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Abstract

This Working Paper introduces the concept of 'carbon capability', provides initial empirical evidence of levels of carbon capability amongst the UK public, and suggests ways in which carbon capability might be promoted. 'Carbon capability' captures the *contextual meanings* associated with carbon, whilst also referring to an individual's *ability* and *motivation* to reduce emissions within the broader institutional and social context. We identify three dimensions of carbon capability: (1) cognitive (knowledge, skills, motivations, etc.), (2) individual behaviour (e.g., energy conservation) and (3) broader engagement with systems of provision and governance (e.g., lobbying, voting, protesting). In this sense, carbon capability contrasts with the narrower, more individualistic concept of carbon literacy. Carbon capability is an analogue to financial capability applied to human-caused climate change, and involves managing budgets, planning ahead, staying informed, and making choices. We also draw on the literature pertaining to public understanding of science, and argue that carbon capability implies a *situated* understanding of carbon. Results of a postal survey (N=550) of residents in Norfolk and Hampshire, UK, are presented, which suggest low levels of carbon capability amongst the public. In terms of the three dimensions of carbon capability: (1) People talk about carbon in abstract terms, others are blamed for climate change, and carbon emissions are rarely linked to personal actions and lifestyles choices. Misperceptions also exist about the relative contribution of activities to causing climate change; and very few people have used a carbon calculator. (2) Few are taking significant steps to lead a low-carbon lifestyle. This is despite a majority claiming to be interested in actions individuals can take to address climate change. (3) Importantly, few citizens consider political action (e.g. writing to their MP) a valid response to tackling climate change. Together this indicates that individuals would benefit from *education to promote understanding and skills* to manage their carbon emissions, as well as structural measures to *enable and encourage* carbon capability. Two strands of ongoing work to promote carbon capability, relating to 'materialising' and 'budgeting' carbon emissions, are described.

Introduction

The UK government's recent Climate Change Bill set an ambitious target of an 80% reduction in greenhouse gas emissions by 2050, although some commentators suggest cuts of up to 90% are required to avoid the most dangerous impacts of climate change (e.g., Bows *et al.* 2006). This level of response to climate change has profound implications for individual choices and behaviour, as well as for the social structures within which these take place. With over one third of many developed nations' carbon emissions coming from private travel and domestic energy use (DEFRA 2007a), individuals clearly have a key role to play in any potential shift towards low-carbon society. An individual can act in several roles towards promoting a low-carbon society, including as a low-carbon employee (through the knock-on effects of individual engagement with climate change on businesses and government), as a low-carbon citizen (e.g., voting for a 'green' policy), as a low-carbon consumer (e.g., buying energy efficient appliances), as a member of a campaigning group to promote a low-carbon society (e.g., Friends of the Earth), and as a combination of these (e.g. working with others to construct low-carbon systems of provision in society, such as local food or community renewable energy projects).

At the moment, however, public engagement with climate change in the UK is limited and energy demand for both domestic uses and transport is rising (DEFRA 2006). Although a large majority of the public now recognises terms such as 'climate change', understanding and emotional buy-in are far lower (DEFRA 2007b; Lorenzoni *et al.* 2007). Behavioural responses to climate change are even more limited; few people are prepared to take actions beyond recycling or domestic energy conservation (Whitmarsh 2009b). In part the problem is one of understanding: there is a general lack of knowledge about the emissions impacts of different actions, including which activities produce the most emissions. However, there are clearly broader structural constraints and disincentives to adopting a low-carbon lifestyle, which reduces individuals' motivation and ability to change their behaviour. From both individual and broader structural perspectives, the UK public appears not to be 'carbon capable'.

In this paper, we first introduce the concept of 'carbon capability', before examining the carbon capability of the UK public. Later, we suggest ways in which carbon capability might be promoted.

Why 'carbon capability'?

The challenge is therefore to identify the range of skills required for the public to engage in and support societal efforts to reduce carbon emissions. We term this 'carbon capability' as an analogue of financial capability. Carbon capability implies having a good grasp of the causes and consequences of carbon emissions, the role individuals play in producing them, the scope for adaptation and reductions in one's personal life and what is possible through collective action, how to manage a carbon budget, where to get help and information, and so on. We define 'carbon capability' as follows (adapted from Seyfang et al. 2008):

"The ability to make informed judgements and to take effective decisions regarding the use and management of carbon, through both individual behaviour change and collective action".

