PRECAUTIONARY ACTION AGAINST OVERHEATING IN ENGLISH HOMES: WHAT INFLUENCES HOUSEHOLDERS' INTENTIONS?

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 risk and recommendations for precautionary actions have been published by government and others. A key player in improving resilience is the householder, who determines whether precautionary measures will be installed in their home. Previous research on flooding has applied Protection Motivation Theory to examine determinants of householder engagement. 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. The findings show that householders are ill-prepared to deal with predicted temperature rises. While perception of threat risk and severity has an influence on their intention to take action, their appraisal of their ability to make changes, of the effectiveness of the changes and of convenience are stronger factors, particularly for flat dwellers. Policy recommendations include raising awareness of specific measures for mitigation and of effectiveness of recommended actions, and targeting older householders.

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

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 and mainland Europe have also been exposed to hotter weather. 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). Climate projections for the UK suggest that mean daily temperatures will increase over the coming decades, 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 a heatwave as severe as that in 2003 estimated already to be between twice and four times more likely due to human influence on climate (Stott, Stone, & Allen, 2004).

Excess deaths due to higher temperatures have been estimated in the UK at 75 extra deaths per week per degree increase (PHE, 2015b). Evidence from research in London suggested that excess deaths can be calculated when temperatures rise beyond 19 ˚C (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 strike healthy, fit and able-bodied adults and children.

The built environment can exacerbate the risks from overheating or help to mitigate the adverse effects. In the UK, it is estimated that people can 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 there has been investigation of the contribution of building regulations and Passivhaus standards to overheating, particularly for new build (Lomas & Porritt, 2017), the focus here is on weather-related overheating in existing domestic building stock. Having set out the evidence for the probability of overheating, the risk to public health and role of the built environment, a summary of the relevant literature is now discussed.

Literature Review

Within the construction literature, the issues around overheating in current stock have received growing attention. A number of studies across England, including some dating back to 2007, have found evidence for overheating in homes even during cool summers (Beizaee, Lomas, & Firth, 2013; Lomas & Kane, 2013; 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 overheating in a 2080 scenario could be fully mitigated through passive measures, they concurred with Porritt and colleagues (2011) on factors that could enhance resilience, with external shading the most effective. Albeit in small scale studies, empirical evidence has already demonstrated the occurrence of overheating in homes, and evidence for the effectiveness of passive mitigation measures.

Based on such research, a number of 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).

The UK domestic built environment is characterised by a predominance of old stock and a low rate of new build. Boardman (2007) has proposed that 87% of the dwellings that will be in use in 2050 are already built. The existing housing stock therefore merits attention as the primary target for measures to mitigate overheating. Although a number of studies have examined the measures that can be taken, the few studies that have considered occupant behaviour 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 commissioning retrofit measures to minimise overheating. The householder is a critical gatekeeper who determines whether or not ‘hard’ adaptation will be conducted on an existing home. In seeking to understand how the current building stock can be upgraded to become more resilient to the warming climate, it is necessary to examine householders’ propensity to take action to upgrade the home. In this, the overheating literature is some way behind that of flooding, in which the need for precautionary behaviours is better understood (Bubeck, Botzen, Kreibich, & Aerts, 2013; Grothmann & Reusswig, 2006; Poussin, Botzen, & Aerts, 2014). From the perspective of construction research, precautionary behaviour is of special importance in that the building sector may act as the agent through which a householder achieves greater resilience.

The focus in this paper is on preparation or precautionary action taken in anticipation of a possible future event, that is, action triggered by the householder to install mitigating measures. Research on climate change preparedness has established that objective factors only partially determine what precautionary action is taken and that actions are risk-specific (Grothmann & Patt, 2005; Porter, Dessai, & Tompkins, 2014). Harries' (2012) work on flooding examined four belief types as mediating factors between experience of flooding and action, and found perception of probability to be a factor. A more extensive framework applied in other research on flooding preparedness is that of Protection Motivation Theory (PMT). Applied widely in risk research since the 1970s, it has proven valuable in recent times in examining influences on preparedness for particular aspects of climate change (Dang, Li, Nuberg, & Bruwer, 2014; Truelove, Carrico, & Thabrew, 2015) and expands on Harries' (2012) framework.. PMT postulates that protection motivation or ‘adaptation intention’ (Grothmann & Patt, 2005), 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. 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 worth the effort. PMT posits that high threat appraisal and high coping appraisal predict intention to undertake the adaptive behaviour.

