Occupants' motivation to protect residential building stock from climate-related overheating: A study in southern England

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Abstract

Temperate zones including the UK and mainland Europe continue to be exposed to increasing temperatures and more frequent heatwaves as global warming continues. The built environment can mitigate the public health risk of overheating and recommendations for precautionary actions on homes have been published by government and industry. A key player in improving resilience is the householder, who can determine whether precautionary measures will be installed in their home. Previous research on flooding has applied Protection Motivation Theory to examine determinants of householder response to risk. However, flooding risks differ from those of overheating in several ways. The current study builds on this work to address the gap on understanding householder propensity to install precautionary measures against overheating. A large-scale survey (n = 1,007) of householders was conducted in the south of England and regression analyses applied to the data. While threat appraisal (perception of threat risk and severity) had an influence on motivation to take action, coping appraisal (perception of ability to make changes, of the effectiveness of the changes and of convenience) was a stronger predictor, particularly for flat dwellers. Previous experience of overheating did not directly influence protection motivation. Age was negatively related to intentions to act but income was not a significant factor. Recommendations for policy and practice include focusing on enhancing coping appraisal, targeting older citizens, customising initiatives by type of property and occupancy, and framing mitigating actions in ways other than protection from overheating.

Keywords: climate change adaptation, climate change resilience, housing, protection motivation theory, overheating.

1. INTRODUCTION

By 2016, global warming had already exceeded 1.1˚C above late 19th century levels (NASA, 2017) and is likely to surpass a 2˚C threshold even if national commitments pledged at COP21 to reduce greenhouse gas emissions are achieved (Rogelj et al., 2016). One of the many consequences of warming planetary systems is the increased risk of higher temperatures, and the likelihood of increased frequency and severity of heatwaves for many geographical locations. Traditionally hot places have experienced record high temperatures in recent years but more temperate zones including the UK, mainland Europe and the US have also been exposed to hotter weather (NOAA, 2018). Heatwaves and wildfires characterised the weather across the northern hemisphere in the summer of 2018, including in the UK, Greece, Japan, the Arctic Circle and North America (Carrington, 2018). Climate projections for the UK estimate that mean daily temperatures will increase over the coming decades, by up to 4.9˚C in southern England by the 2080s (central estimate, UKCP, 2009). Likelihood of extreme temperature events also increases, with the probability of the heatwave in Northern Europe in the summer of 2018 estimated as twice as likely due to human influence on climate (WWA, 2018).

The risk to public health from higher temperatures was evidenced by the August 2003 heatwave in Europe which led to 15,000 excess deaths (PHE, 2015a). In the UK, excess deaths due to higher temperatures have been estimated at 75 extra deaths per week per degree increase (PHE, 2015b). Evidence from research suggested that heat-related deaths in London begin to increase when temperatures rise beyond the relatively low value of 19 ˚C/66 ˚F (Hajat, Kovats, Atkinson, & Haines, 2002). Individuals especially vulnerable to the effects of higher temperatures include older people, infants, those with chronic or severe illnesses or alcohol/drug dependence, and those living in south-facing flats or in urban areas (PHE, 2015b). It is notable that, depending on the severity and duration of a heatwave, adverse effects can also strike healthy, fit and able-bodied adults and children (ibid.).

The built environment can exacerbate the risks from overheating or help to mitigate the adverse effects. It is estimated that people in the UK spend over 90% of their time indoors (Schweizer & al., 2007) thus the resilience of the building stock to overheating has a major role to play in protecting occupants from excessive heat. While buildings themselves can cause overheating – and there have been investigations in construction research of the contribution of building regulations and Passivhaus standards to overheating (Lomas & Porritt, 2017) - the focus here is on climate-related overheating.

Adaptation of the built environment for the changing climate is a primary challenge for sustainable construction (Kibert, 2016). Much research has focused on sustainability at a large scale in the industry, considering major contractors and clients, and new development. Essential though these foci are, they overlook the crucially important nature of the existing building stock. In the UK, an estimated 75-85% of buildings that will be in use in 2050 are already built (Jugdoyal, 2017). The modification of existing buildings is typically conducted by small-to-medium sized firms, that is, actors operating outside of large development programmes. In particular, on residential housing stock, householders may carry out works themselves and also act as the client for refurbishment, extension and other modification projects. As such, they are critical actors within the construction sector but are frequently overlooked. They may act firstly as construction clients. Second, and of greater long-term importance, they are the gatekeepers who determine what changes will be made that will shape the built environment for decades to come. As such, it is crucial to understand their motivations. While previous research has examined householders' intention to protect against flooding (discussed in Section 1.2), to our knowledge, no research has yet addressed the issue of climate change-related overheating and householder intentions. The current study aims to address this gap by examining the motivation of householders and tenants in the UK to modify their homes to protect against overheating. It offers novel extension to current knowledge in investigating householder motivations to contribute to a built environment resilient to overheating, in its use of a theoretical framework not previously applied in this domain, and in its assessment of current levels of intention to take action.

Having set out the evidence for the probability of overheating, the risk to public health and role of householders, a summary of the relevant literature is now discussed. Evidence of overheating in homes, recommended mitigating actions, inadequacy of policy assumptions of 'rational utility' to trigger action and the theoretical framework of Protection Motivation Theory are discussed, before the method is described, and findings presented and discussed in the following sections.

