38%. During the computer-assisted face-to-face interviews, householders answered structured questions on their home's built-form, heating technologies, heating practices and socio-demographics. A structured interview with pre-defined answer categories is a quantitative research method commonly employed in survey research. The aim of this approach was to ensure that each interviewee is presented with exactly the same questions in the same order. This method was preferred to open-ended questions because it ensured that answers could be reliably aggregated and that comparisons could be made with confidence between sample subgroups or between different survey periods. Following the interview, households that agreed to be involved in a future survey were sent self-completion questionnaires. The sample size would have made interviews too expensive to realize, and open-ended questions too time-consuming to analyse. Hence, a mail survey was used to collect the responses on attitudes. The component that included questions on home heating energy use attitudes was directed to up to three adults in each household. 63% of eligible households responded to the questionnaire.

2.1.2. Measuring sensor-based estimates central heating hours & maximum temperature

After the face-to-face interviews, 387 households agreed to the request to place two temperature sensors in their homes, recording temperatures in the living room and bedroom from mid July 2007 to early February 2008. HOBO UA 001-08 sensors were used. These were self-contained data loggers that were programmed to record spot temperature every 45 min, resulting in 32 measurements per day. They are small, silent and with a reported accuracy of ±0.47 °C; calibration measurements were taken on each sensor before the installation. Homeowners, sometimes with the help of interviewers, placed the sensor with the instruction of "on a shelf or other surface between knee, head height away from any heat sources and away from direct sunlight". Hobos from 275 living rooms were returned; 110 were not returned and 2 were faulty. In this study, the analysis focused on living room temperature data in the winter months over a 92-day period between 1st November 2007 and 31st January 2008. The living room temperature was selected as the dependent variable because this study wanted to measure the temperature in a room used by the couple during their awake hours. According to the definitions by EHCS [21], compared with bedroom, living room might be more frequently shared by family, especially during daytime when they all might have a chance to set the thermostat. According to the average daily external temperature created from the data of local weather stations within the respondent's Government Office Region, all of these days had maximum external temperatures of no higher than 15.5 °C [3], meaning those days were considered heating days where the heating was assumed to be in use. For more details on data collection method, please see [20,22].

It was assumed that, during the recorded winter period, internal temperatures would decrease when the central heating system was turned off, because of heat loss through the building fabric. Therefore, central heating active periods were estimated as those periods during which living room temperatures were not falling, by comparing the measured internal temperatures with the external temperatures and the internal temperatures between sensor time intervals. This might make the assumption occasionally incorrect when high solar gains or use of secondary heating were the cause of the rise in living room temperatures rather than the use of the central heating. The time intervals during which the central heating system was assumed to be active is defined as those where the living room temperature at time interval $i+1$ is higher than the temperature at time interval i. For heating days, they were defined as those days with the estimated central heating active time longer than 2 h. Estimated active hours of central heating per day were calculated for each home. They were computed as the mean value of the heating hours for each heating day over all heating days. To arrive at the number of heating hours of each single heating day, the sensor time interval (45 min) was multiplied by the number of time intervals during which the heating was estimated to be on (the temperature was not falling).

For each day, the maximum temperature was identified for each home, and this value was then averaged across the three winter months. It was assumed that this maximum temperature reflected approximately the residents' demand for heating temperature.

2.1.3. Measuring socio-demographics and building variables

Socio-demographic and building-demographic variables were derived from answers given by the main respondent during the computer-assisted personal interview. Accommodation type was coded by the interviewer directly. The wall insulation variable was derived from building year, external wall type, cavity wall insulation status, according to the u-values in SAP 2005 [23]. Questions measuring socio-demographics used National Statistics harmonised methods, which defined how questions on