Carbon capability captures the *contextual meanings* associated with carbon, whilst also referring to an individual's *ability* and *motivation* to reduce emissions within the broader institutional and social context. As such we identify three core dimensions of carbon capability:

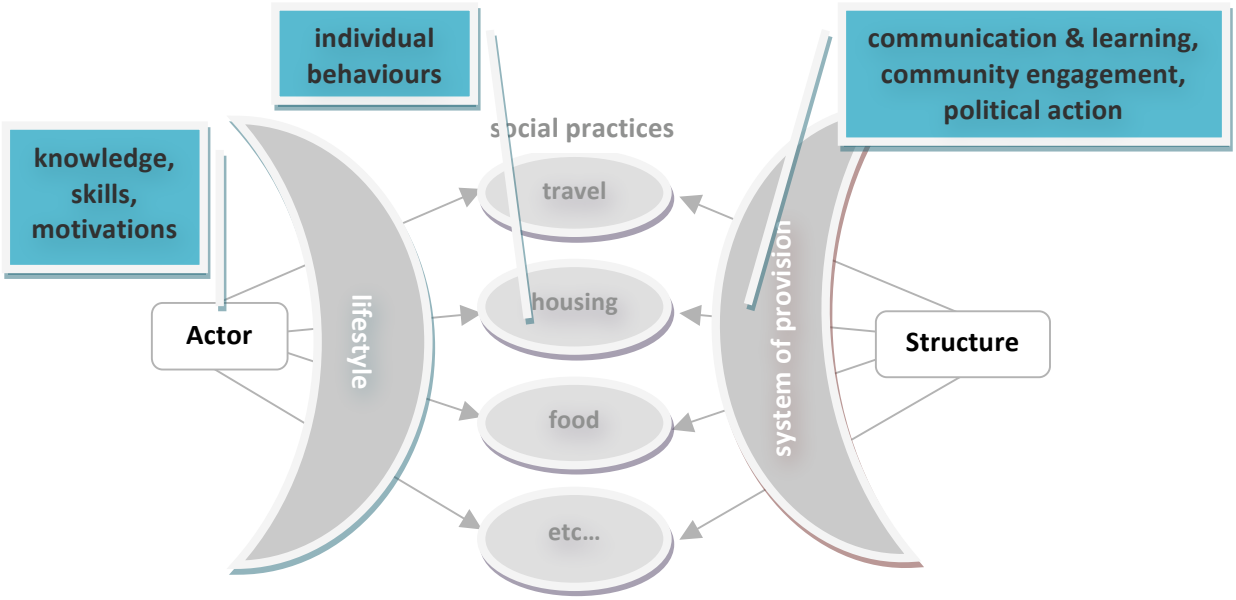
(1) cognitive/evaluative (knowledge, skills, motivations, judgements, etc.),
(2) individual behaviour (e.g., energy conservation), and
(3) broader engagement with systems of provision and governance (e.g., lobbying, voting, protesting, directly creating alternatives).

In contrast to the concept of carbon literacy, then, carbon capability is not defined in a narrow individualistic sense of solely knowledge, skills and motivations (although these are important components); rather, if people are genuinely carbon capable they will understand the limits of individual action and where these encounter wider societal institutions and infrastructure, or systems of provision,

and so prompt the need for collective action and other governance solutions. Also, a genuinely carbon capable individual appreciates that there are barriers in current systems of provision which limit the ability of an individual to act, and that much consumption (and hence carbon emissions) is inconspicuous, habitual and routine, rather than the result of conscious decision-making (van Vliet *et al.* 2005). Consistent with the literature on social practices and structuration (e.g., Giddens 1984; Spaargaren 2003), we see individual cognitive decisions about consumption, within individuals' brains, as mediated through socially-shaped lifestyle choices, resulting in sets of practices which are in turn delimited by social systems of provision and the rules and resources of macro-level structures. That is, individual choices both shape and are shaped by wider social structures.