1.1 Overheating studies

Within the construction literature, the issues around overheating in current stock have received growing attention. A 2007 study of 252 homes across England found overheating across all housing types during the coolest summer since 1993 (Beizaee, Lomas, & Firth, 2013), and a 2009 study in 268 dwellings in Leicester, a city in central England, measured overheating in almost 90% of bedrooms (Lomas & Kane 2013). Assessing temperatures in social housing stock that was not at particular risk of heat gain over two relatively cool summers, Mavrogianni et al. (2015) nevertheless found evidence of overheating as did Mavrogianni et al. (2017) with an opportunity sample of 89 households in the London area. They found that existing domestic building stock typically lacks passive mitigation measures, finding that only 6% had overhangs, awnings, shutters or vegetation to provide shade (Mavrogianni et al. 2017). The importance of passive mitigation was underlined by Porritt et al. (2011) who argued that Victorian terraced dwellings (a common form of UK housing dating from the late 19th century) could avoid overheating even in medium-high scenarios for 2080 through passive measures alone, which included provision of exterior shutters, wall insulation and a pale exterior surface. Although Gupta and Gregg (2012) disagreed that 2080s overheating scenarios could be fully mitigated through passive measures, they concurred with Porritt and colleagues on factors that could enhance resilience, with external shading the most effective. In sum, empirical evidence from measurement in the existing homes - albeit in small scale studies - has already demonstrated the occurrence of overheating, and evidence for the effectiveness of passive mitigation measures.

Based on such research, a number of government and industry reports have proposed modifications to existing homes which can provide effective mitigation of overheating, including solar reflective or pale coatings to external façades, wall insulation especially external, maintaining exposed thermal mass, external shading such as shutters and awnings, effective ventilation, and managing the microclimate adjacent to the building through provision of green spaces, trees and water features (ARCC CN, 2013; PHE, 2015b).

Although previous research has examined the effectiveness of measures taken, the few studies that have considered the role of the occupant in responding to overheating have been limited to reactive responses to high temperatures (Coley, Kershaw, & Eames, 2012; Mavrogianni et al., 2017). However, such studies failed to recognise the behavioural aspects of precautionary protective action, such as commissioning retrofit measures to minimise overheating, thus overlooking the critical role of occupants as gatekeepers of the current domestic building stock. In seeking to understand how the current building stock can be upgraded to become more resilient to the warming climate, it is important to understand how willing householders are to take action to upgrade the home.

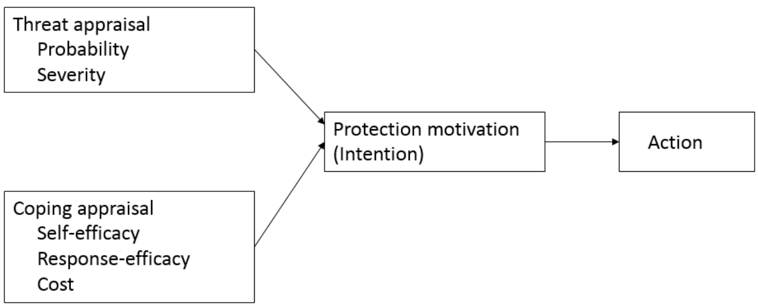
The assumption that individual behaviour will be motivated to prepare for climate change by 'rational utility' is enshrined in UK policy: the National Adaptation Programme declares "if adapting to climate change is in the private interests of an individual…then it should occur naturally" (DEFRA 2013:7). The implicit assumption is that the interests and therefore actions of the individual will align with policy preferences, in this case taking adaptive action to protect one's health and property. However, decades of research demonstrate otherwise: from cognitive biases (Kahneman, Slovic & Tversky, 1982) to evaluation of personal adaptive capacity (Bubeck et al, 2013), a range of psychological factors have been shown to contribute to behavioural choices. Termed the 'risk perception paradox', there is ample evidence that perceptions of even high levels of risk do not necessarily lead to motivation or action to protect oneself (Wachinger, Renn, Begg, & Kuhlicke, 2012). With respect to preparation for flooding, for example, it has been argued that objective factors only partially determine what action is taken (Grothmann & Patt, 2005). The cost-benefit analysis of investment of money and time versus gains in protection is not the only important factor.

1.2 Theoretical framework

Within the literature on understanding individuals' responses to risks from natural hazards, including climate change risks, a widely applied theoretical framework is that of Protection Motivation Theory (PMT: Rogers, 1983). Originating in health psychology and used extensively in risk research since the 1970s, PMT has proven valuable in recent times in examining influences on preparedness for aspects of climate change such as farmers' responses to drought (Dang, Li, Nuberg, & Bruwer, 2014; Truelove, Carrico, & Thabrew, 2015) and householders' responses to flood threat (Bubeck et al., 2013).

PMT postulates that protection motivation, that is, the intention to enact a particular behaviour to mitigate a threat, is a proximal determinant of behaviour and is itself primarily determined by threat appraisal and coping appraisal. Figure 1 depicts a simplified model of PMT. Threat appraisal encapsulates the individual's evaluation of threat risk with two measures: probability of the specific threat and severity of outcome if the threat is realised. Coping appraisal, termed 'adaptive capacity' by Grothmann and Patt (2005), combines three constructs: self-efficacy, that is, belief in one's own capacity to enact the behaviour; response-efficacy, that is, belief in the effectiveness of the action; and cost, that is, time, effort and monetary cost to undertake the action. Thus people with a high level of coping appraisal for an action feel that they have the personal resources to complete the action, that the action will be effective in reducing the threat and that the personal cost will be affordable and worth the effort. PMT posits that a threshold level of threat appraisal is necessary in order to motivate action, and that a combination of high threat appraisal and high coping appraisal predict protection motivation, that is, intention undertake the adaptive behaviour.

