Householders as actors for urban resilience: what influences the intentions of English householders to take precautionary action against overheating?

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Abstract
Many regions globally, including temperate zones, are exposed to increasing temperatures and more frequent heatwaves as global warming continues. As part of urban resilience, there is much that householders can do to minimise the risk of overheating in their homes. Previous research on flooding has applied Protection Motivation Theory to examine determinants of householder engagement with precautionary action. 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, the effectiveness of the changes and convenience are stronger factors, particularly for flat dwellers. The study shows that, in addition to climate change predictions and evidence in building science, knowledge of behavioural determinants is essential for policy aimed at engaging householders as actors for urban resilience to increasing temperatures.

Keywords: overheating, resilience, protection motivation theory

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 (Bureau of Meteorology, 2017) but more temperate zones including the UK and mainland Europe have also been exposed to hotter weather. Increasing urbanisation exacerbates the risks. Although urban heat island (UHI) effects tend to be lower in (sub)tropical regions than in temperate zones (Roth, 2007), growing rates of urbanisation in East Africa, the Middle East and the Indian subcontinent are argued to lead to higher UHI intensity (McCarthy, Best, & Betts, 2010).

The risk to public health from higher temperatures was evidenced by the August 2003 heatwave in Europe which led to between 22,000 and 45,000 excess deaths (Patz, Campbell-Lendrum, Holloway, & Foley, 2005). Correlation between increased temperature and excess mortality has been established, with safe upper bounds ranging from 16.5˚C in the Netherlands, to 19˚C in London (Hajat, Kovats, Atkinson, & Haines, 2002) to 29˚C in Taiwan (Patz et al., 2005), demonstrating an effect relative to mean temperatures. 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 event, 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. Evidence from South Africa demonstrated that housing type impacts on temperature-related mortality (Scovronick & Armstrong, 2012). Thus the resilience of the building stock to overheating has a major role to play in protecting occupants from excessive heat (Coley & Kershaw, 2010). Although the design of new homes is critical to improving protection from higher temperatures, in most regions, the majority of the population resides in, and moves between, existing dwellings. Most retrofit is cheaper and more convenient than new build so examining changes to existing housing stock to mitigate overheating is at least as important as considering new homes. The householder can be a critical gatekeeper for changes to current building stock, determining whether or not adaptation will be conducted on an existing home.

The UK has a particularly acute problem with old housing stock, with 87% of the dwellings that will be in use in 2050 already built (Boardman, 2007). The current study focuses on the UK context, and the south of England in particular. Regional climate projections, despite their necessary uncertainty (Ziervogel et al., 2014), offer potential for assessing vulnerability to risk and preparedness. For the UK, under a high emissions scenario, average summer temperature increases of between 2.8 and 3.1˚C (central estimates) are estimated for midland and southern England by the 2050s, increasing to between 4.4 and 4.9˚C in the 2080s, compared to the 1961-1990 average (UKCP, 2009).

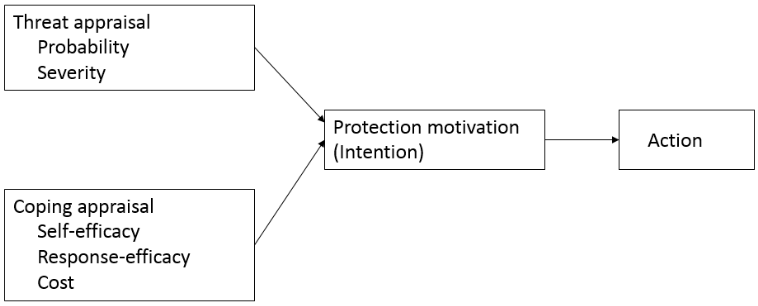
Within the construction literature, the issues around overheating in current stock have received growing attention. In a 2007 study of 252 homes across England, Beizaee et al. (2013) found overheating across all housing types during the coolest summer since 1993, and a 2009 study of 268 dwellings in Leicester, a city in central England, measured overheating in almost 90% of bedrooms (Lomas & Kane, 2013). During two relatively cool summers, measuring temperatures in social housing stock that was not at particular risk of heat gain, 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 argued that the European adaptive model of overheating underestimated occupant discomfort and that existing domestic building stock may lack passive mitigation measures, finding that only 6% had overhangs, awnings, shutters or vegetation to provide shade. 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 19^{th} 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. Evidence suggests that few households have air conditioning - the study of Mavrogianni et al (2017) found air conditioning in only 4% of homes in their sample. Increased energy demand caused by greater prevalence of household air-conditioning would exacerbate greenhouse gas emissions, emphasising the importance of effective and widespread passive approaches to minimising overheating. Thus the literature has shown evidence of overheating already occurring across the UK, albeit in small scale studies. This is consistent with evidence of vulnerability to heat in cooler temperate regions (Patz et al. 2005).