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. While home ownership increased the level of adaptation intention, experience of flooding, and both threat and coping appraisal influenced the level of intention, although the contribution of threat appraisal was small. Income and age were not related to intention. In contrast, Zaalberg and colleagues (2009) found that neither self-efficacy, a component of coping appraisal, nor previous experience were related to intention to undertake preventative action against flooding. Looking at what they termed structural changes to the home to increase protection against flooding, Bubeck et al. (2013) found that self-efficacy but not response-efficacy related to intention. Previous experience and level of income also showed a positive relationship with intention. Thus, although

PMT has proved useful in considering precautionary action against flooding, evidence is mixed and this may be due to different types of behaviour of interest.

The perception of threat from overheating is different from the case of flooding in terms of recency of extreme events, visibility and vulnerable populations. With the theoretical understanding that evaluation of threat and of adaptive capacity may influence the likelihood of intention to undertake precautionary action, and that these subjective evaluations are threat and action specific, there is a clear need to examine the determinants of actions to mitigate overheating in preparation for future events. To our knowledge, the current study is the first to apply PMT to precautionary behaviour of householders in this domain. The study examines determinants of precautionary behaviour aimed at mitigating the threat of overheating in homes. Further, all buildings are not equally susceptible, for example, flats can be at higher risk (PHE, 2015a). All households may not have the same freedom of action (cf tenant versus homeowner differences, Grothmann & Reusswig, 2006; Poussin et al., 2014). Finally, intention and action may vary with action type, and this has not yet been investigated in depth to our knowledge. The current research aimed to answer the following questions:

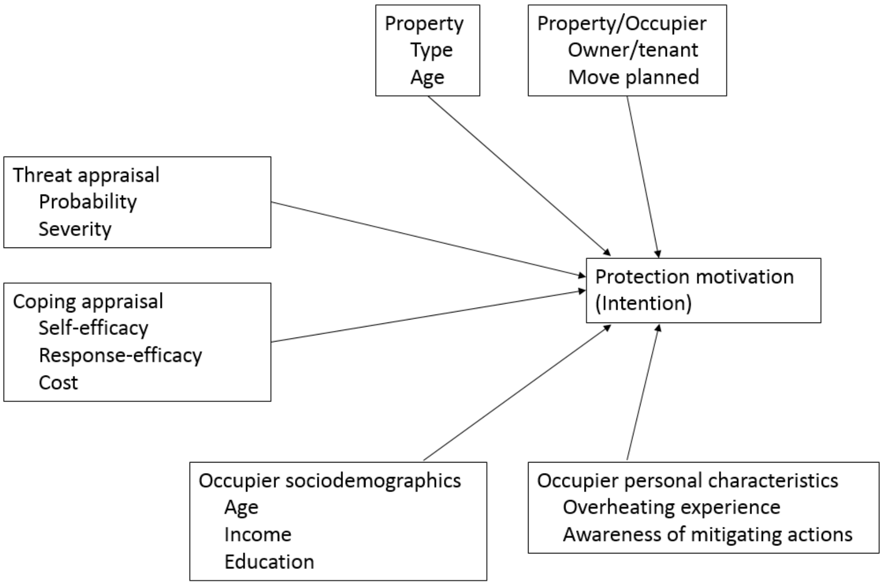
- What are the determinants of intention to take precautionary action against overheating?
- How do these differ between
    - Homeowners and tenants?
    - Occupants of flats and houses?
    - Different types of action?

METHOD

Selecting the south and midlands of England as more threatened by increasing temperatures, an online survey was conducted in September 2016, using an established market research organisation. A total of 1007 completed questionnaires were collected. Rather than retrospectively assessing response rate, representativeness was achieved through completion of quotas mirroring national ratios for key criteria: criteria for UK national representativeness were set and met for gender, age, home owner versus tenant and house type.