Figure 1 depicts these multiple aspects of carbon capability, which comprise cognitive, behavioural and structural dimensions (i.e., knowledge, skills, motivations, individual behaviours, communication and learning, community engagement and political actions). Many studies show people face considerable obstacles to low-carbon lifestyles. These range from insufficient knowledge about effective actions, through perceived social inaction and the 'free rider effect', to inadequate or unattractive alternatives to energy intensive activities such as driving (Lorenzoni *et al.* 2007). Carbon capable actors will be aware of, and seek to influence through collective and political mechanisms, the right-hand side of the diagram (i.e., policies, systems of provision, infrastructure, etc.) in order to overcome the structural barriers to low-carbon lifestyles and societies.

Figure 1. Individual and structural aspects of carbon capability (mapped onto social practices model of sustainable consumption; Spaargaren, 2003)



Carbon capability is an analogue to financial capability applied to human-caused climate change (Seyfang *et al.* 2007). Financial capability can be defined as 'the ability to make informed judgements and to take effective decisions regarding the use and management of money' (National Foundation for Educational Research, quoted in AdFLAG, 2000 para 4.2). A recent study established indicators of financial capability and conducted a UK baseline survey. It covered four key areas of attitudes and practice: managing money, planning ahead, choosing products and staying informed (Atkinson et al, 2007). It found that although most people in the UK are competent at 'making ends meet,' almost half are unable or unwilling to plan for the future and there is 'wide variation' in the degree to which people stay informed about things which are likely to affect their finances (Atkinson et al, 2007, p. 33). Translating these concepts and techniques into carbon management, 'carbon capability' therefore refers to technical, material and social aspects of knowledge, understanding and practice.

Indeed, there are the same driving forces, and comparable consumer issues with both types of capability, which require a holistic approach to learning about sustainable consumption in both financial and resource terms. Increasing consumption (linked to rising levels of personal credit and subsequent debt) is a major barrier to low-carbon living (Cohen, 2007). Excessive material consumption in developed countries is widely acknowledged as a principal cause of unsustainable development, while at the same time driving developed nations' economic growth (Simms 2006). Given the state's reliance upon this economic development model, government's response has been to emphasise individuals' responsibility to successfully navigate financial markets, and to promote 'financial capability' (implying both actions and knowledge) as a basic skill required for financial inclusion. This implies a deregulated economy governed not by government, but rather by individual producers and consumers' self-restraint (Binkley 2006). If government is relying on individuals to manage their behaviour in this way, then people need to be skilled, motivated and capable of doing so.

Managing material consumption and managing carbon are also similar in the way that they have intangible aspects. The sheer intangibility of credit finance compared with cash has also contributed to its widespread acceptance (although recently cash has made a comeback, as a visible way of controlling spending, BRC, 2008), bringing attendant social problems (Cohen, 2007). Similarly, the negative impacts of increasing carbon emissions are easily ignored because of their intangibility. One of the challenges therefore for promoting carbon capability is to increase the visibility of carbon and re-materialise energy use in day-to-day activities and choices. Carbon capability is about transforming understandings of carbon from an inevitable (invisible and overlooked) waste product of modern lifestyles, to viewing it as a potent contributor to the atmospheric system, a substance to be carefully managed.

From the perspective of individual learning, we draw on the literature pertaining to public understanding of science, and argue that carbon capability implies a *situated* understanding of carbon. In recent years, there has been a shift away from seeing scientific literacy as defined by knowledge of abstract scientific 'facts', towards investigating the contextual meanings of science applied in everyday life. This broader, more socially-embedded definition of scientific literacy includes an understanding of the dynamic process of scientific knowledge construction (rather than science as a codified and stable body of knowledge) and of scientific uncertainty, as well as how day-to-day decisions can be informed by scientific concepts and perspectives (e.g., Claeson *et al.* 1996; Whitmarsh *et al.* 2005). Scientific knowledge (for example, 'facts' about greenhouse gas emissions) is interpreted in diverse ways by different individuals - according to their prior beliefs, knowledge, emotions, and situational factors. Thus, information provision is inadequate to encourage lifestyle change or promote public acceptance of policy. The so-called 'information deficit model', which assumes that the public are 'empty vessels' waiting to be filled with information which will propel them into rational action, has implicitly underpinned much public policy but is widely criticised as inappropriate and ineffective (e.g., Irwin and Wynne 1996). This is not to say that education is not *part of* an effective public engagement and social change agenda; but rather that it should be based on an understanding of individuals' existing knowledge, their concerns and abilities, and broader institutional relationships, and should be accompanied by efforts to provide greater opportunities for public participation in democratic policy-making.