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). However, knowledge of mitigating actions does necessarily translate into behaviour, as studies of the 'information deficit model' have demonstrated (e.g. Murtagh, Gatersleben, & Uzzell, 2014). Knowledge of human behaviour is also critical and it is this that the research below investigates.

. Although a number of studies have examined the measures that can be taken on existing dwellings, the few studies that have considered occupant behaviour have been limited to reactive responses to high temperatures. Coley et al. (2012) compared hard (building modifications such as external shutters) versus soft measures (behavioural responses such as opening windows) arguing that combinations of behavioural adaptation could be as effective as changes in building design. Mavrogianni and colleagues (2017) also examined aspects of behaviour in response to overheating. However, in common with most other studies to date, they failed to recognise the behavioural aspects of installing or commissioning retrofit measures to minimise overheating. 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 both precautionary and reactive behaviours is better understood, through studies in the European context (Bubeck, Botzen, Kreibich, & Aerts, 2013; Grothmann & Reusswig, 2006; Poussin, Botzen, & Aerts, 2014). Precautionary behaviour, taken in advance of a flood, can provide potentially significant reduction in damage when compared to reactive behaviour, taken during a flooding event (Grothmann & Reusswig 2006). Precautionary behaviour taken in advances of high temperatures has important social benefit, protecting not just the decision-maker but family, tenants and visitors. The warning period for heatwaves is very short, and most deaths occur within the first two days, so preparedness can save lives (PHE, 2015a).

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 in England 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). A theoretical framework found to be particularly useful in structuring the behavioural determinants of precautionary action is that of Protection Motivation Theory (PMT). Applied widely in health and 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). 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 (see Fig. 1). 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 the 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.

Fig. 1 Protection Motivation Theory (simplified)



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, income and age were not related to intention. Previous experience of flooding, and both threat and coping appraisal influenced the level of intention, although the contribution of threat appraisal was small. 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. More recently, Bubeck et al. (2013) looked at propensity to undertake structural changes to the home to increase protection against flooding: they found that self-efficacy but not response-efficacy related to intention. Previous experience and level of income also showed a positive relationship with intention. In a French study, Poussin et al. (2014) investigated risk attitudes and social factors alongside PMT. They found that threat appraisal was not related to mitigation measures. Older households had more measures completed and owners rather than tenants had taken more action. 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?

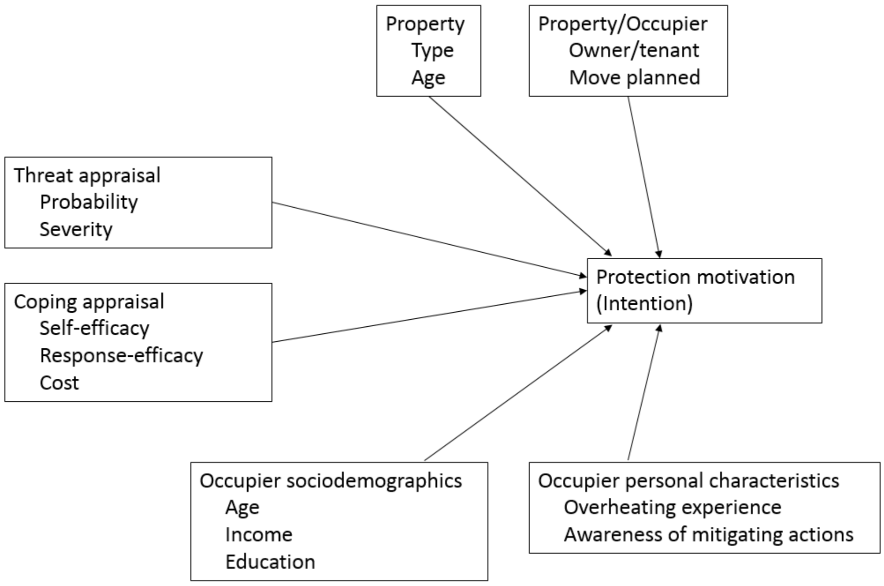
- Occupants of flats and houses?
- Different types of action?