Four types of questions were asked, summarised in Fig. 1. Characteristics of the property and occupier included age of home, house type (see Table 1), and owned or rented and whether the householder was planning to move home. Sociodemographics included age, personal income and level of education. Proposed predictor variables were measured as follows. Measurement of threat appraisal was based on Poussin et al. (2014) with two items measuring threat risk and two item measuring threat severity. Cronbach alpha was .89, indicating a reliable scale. Based on national guidelines for reducing overheating in homes (DECC, 2015; NHBC, 2012), nine actions were selected and grouped as insulation (walls, roof), ventilation (including night ventilation), shutters/awnings, pale exterior and planting (trees, grass, water features near the external walls). Coping appraisal for each of the five action groups 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). Respondents were asked whether they had experienced overheating in their current home (scale of 1 to 6). Awareness of the recommended actions to mitigate overheating was measured on a scale of 0 to 12 (nine recommended actions and three exacerbating items). Finally, the dependent variable in the analysis was ‘intention’: participants were asked if they intended to take each action in the next three years. The responses were aggregated by action groups and summed to provide an overall score of intention. Of the responses on intention, 70% were 0 indicating no intention, and the aggregated measure was converted to a dichotomous variable of zero and non-zero.

Fig. 1 Model of determinants of intention to undertake mitigating action



FINDINGS

Table 1 summarises participant and property characteristics (n = 1007) and Table 2 presents descriptive statistics for the key variables.

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)	Less than £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%

Two thirds of the sample had experienced overheating on at least a few occasions. Perception of threat from overheating was moderate to low (range 1 - 6, mean 2.71, std. dev. 1.21) whereas coping appraisal was slightly higher but still moderate (range 1 - 6, mean 3.51, std.dev. 1.06). Awareness of mitigating actions was moderately low (range 0 - 12, mean 4.91, std. dev. 2.92) and intention to undertake some or all of the nine recommendations to mitigate overheating was very low (range 0 - 9, mean .84, std. dev. 1.72).

Logistic regression analyses were run for intention, conducted sequentially in the order: property and occupier characteristics, sociodemographics, personal characteristics (experience of overheating, awareness of recommended actions) with threat and coping appraisal as the final step. Table 2 presents the significant findings for owners and tenants; and for house and flat dwellers.

Table 2 Regression of Intention for Owners and Tenants, and House and Flat Dwellers

	Intention B (Unstandardised coefficient)			
	Owners N = 600	Tenants N = 239	House Dwellers N = 666	Flat Dwellers N = 191
Property type	-.22*	-	-.26*	X
Participant age	-.04***	-.04***	-.03***	-.06***
Awareness of mitigating actions	-	-	.07†	-
Threat appraisal	.45***	.36*	.51***	-
Coping appraisal	.69***	.89***	.61***	1.25***
Cox and Snell R2	.28	.27	.23	.43
Nagelkerke R2	.39	.37	.32	.57

*Notes: Only significant coefficients presented. - non-significant; X not included in analysis. *** p<.001; ** p <.01; * p<.05; † p < .1. Larger values of Cox and Snell R2, Nagelkerke R2 indicate higher levels of variance explained by the model.*

In the sequential regression, before threat and coping appraisals were added, overheating experience was significant for owners ($B = .22$, $p < .05$) and for house dwellers ($B = .19$, $p < .05$), and awareness of mitigating actions was significant for house dwellers (B = .09, $p < .05$), remaining marginally significant when threat and coping appraisal were included, as shown in Table 2.

For both owners and tenants, threat and coping appraisal were the primary determinants of intention in line with PMT. Age also contributed a small amount of variance and, interestingly, was negatively related to intention, 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 suggests that intention was more likely for occupiers of terraced properties and semi-detached than detached. A similar pattern held for the sample split into house and flat dwellers: coping appraisal was the strongest factor followed by threat appraisal, except for flat dwellers where threat appraisal became non-significant, with significant difference between the coefficients for threat and coping appraisal (z = 3.37).

Regressions were additionally conducted by action type (see Table 3).