Fig. 1 Protection motivation theory (simplified model)



The model additionally predicts that high threat appraisal and low coping appraisal will lead to non-protective action, such as a sense of fatalism, which has a negative influence on protection motivation. As a first investigation, to our knowledge, of the applicability of PMT to the threat posed by overheating, a simplified model was used and the paths and variables relating to non-protective action were not explored in the current study.

No published studies were found which had applied PMT to overheating threat but several studies have explored PMT and responses to flooding. Grothmann and Reusswig (2006) applied PMT to examine the question of why some householders take action to protect themselves against the risk of flooding while others do not. They tested socioeconomic characteristics and previous flood experience alongside the psychological variables in PMT. Both threat and coping appraisal influenced the level of protection motivation, although the contribution of threat appraisal was small. Home ownership and previous experience of flooding also contributed to the level of protection motivation, and income and age were not related. A study applying PMT to precautionary action against landslides also found that experience of the hazard was positively related to intention to act (Mertens et al., 2018). In contrast, Zaalberg and colleagues (2009) found that neither previous experience nor self-efficacy, a component of coping appraisal, were related to protection motivation against flooding. Poussin et al. (2014) also concluded that previous experience of flooding did not drive intention to take precautionary action for flood-prone householders in France. A recent meta-analysis of PMT and flood response, of 47 studies with a total of over 35,000 participants, concluded that previous experience could influence protection motivation indirectly through threat appraisal (Bamberg, Masson, Brewitt, & Nemetschek, 2017). Overall, the meta-analysis by Bamberg and colleagues (2017) showed a relationship between both threat appraisal, coping appraisal and the dependent variable, testing both protection motivation (intention to act) and actual behaviour as dependent variables. Coping appraisal tended to be the stronger determinant. Thus, PMT has proved useful in identifying key psychological factors which predict precautionary action against flooding, although evidence on other variables is mixed.

However, overheating and flooding represent quite different types of threat. Visual impact and newsworthiness draw public attention to flood events but far less to heatwaves. When mass media include coverage of heatwaves in the UK, the content tends to emphasise public enjoyment of sunshine. Excess deaths from heatwaves have been concentrated amongst the elderly or chronically ill rather than amongst the able-bodied (PHE 2015b) and the impact of overheating on health and productivity is simply not as visible or as newsworthy as flooding. This then raises the question: Does PMT also provide insights into precautionary action against overheating?

In this study, we draw on the simplified model of PMT in Figure 1 and the literature discussed above to frame the initial hypotheses:

H1: Appraisal of threat from overheating is positively related to protection motivation, that is, intention to take actions to make the home less susceptible to heat.

H2: Coping appraisal is positively related to protection motivation.

H3a: Previous experience of overheating is positively related to threat appraisal.

H3b: Previous experience of overheating is positively related to protection motivation.

A factor not addressed in much of the work on flooding is the level of householder knowledge on the actions that could be taken. For overheating, although governmental and industry bodies have issued recommended modifications for properties (DECC, 2015; NHBC, 1012), there is little evidence available on people's knowledge of these actions or the influence of such knowledge on their intention to carry out the actions. We expect that knowledge will not directly influence intention (Simcock & al., 2014) but that it may be positively related to coping appraisal: the more the individual knows about mitigating action, the more likely that s/he feels capable of coping with an overheating event.

H4: Knowledge of mitigating actions is positively related to coping appraisal.

Previous research has shown flats to be more at risk of overheating than houses, with potentially different constraints on occupants' actions (Baborska-Narożny, Stevenson, & Grudzińska, 2017; Lomas & Kane, 2013), thus both threat and coping appraisal may differ between flat and house dwellers. Homeownership too may differentially affect precautionary action and intention (Grothmann & Reusswig, 2006) and different levels of coping appraisal may contribute. This leads to the next set of hypotheses:

H5a: Threat appraisal is greater for flat dwellers than for house dwellers

H5b: Coping appraisal is lower for flat dwellers than for house dwellers

H5c: Coping appraisal is lower for tenants than for homeowners

Finally, acknowledging that the types of action recommended for mitigating overheating risk may also serve other purposes (e.g. additional insulation may increase warmth in cold weather and reduce energy bills), we will investigate additional reasons for taking such actions.

H6: Occupiers have multiple motivations for undertaking changes to their homes.

These hypotheses build from the literature primarily on householder responses to flooding, in the absence of previous studies on climate change-related overheating. The theoretical framework found to be valuable in the flooding domain is applied here to address the research questions: To what extent are occupants motivated to protect residential building stock from climate-related overheating and what factors influence their motivation? We argue that understanding people's motivation to take action to protect their homes is essential in order to make progress towards a more resilient built environment.

2. METHOD

As the south and midlands of England is predicted to be more threatened by increasing temperatures than more northerly areas, these regions were selected as the target area for study. An online survey was conducted in September 2016, using an established market research organisation. A total of 1,007 completed questionnaires were collected. Representativeness was achieved through completion of quotas mirroring national ratios for key criteria: gender, age, home owner versus tenant and house type. Three types of questions were asked, on PMT variables, property characteristics and occupier characteristics.