Similarly, we argue that there is a need to avoid a 'deficit model' in relation to carbon literacy, and to explore situated meanings of carbon and energy in everyday life and decisions, within the broader context of structural opportunities for and barriers to low-carbon lifestyles. Further, given the complexity and uncertainty (both informational and moral) associated with climate change (see Hulme 2009), carbon capability implies an ability to evaluate the reliability (bias, agenda, uncertainty, etc.) of different information sources about how to achieve a carbon capable lifestyle. For example, media representation of climate change as controversial and uncertain may be more reflective of journalistic norms (of balance, dramatisation, politicisation, etc.) than of schism within mainstream scientific opinion (Hargreaves et al. 2003; Zehr 2000). Currently, however, much of the public is poorly equipped to deal with scientific uncertainty and tend to be confused by expert disagreement; for example, most people

agree that 'there is so much conflicting information about science that it is difficult to know what to believe' (Poortinga and Pidgeon 2003).

Drawing on these literatures on financial capability, scientific literacy, and sustainable consumption and behaviour, leads us to consider carbon capability as implying a critical understanding of:

- the causes and consequences of carbon emissions;
- the role individuals - and particular activities - play in producing carbon emissions;
- the scope for (and benefits of) adopting a low-carbon lifestyle;
- what is possible through individual action;
- what carbon-reduction activities require collective action and infrastructural change;
- managing a carbon budget;
- information sources - and the reliability (bias, agenda, uncertainty, etc.) of different information sources - for achieving a carbon capable lifestyle; and
- the broader structural limits to and opportunities for sustainable consumption.

In light of these multiple dimensions, and considering the ways in which energy and carbon are embedded in all our other daily social practices, carbon capability may be seen as a pre-requisite for other aspects of sustainability literacy and capability, for example around well-being, community, food, transport, housing, social justice, climate adaptation, and governance.

How carbon capable is the UK public?

Evidence of this cultural shift towards promoting carbon capability includes the development of 'carbon calculators' and discussion about managing 'carbon footprints' (e.g., Siegel 2007). Yet we know little about how well these new tools and concepts are understood and used by individuals, households, or communities. Research on public attitudes to climate change shows that most people think of the issue as being caused by, and affecting, other people (e.g., Lorenzoni and Pidgeon 2006; Whitmarsh 2009a). Typically, industry or other countries are blamed for causing climate change; and impacts are seen as befalling other countries and future generations (Whitmarsh, 2009a)[1]. In our research, we are interested to find out what this apparent lack of engagement with climate change means for carbon capability amongst the UK public.

To investigate this, we carried out a postal survey in August-October 2008 in Norfolk and Hampshire, UK. Three thousand questionnaires were distributed to a random sample of residents, drawn from the electoral register, within nine wards (six in Norfolk, three in Hampshire) representing both urban and rural and diverse socio-demographic profiles. The eight-page questionnaire included both closed and open questions, and addressed knowledge, understanding, attitudes, values and behaviours, as well as demographic variables. Several of the measures used, including behavioural measures (see DEFRA 2008a), were adapted from previous studies. (In addition to questions about carbon capability, attitudes to climate change and carbon offsetting were also measured; some of these findings are shown in Appendix 2 and others are reported elsewhere, e.g., Whitmarsh 2008). Questionnaires were piloted and revised according to feedback from pilot respondents.

In total, we received 550 responses from the postal survey (representing a response rate of 18.3%). Participants in the postal survey were broadly demographically representative of the total population sampled (see Appendix 1), although somewhat more qualified (26% have a degree, slightly more than the national average of 20% according to 2001 census data). Quantitative data was analysed in SPSS; and qualitative data was coded thematically in NVivo. (The broad themes identified in Table 2 reflect our interest in divergence from scientific discourses about climate change and carbon, and the extent to