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. The 20-minute questionnaire had been qualitatively piloted with a small sample and quantitatively piloted with a sample of 100 participants beforehand which resulted in minor clarifications in wording. 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. 2. Characteristics of the property and occupier included age of home, house type (see Table 1), and owned or rented. Sociodemographics included age, gender and personal income. 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). 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. 2 Model of determinants of intention to undertake mitigating action



Findings

Table 1 summarise 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	Purpose-built flat	18.8%
	Flat conversion	6.1%
	Mid-terrace	26.8%
	Semi-detached	27.9%
	Detached	18.9%
	Other	1.5%

Table 2 Key variables: descriptive statistics

Variable	Range	Mean	Std. Dev.
Threat Appraisal	1 – 6	2.71	1.21
Coping Appraisal	1 – 6	3.51	1.06

Overheating experience	1 – 6	2.6	1.2
Awareness of Precautionary Actions	0 – 12	4.91	2.92
Intention	0 – 9	.84	1.72

While there was some perception of threat from overheating, the level was moderate to low whereas coping appraisal was slightly higher but still moderate. Two thirds of the sample had experienced overheating on at least a few occasions. Awareness of mitigating actions was moderately low and intention to undertake some or all of the nine recommendations to mitigate overheating was very low.

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 3 presents the significant findings for owners and tenants; and for house and flat dwellers.

Table 3 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 R^2	.28	.27	.23	.43
Nagelkerke R^2	.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 R^2, Nagelkerke R^2 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 at $p < .05$ for house dwellers (B = .09), remaining marginally significant when threat and coping appraisal are included, as shown in Table 3.

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 is more likely for owners of terraced properties and semi-detached than detached. A similar pattern held for the sample split into house and flat dwellers: coping appraisal was 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 4).

Table 4 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 R^2	.24	.26	.23	.26	.2
Nagelkerke R^2	.32	.35	.39	.38	.34

Notes: As Table 3

Coping and threat appraisal contributed to intention to undertake all five action types. Age made a consistently 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 with English householders show 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 suggest that the occupants of English domestic building stock are unprepared for a warming climate, despite a moderate level of recognition of the threat of overheating.

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 in studies on flooding (Grothmann & Reusswig, 2006; 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 appears necessary.

In the overall analyses, awareness was marginally significant for house dwellers. The findings by action type showed that awareness of actions for mitigation raises 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, it is not a strong determinant for others.

Previous experience of overheating showed a weaker relationship with intention than is assumed in government policy. Considering intention in general, previous experience made statistically significant contribution before threat and coping appraisals were included. This was also the case for the specific actions relating to shutters, planting and a pale exterior. While this is promising in its implication that householders experiencing overheating may be more motivated to intend to take particular actions, these actions may be limited and were the less costly and inconvenient among the recommendations. Thus policy cannot rely on experience of overheating alone to lead to leading to intention to take 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, particularly for the elderly, ill and very young, may encourage greater intention to act. More importantly however, 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, and addressing barriers including convenience. 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 contribution to intention to act was related to such awareness. Targeting older citizens appears particularly important as the findings imply less 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.

The generalisability of the findings is somewhat difficult to gauge. On the one hand, there is argument that intention to take mitigating action is context-specific (IPCC, 2014); on the other, the psychological model of PMT may describe universal tendencies and the framework has been usefully applied with Vietnamese farmers (Dang et al., 2014). More research is needed to examine PMT across regions. A particular question is whether there are differences in intention or action between those who live in planned housing and the 30-50% of urban dwellers in Africa (Dodman et al., 2015) who live in informal settlements. The current study suggests that knowledge and awareness of specific mitigating actions, combined with action to enhance people's perception of their capacity to take action and of effectiveness of the action, could increase the contribution of householders to urban resilience in the face of rising temperatures.

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