Proposed predictor variables from PMT were measured as follows. Measurement of threat appraisal was based on Poussin et al. (2014) with two items measuring threat risk and two items measuring threat severity. Cronbach alpha was .89, indicating a reliable scale. Coping appraisal for each of five types of action (described below) was measured through two items assessing self-efficacy, two items assessing response efficacy, and one item for convenience of implementing the action. These formed reliable scales (all Cronbach alphas greater than .7). Finally, the main dependent variable in the analysis was protection motivation (intention to take precautionary action): participants were asked if they intended to take each action in the next three years. The responses were aggregated by action groups (described below) and summed to provide an overall score of protection motivation. Of the responses on protection motivation, 70% were 0 indicating no intention to take action. The aggregated measure was therefore converted to a dichotomous variable of zero and non-zero for the analyses.

Characteristics of the property included type of dwelling (see Table 1), and type of occupancy (owned or rented). Characteristics of the occupant included sociodemographics (age, personal income and level of education), experience of overheating in current home and knowledge of mitigating actions. Respondents were asked whether they had experienced overheating in their current home (scale of 1 to 6, labelled as Never, Once, On a few occasions, Quite often, Frequently, Constantly). Overheating was defined with respect to householder subjective experience: “By ‘overheating’, we mean that the temperature inside the home is high enough to make it difficult to sleep at night or uncomfortable to do what you want to do during the day, on at least one occasion.” Knowledge of the recommended actions to mitigate overheating was measured on a scale of 0 to 12 (nine recommended actions and three exacerbating items, reverse scored). The recommended actions were based on national guidelines for reducing overheating in homes (DECC, 2015; NHBC, 2012), and were grouped in subsequent analysis as (i) insulation (walls, roof), (ii) ventilation (including night ventilation), (iii) shutters/awnings, (iv) pale exterior and (v) planting (trees, grass, water features near the external walls). For each of the nine actions, participants were asked if they had already implemented the action, and the reasons why they had done so: five options were offered (“It makes my home more comfortable [Comfort]”, “Some of my friends or neighbours have this [Neighbours]”, “It makes my home look nicer [Aesthetics]”, “It helps to reduce overheating [Overheating]”, “It adds to the financial value of my home [Financial value]”), each rated on scales of 1 to 6 anchored at Strongly disagree (1) to Strongly agree (6).

3. FINDINGS

3.1 Descriptive statistics

Descriptive statistics are presented in this section. For participant and property characteristics, see Table 1, and for key variables, see Table 2.

Table 1 Sociodemographic and property-related variable: descriptive statistics

Variable	Category	
Gender	Female	50.8%
	Male	49.2%
Participant age	Mean	50.58
	Range	18 - 85
Income (personal monthly net)	Up to £1,000	23.2%
	£1,001 - £2,000	35.2%
	£2,001 - £3,000	17.4%
	£3,001 - £4,000	8.0%
	Over £4,001	6.2%
	Not given	10.0%
Home ownership	Owner	66.0%
	Tenant	31.8%
	Other	2.2%
Property type†	Flat	24.9%
	Mid-terrace	26.8%
	Semi-detached	27.9%

	Detached	18.9%
	Other	1.5%

† Flat = apartment; mid-terrace = townhouse; semi-detached = duplex.
N = 1,007.

Threat appraisal was moderate to low (mean 2.71) and coping appraisal was moderate (3.51) across the sample (see Table 2). Motivation to undertake some or all of the nine recommended actions to mitigate overheating was very low (mean .84).

Table 2 Key variables: descriptive statistics and correlations

Variable	Range	Mean	Std. Dev.	Thr. Appr	Coping Appr	Exper-ience	Know-ledge
Threat appraisal	1 – 6	2.71	1.21				
Coping appraisal	1 – 6	3.51	1.06	.27**			
Overheating experience	1 – 6	2.6	1.2	.60**	.17**		
Knowledge of Precautionary Actions	0 – 12	4.91	2.92	-.03	.09**	.08*	
Protection motivation	0 – 9	.84	1.72	.39**	.30**	.21**	-.08*

Note: ** p <.01; * p < .05

Two thirds of the sample had experienced overheating on at least a few occasions, across all housing types. The highest mean of overheating experience was that of flat-dwellers. Although this was higher than that of occupants of terraced houses at a statistically significant level (t = 2.52, df = 518, p < .05, d = .22), there was no significant difference with other housing types (mean values flats 2.80, terraced 2.51, semi-detached 2.62, detached 2.68). Subjective overheating experience did not differ significantly between homeowners and tenants.

3.2 Hypotheses testing

H1 and H2 Threat appraisal and coping appraisal are positively related to protection motivation.

Due to its pronounced skew, protection motivation was treated as a binary variable and a logistic regression analysis was run to establish the relationship with threat appraisal and coping appraisal. The model as a whole was significant and both variables contributed significantly (see Table 3).

Table 3 Logistic regression of protection motivation onto threat and coping appraisals

		95% CI for Exp (B)			
	Exp (B)	Lower	Upper	B	SE (B)
Constant	.08			-2.54***	.56
Threat appraisal	1.85	1.6	2.13	.61***	.07
Coping appraisal	2.05	1.72	2.43	.72***	.09
R_N^2	.28				

*Notes: ***p <.001. R_N^2 = Nagelkerke coefficient of determination.*

Additional predictors examined in previous research on flooding were also tested here. The analysis was re-run sequentially to include occupant characteristics (age, gender, education, income, experience of overheating, and knowledge of recommended actions) as Step 1, and threat and coping appraisal as Step 2. Threat appraisal and coping appraisal remained significant and the variance explained by the model increased (Δs -2LL = -116.27, R_N^2 = +.13), demonstrating that threat appraisal and coping appraisal explain additional variance over occupant characteristics. H1 and H2 were therefore supported.