Table 3 Regression of Intention for Action Types

	Insulation	Ventilation	Shutters/ Awnings	Plants	Pale exterior
N	348	332	781	580	559
Property age (newness)	-	-	.08*	-	-
Age	-.05***	-.05***	-.03***	-.03***	-.03***
Education	-	.23*	-	-	-
Awareness of specific mitigating action	.42*	-	-	.61**	-
Threat appraisal	.26*	.33*	.83***	.44***	.67***
Coping appraisal	.49***	.49**	.62***	.9***	.53**
Cox and Snell R2	.24	.26	.23	.26	.2
Nagelkerke R2	.32	.35	.39	.38	.34

Notes: As Table 2

Coping and threat appraisal contributed to intention to undertake all five action types. Age made a consistent small, negative contribution to all actions. To ensure that this negative relationship was not an artefact of older householders having already completed actions and therefore indicating no future intention, regressions were re-run for each of the nine actions, excluding respondents who indicated that they had already carried out the action: the pattern of results remained the same. For insulation and planting, awareness that these are mitigating actions was positively related to intention. The occupiers of newer properties were slightly more likely to intend to install shutters or awnings. Before threat and coping appraisals were included in the regression, overheating experience was significantly positively related to intention regarding shutters, planting and a pale exterior, but not insulation or ventilation.

DISCUSSION

The findings from this large-scale survey show that perception of threat and awareness of mitigating actions are moderate to low, and that measured intention to undertake precautionary action to mitigate the effects of weather-related overheating is very low. Indeed it is possible that actual intention may be even lower than measured, as some participants may never have considered precautionary action until prompted by the research. This would indicate that the occupants of English domestic building stock are unprepared for a warming climate.

The PMT variables of threat and coping appraisal were the strongest predictors of intention to undertake precautionary action, over and above property characteristics and sociodemographic variables. However, for flat dwellers, coping appraisal alone was statistically significant as had been found for householders in general in studies on flooding (Poussin et al. 2014). This suggests that although recognition of threat is a factor, perception of one's capacity to take action and of the anticipated effectiveness and convenience of the action are more important determinants of mitigating behaviour. This is particularly the case for flat dwellers who may face more constraints on building changes than house dwellers.

When it came to specific actions, 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, 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.

The significant and negative (albeit small) relationship of age to intention to take precautionary action is of concern, indicating that older residents are less likely to plan changes to their home to cope with overheating. Given the vulnerability of the elderly to the adverse effects of overheating, a policy focus on older householder is warranted.

In the overall analyses, awareness was marginally significant for house dwellers. The findings by action type showed that awareness of specific actions for mitigation raised intention to carry out changes: this held for insulation and planting but not for ventilation, shutters or a pale exterior. The implication was that, while knowledge and awareness may be important to encourage some actions, they were not strong determinants for others. This aligns with earlier findings on flooding, that while awareness is a factor, intention to act depends on perception of probability and consequences (Lamond & Proverbs 2008).

Interestingly, we did not find a relationship between income and intention to undertake actions to protect against overheating, either in the overall analyses or examining intention to undertake specific actions. This suggests that financial constraints may not be a primary barrier to installing mitigating measures, echoing Harries' (2012) finding for flooding of no correlation between financial factors and action. The absence of a strong relationship between income and action or intention provides evidence for non-financial motivations which offer scope for ways beyond pecuniary incentives to encourage further precautionary action.

CONCLUSION

Householders in southern England are ill-prepared for the predicted increase in summer temperatures and heatwaves, with very low intention to undertake building changes to mitigate the risk. However, the application of PMT suggests guidelines for policy initiatives to address the challenge. For house dwellers, greater awareness of the increasing risk of overheating and the severity of impact of rising temperatures may encourage greater intention to act. Awareness alone is insufficient however. More importantly, for all householders, initiatives to enhance coping appraisal are likely to foster increased intention to implement mitigating actions. Enhancement of coping appraisal could include providing information on the effectiveness of recommended actions to enhance response efficacy. Campaigns to raise awareness of specific actions such as increased insulation and planting near the external walls may also be successful as the findings showed that intention to act was related to such awareness. Targeting older citizens appears particularly important as the findings imply lower intention to act in older age groups. With potentially greater constraints on their scope of action, a focus on flat dwellers should emphasise what can be done, to strengthen self-efficacy. Combined with knowledge of recommended actions, it could be possible for flat dwellers collectively to pursue the installation of awnings to all glazing on a southern façade, for example.

Finally, in recognition of somewhat different factors influencing different types of building changes, advice on mitigating actions by housing type, and particularly for flats, could raise both awareness and coping appraisal leading to greater action by householders.

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