H3a Previous experience of overheating is positively related to threat appraisal.

The strong correlation between experience of overheating and threat appraisal ($r = .6$, $p < .01$, see Table 2) provided initial support for H3a. For a more robust test, a multiple regression analysis was conducted to examine experience jointly with other predictors of threat appraisal that had been examined in previous research on flooding. Threat appraisal was regressed onto occupant characteristics: age, education, income, experience of overheating, knowledge of recommended actions. The model was significant ($F(6,984) = 125.06$, $p < .001$, Adj. R^2 = .43) and overheating experience was the strongest predictor ($\beta = .54$, $p < .001$). That is, those who had more frequent experience of overheating had higher levels of threat appraisal. H3a was therefore supported.

H3b Previous experience of overheating is positively related to protection motivation.

As noted in testing H1 and H2, the logistic regression in which predictors of protection motivation were tested found overheating experience to be non-significant (see Table 3). H3b was not supported.

H4 Knowledge of mitigating actions is positively related to coping appraisal.

Table 2 shows a small positive relationship between knowledge of mitigating actions and coping appraisal ($r = .09$, $p < .01$). A regression analysis of coping appraisal onto occupant characteristics also found knowledge of mitigating actions to be significant ($\beta = .12$, $p < .001$; $F(6, 850) = 18.51$, $p < .001$, Adj. $R^2 = .11$). H4 was therefore supported.

H5a Threat appraisal is greater for flat dwellers than for house dwellers.

Flat dwellers' perception of threat was greater than that of house-dwellers at a statistically significant level (flat dwellers mean threat appraisal 2.95, house-dwellers mean 2.63, $t = 3.45$, $df = 391$, $p < .01$, $d = .26$), providing support for H5a.

H5b Coping appraisal is lower for flat dwellers than for house dwellers.

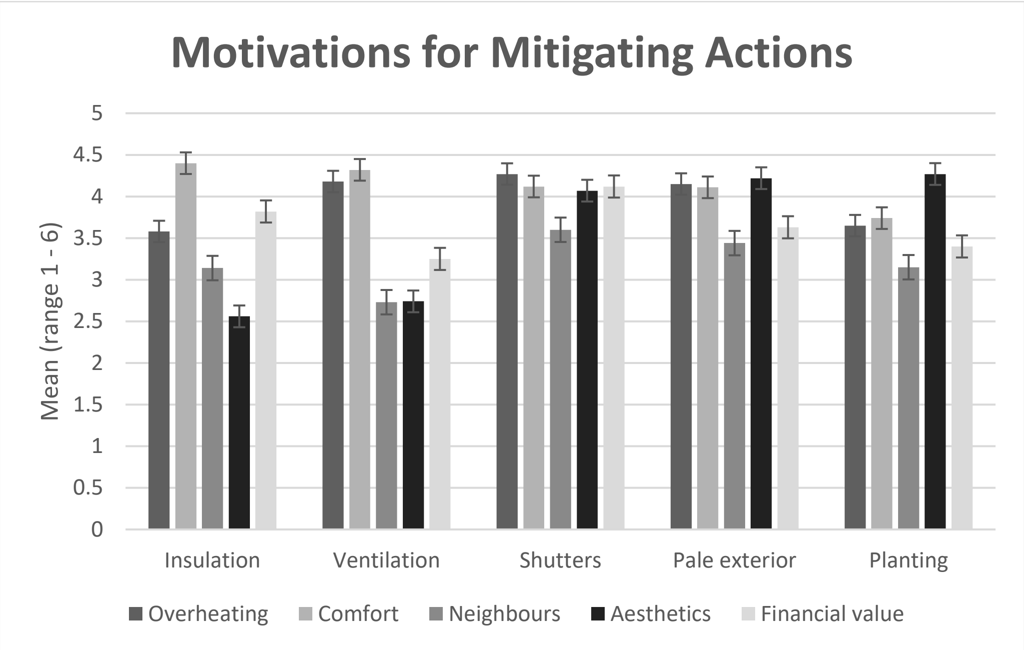
H5c Coping appraisal is lower for tenants than for homeowners.

House-dwellers' coping appraisal was greater than that of flat-dwellers at a statistically significant level (house-dwellers mean 3.55, flat-dwellers mean 3.36, $t = 2.02$, $df = 862$, $p < .05$, $d = .17$), as was the coping appraisal of homeowners compared to tenants (owners mean 3.57, tenants 3.34, $t = 2.84$, $df = 844$, $p < .01$, $d = .22$), supporting H5b and H5c

H6: Occupiers have multiple motivations for undertaking changes to their homes.

The motivations for different action types are summarised in Figure 2. Mean values above 3 indicate agreement that the factor was influential in undertaking the action type. All five action types show multiple factors above this level. The data demonstrated multiple motivations for undertaking different types of works on a home, supporting H6. Overheating was the strongest motivator for installing shutters and awnings, comfort the strongest motivator for improving insulation and ventilation, and aesthetics the strongest motivator for a pale external finish and planting near the exterior.

Fig. 2 Motivations for mitigating actions by type (95% confidence level error bars)



3.3 Additional analyses

Table 4 Regression of protection motivation for owners and tenants, and house and flat dwellers

	Protection motivation Exp B [95% Confidence Intervals]			
	Owners n = 600	Tenants n = 239	House Dwellers n = 666	Flat Dwellers n = 191
Property type	.81*	.85	.79	X
	[.65 – 1.0]	[.61 – 1.18]	[.62 – 1.02]	
Participant age	.96 ***	.96***	.97***	.93***
	[.95 - .97]	[.94 - .98]	[.95 - .98]	[.9 - .96]
Threat appraisal	1.6***	1.48*	1.7***	1.16
	[1.27 – 2.01]	[1.05 – 2.09]	[1.38 – 2.08]	[.74 – 1.81]
Coping appraisal	1.99***	2.38***	1.86***	3.33***
	[1.59 – 2.51]	[1.65 – 3.43]	[1.51 – 2.3]	[2.09 – 5.31]
R_N^2	.38	.35	.32	.56

*Notes: Only significant coefficients presented. X not included in analysis. *** p <.001; ** p <. 01; * p < .05. Larger values of R_N^2 (Nagelkerke) indicate greater predictive ability.*

Threat appraisal and coping appraisal were established as factors of protection motivation in H1 and H2. Support was also found for different levels of threat appraisal in house versus flat dwellers (H5a), and different levels of coping appraisal in house versus flat dwellers (H5b) and homeowners versus tenants (H5c). Further regressions were conducted to examine the relationship between threat and coping appraisals and protection motivation by property type (house versus flat) and type of occupancy (owner versus tenant). For both owners and tenants, threat appraisal and coping appraisal were the primary determinants of protection motivation in line with PMT (see Table 4). However, in the case of house versus flat dwellers, threat and coping appraisals remained significant for house dwellers but threat appraisal became non-significant for flat dwellers, with significant difference between the coefficients for threat and coping appraisals (z = 4.22; Steigert 1980). Age also contributed a small amount of variance in all models (Table 4 presents Exp(B) values; B ranged from -.07 to -.04 in these analyses) and, interestingly, was negatively related to protection motivation, that is, the older the participant, the less likely they were to intend to carry out actions to minimise overheating. A negative relationship with property type for owners suggests that protection motivation was more likely for owners of terraced properties and semi-detached than detached. Income and gender were non-significant in all regressions.

H3a demonstrated that overheating experience was positively related to threat appraisal. In the same model, age was found to be significant (β = -.26, p < .001, F(6,984) = 125.06, p < .001, Adj. R^2 = .43) while income, level of education and knowledge of mitigating actions were not significant. That is, older people had lower perception of threat.

Because earlier studies, albeit on flooding (Grothmann & Reusswig, 2006), had found a relationship between previous experience and protection motivation, the regressions of protection motivation were re-run sequentially, with occupant characteristics in Step 1 and threat and coping appraisals in Step 2. In Step 1, overheating experience was significant for all ($B = .20$, $p < .01$), owners ($B = .22$, $p < .05$) and for house dwellers ($B = .19$, $p < .05$). However, the relationship was no longer reached statistical significance in Step 2. This evidence supports an indirect relationship between previous experience and protection motivation.

Having found in support of H5c that coping appraisal differed significantly between homeowners and tenants, the three components of coping appraisal (self-efficacy, response efficacy, convenience) were also tested for difference. No significant difference was found for response efficacy and convenience, demonstrating that occupants' perceptions of effectiveness of actions to protect against overheating and of their convenience did not differ by type of occupancy. Self-efficacy, however, was significantly higher for homeowners (owners mean 3.85, tenants mean 3.20, $t = 5.71$, $df = 844$, $p < .001$, $d = .44$). These findings suggest that, unsurprisingly, homeowners feel that they have greater capability to carry out protective actions on their homes than do tenants.

As different action types may have a different pattern of predictors (Poussin et al., 2014), logistic regressions were additionally conducted by action type. The patterns found above remained generally constant across all five: threat appraisal and coping appraisal were the strongest predictors, and age made a consistently small negative contribution to all actions. However, some differences in the patterns of relationships were found. For installation of shutters, awnings or overhangs or painting the external façade of the property a pale colour, threat appraisal was a stronger predictor than coping appraisal (Exp(B) shutters threat appraisal 2.29, coping appraisal 1.85; pale exterior threat appraisal 1.94, coping appraisal 1.7), that is, perception of the risk of threat and its likely severity was more important than one's perception of self-efficacy to take action, effectiveness of the action or convenience. This appears logical for actions which are relatively easier for householders to undertake and bear a clear relationship with the threat. Knowledge of specific mitigating actions was significant for insulation (Exp(B) 1.52) and planting (Exp (B) 1.83) but not for the other action types. The findings point to the need to examine protection motivation at the level of specific action types, for which levels of coping appraisal will vary, as well as more generally.

4. DISCUSSION

Householders are key actors in construction in the context of the existing residential building stock. This study examined their preparedness to modify their homes to minimise the impact of climate change-related overheating. PMT, a theory which posits the importance of psychological constructs in explaining the risk perception paradox and which has been usefully applied in other studies of responses to natural hazard risks, framed the study. A large-scale survey was conducted in southern England. The findings showed that threat and coping appraisals were the strongest factors contributing to protection motivation and that the relationship varied with type of property (flat versus house) and of occupancy (ownership versus tenancy). That is, the results demonstrated that psychological factors are more important than socioeconomic in affecting intention to act to protect one's home from overheating. Previous experience of overheating influenced threat appraisal but not protection motivation directly. Knowledge of mitigating actions was positively related to coping appraisal and occupants had multiple motivations for taking actions that could mitigate overheating. The findings offer novel contribution to the literature in examining householder motivations to contribute to a more resilient built environment, in applying a theoretical framework not previously used in this domain, in evaluating current levels of intention and in the findings as summarised. The study has implications for theory in the context of responding to overheating and for practical and policy applications which will now be discussed

4.1 Implications for theory

The survey measured property characteristics (type of property, type of occupancy) as well as sociodemographic variables. However, over and above these factors, the key variables from Protection Motivation Theory of threat and coping appraisals were the strongest predictors of protection motivation, increasing the variance explained by a statistically significant amount (10 – 13%). This adds to the evidence on PMT from prior research on flooding (Bamberg et al., 2017). The findings therefore demonstrate the importance of understanding the psychological factors which affect behavioural motivation. While studies on overheating in homes from the perspective of building science are important, they cannot in themselves indicate how change will happen: insights from psychology theory and research are needed.

The relative weight of coping compared to threat appraisal is consistent with the findings of Poussin et al. (2014), Grothmann and Reusswig (2006) and others. This contradicts assumptions implicit in UK policy- that awareness of a threat will drive action. The findings add to the ample evidence from other fields (such as awareness of health risks and levels of smoking in health psychology – Heikkinen et al., 2010) that awareness of a threat does not necessarily result in behaviour change. The findings here showed that, in respect of protection motivation against overheating, it is in fact perception of one's capacity to take action and of the anticipated effectiveness and convenience of the action that has a greater effect on motivation to act. This may shed light on the risk perception paradox (Wachinger et al., 2012) in this domain, pointing to factors which attenuate the relationship between threat perception and intention to act.

The analysis by type of occupancy and by type of dwelling showed differences in the relationship between threat and coping appraisal and protection motivation. In particular, for tenants, threat appraisal contributed less to intention to act than for owners, and even more so for flat dwellers, for whom threat appraisal became non-significant. Because tenants and flat dwellers are likely to face more constraints on building changes than house dwellers, the weaker effect of threat appraisal may be due to higher levels of constraints or perception thereof. This speaks to the argument of Mertens and colleagues (2018) for the critical role of self-efficacy. It may explain earlier findings on flooding in which threat appraisal was found to contribute little to protection motivation (Poussin et al., 2014; Grothmann & Reusswig, 2006). Theoretically, this may imply a modified PMT-based model, because of the different nature of the impact of overheating compared to flooding, particularly the lack of visibility and absence of objective measures such as cost of damage or height of flood water. Threat appraisal may play a less important role in protection motivation.

Alternatively, other models could be elaborated which focus on coping appraisal. The work of Mertens and colleagues highlighted self-efficacy: individuals' self-beliefs in their capacity for action. More work is needed on the sub-factors of self-efficacy within the built environment: are perceptions of physical strength or knowledge of DIY (do-it-yourself home modifications) relevant, or are perceptions limited to capacity to find and instruct a tradesperson? Further work is needed on convenience: how are perceptions formed of time and cost resources? Other factors may play a role: social norms and previous experience of DIY, for example. More generally, the findings may suggest that in conditions of widely varying or very constrained behavioural control, it is coping appraisal that holds the key to behaviour change.

The findings contradicted the conclusions of Grothmann and Reusswig (2006) that previous experience may contribute directly to motivation to act, in the case of flooding, and supports the case for an indirect relationship through threat appraisal (Bamberg et al., 2017). Again, this points to a more nuanced understanding of how experience of a risk may or may not drive action for future protection.

Knowledge of the sorts of action that could be taken indirectly influenced the level of coping appraisal, thus knowledge of possible solutions can be beneficial in leading to motivation to take protective action. However, the relationship between knowledge of the actions and coping appraisal was not large, showing that knowledge alone is insufficient to drive motivation - an important counter-intuitive finding consistent with results in many other fields, from flooding (Lamond & Proverbs, 2008) to professional education (Marteau, Sowden, & Armstrong, 2002) to feedback on energy use (Abrahamse & Steg, 2011).

A particularly worrying outcome was the negative relationship of age, albeit small, with both threat and coping appraisals. This means that older participants were less likely to consider overheating to be a probable or severe threat, and were also less likely to believe that they had the capacity to take effective action. Combined, this suggests that older residents have lower protection motivation than younger adults despite being a particularly vulnerable group in terms of the risk of overheating to health (PHE, 2015b). It is feasible that the older respondents were applying psychological distancing to cope with the threat (McDonald et al., 2015) and it can be speculated that this may be a defence mechanism to protect against their higher vulnerability to heat. The negative relationship between age and coping appraisal is perhaps easier to explain: whether through the physical demands of DIY or the social demands of finding a competent tradesperson, the older participants may have felt less able than younger adults.

Interestingly, we did not find a relationship between income and motivation to undertake actions to protect against overheating, either in the overall analyses or when examining specific actions, and this is consistent with previous findings on structural changes to defend against flooding (Grothmann & Reusswig, 2006; Poussin et al., 2014). This suggests that financial constraints are not a primary barrier to installing mitigating measures, echoing Harries' (2012) finding for flooding of no correlation between financial factors and action.

4.2 Practical and policy implications

The very low intention to take protective action, irrespective of previous experience of overheating, points to an urgent need for industry and policy initiatives. Indeed, this has been recognised in a recent climate change risk assessment presented to the UK government which ranks overheating as one of the two areas of highest priority, requiring urgent action in the next five years (DEFRA, 2017). The perspective presented here – of householders as actors in the construction sector and built environment – makes clear that industry too needs to become more active in enhancing capacity and knowledge in their customers, as well as national and local government, bodies concerned with public health, non-governmental organisations such as citizens' advice and those serving the elderly.

The evidence presented suggests that little or no precautionary action will be taken if it is left to householders to act out of their perceived 'personal interest', and that financial cost does not appear to be an important factor. The case has been made that overheating is more challenging than flooding in terms of communicating levels of threat. However, this may change if summer temperatures reach or exceed the levels of 2018 on a regular basis. Although it is argued elsewhere that a sufficiently high level of threat perception is needed to trigger action (de Boer, Botzen, & Terpstra, 2015), heightened perception of threat without a higher level of coping can result in the ‘fatalism trap’ (Mertens et al., 2018) and inertia. The dominant influence of coping appraisal found in our study underlines this risk. The application of PMT suggests guidelines for policy initiatives to address the challenge.

First, we suggest that targeting coping appraisal is likely to be particularly effective in increasing protection motivation. Enhancement of coping appraisal could include providing information on the effectiveness of recommended actions in order to enhance response efficacy; creating a certification scheme for tradespeople qualified to carry out building modifications such as fitting awnings or better ventilation, to enhance self-efficacy; and focusing on the convenience of external works (reflective paint, planting). Second, campaigns to raise knowledge of specific actions and their role in mitigating overheating, such as increased insulation and planting near the external walls, may also be effective as the findings showed that such knowledge was related to motivation to act, as well as to coping appraisal. However, the relatively moderate contributions of knowledge indicate that it is useful but not sufficient in isolation. Third, targeting older citizens appears particularly important as the findings show lower protection motivation in older age groups. Here, a focus on coping appraisal would best be combined with aiming to raise knowledge and awareness of the threat of higher temperatures to older age groups, given the negative relationship of age with both threat and coping appraisals but subject to the caveats on threat appraisals above. Fourth, initiatives should recognise the somewhat different factors influencing different types of building and different types of occupancy. Policy and interventions should focus on raising knowledge of possible mitigating actions but also on how flat dwellers and tenants can achieve change, given the strong relationship of coping appraisal with protection motivation. Examples of collective action by flat dwellers to pursue the installation of awnings to all glazing on a southern façade or of tenants successfully reporting problems of overheating to their landlords, for example, may speak to some of the particular issues concerning self-efficacy with which these subgroups need to deal. Such modelling, as well as enactive experience and persuasion, are mechanisms for enhancing self-efficacy (Bandura, 1997). Finally, the evidence of multiple motivations for changes to homes shows that encouraging mitigating actions can be framed in ways other than protection from overheating. The findings here echo those of Bamberg et al. (2107) in demonstrating a relatively moderate amount of variance explained by PMT. We suggest that consideration of other motivations could explain additional variance. Actions such as planting close the exterior of the home or applying a pale, reflective finish could be promoted on the grounds of aesthetics or fashion.

4.3 Generalisability and future research

The survey was conducted in the south of England where the climate has been temperate and overheating is predicted to become more serious. The findings are therefore directly relevant to a number of other geographic areas, including northern Europe and some areas in North America (ISC, 2018). In similar climatic zones, traditional building techniques and social norms have developed around summer heat being valued but not perceived as extreme or dangerous. The increasing frequency of heatwaves presents increased public health risks unless protective measures are taken, and householders’ intention to enhance the resilience of their homes is an important prerequisite. Generalisability of the findings to other climatic regions is somewhat difficult to gauge. On the one hand, the psychological model of PMT attempts to describe universal tendencies in response to risk. PMT has been usefully applied to responses to climate change in Vietnam (Dang et al., 2014) and Sri Lanka (Truelove et al., 2015), providing evidence for its universality. On the other hand, however, there is argument that protection motivation is context-specific (IPCC, 2014) and we briefly consider possible differences between regions.

In the UK, a majority of people own their home (ONS, 2016). In contrast, in a number of countries in northern Europe, long-term tenancy is more usual than home ownership and the contractual responsibilities and limitations on landlord and tenant are likely to have greater impact on the residential built environment as a whole. In high-income countries including the UK, changes to homes, particularly in urban and suburban settings, are subject to planning and building regulation. For larger changes (such as extensions), building professionals tend to be appointed. Although not explored in the current study, these are likely to influence homeowners' perception of self-efficacy in making changes. In contrast, in low income countries, dwellings and their modification may be informal and without external regulatory controls. Residents may be more capable of adapting their homes themselves. These factors could increase perceived self-efficacy. Beyond the regulatory regime, different socio-historical and geographic conditions create different contexts for householder behaviour. In hotter climates, vernacular building has developed ways of protecting occupants such as compact and massive buildings to minimise thermal conductivity, external shading, planting and water features (Lauber, 2005). However, colonial influences have affected modern building in economically-disadvantaged countries (Beccali, et al., 2018). Recent work on bioclimatic architecture stresses the relevance of context as well as overarching principles for achieving thermal comfort (Manzano-Agugliaro et al., 2015). In sum, regulatory, cultural, historical, geographic and social factors will influence householders' motivation to take action. The current study demonstrated that PMT offers initial insight into relevant factors but additional empirical and theoretical work is required across regions to explain further variance in householders' intention to act.

4.4 Conclusion

Householders, in their role as actors and gatekeepers controlling changes to the existing built environment, are crucial to more sustainable and resilient construction. Understanding the psychological factors governing protection motivation adds valuable insights into propensity to take action. Enhancing people's perception of their capacity to take action and of effectiveness of the action, combined with greater knowledge of specific mitigating actions, could increase the contribution of householders to societal resilience in the face of rising temperatures.

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