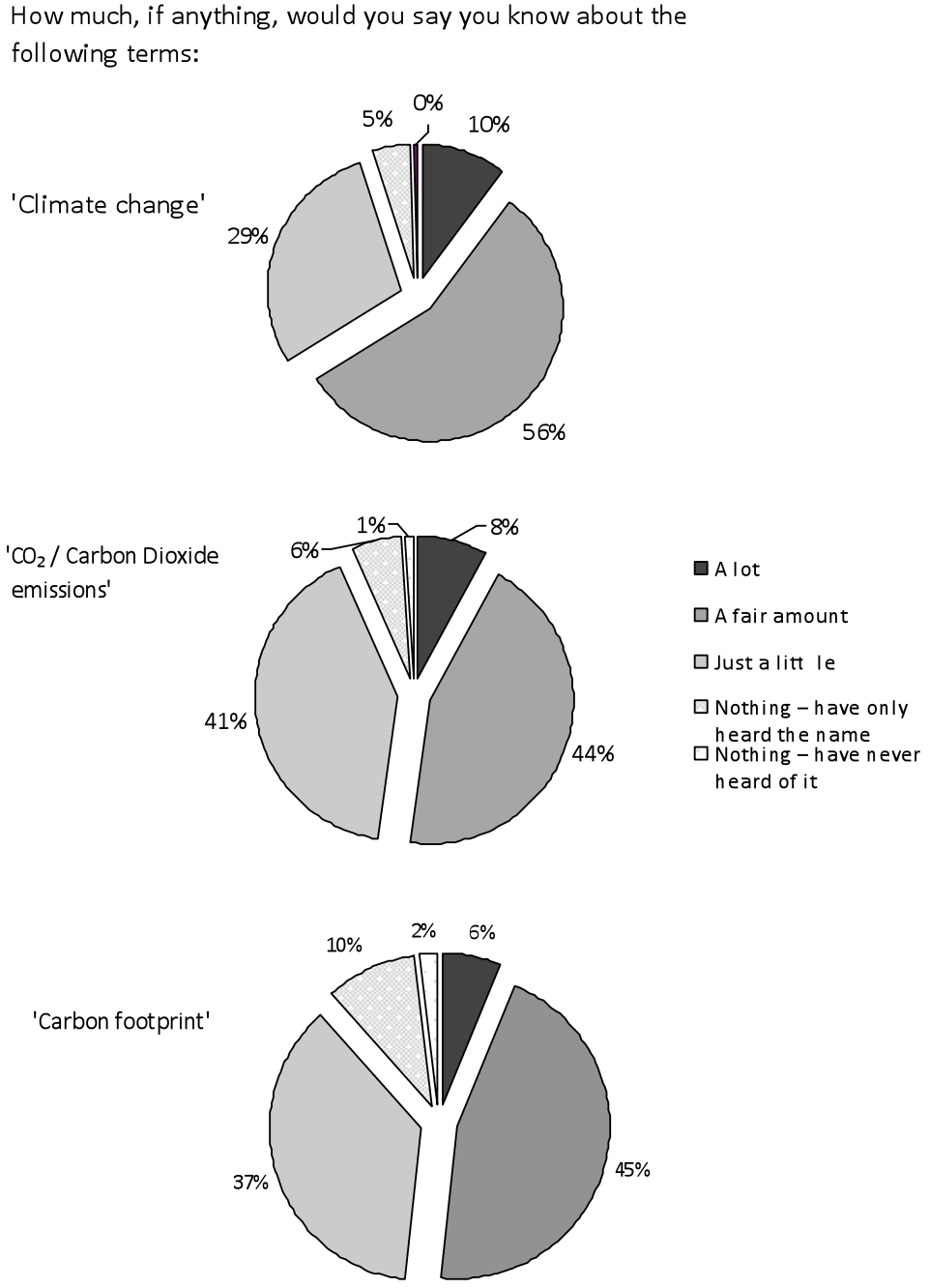
[1] Developed countries are responsible for the greatest proportion of global carbon emissions (Houghton 2004); and energy used in the home and for personal transport accounts for up to half the UK's total energy use (DTI 2002). Furthermore, while some of the worst impacts of climate change are likely to affect developing countries, developed countries will be (and are being) affected by more extreme weather events, rising sea levels, heat waves, flooding, and so on (Hulme et al. 2002; DoH 2001).

which individuals appropriate and relate to aspects of the issue). Survey findings relating to carbon capability are described here:

Knowledge about carbon and climate change

We found that awareness of key terms is fairly high, although knowledge about 'climate change' is somewhat higher than knowledge about 'carbon dioxide' or 'carbon footprints' (see Figure 2). Yet while most people have at least heard of carbon footprints, only 1 in 10 (90%) stated they have used a carbon calculator to work out their carbon footprint.

Figure 2. Knowledge about carbon and climate change

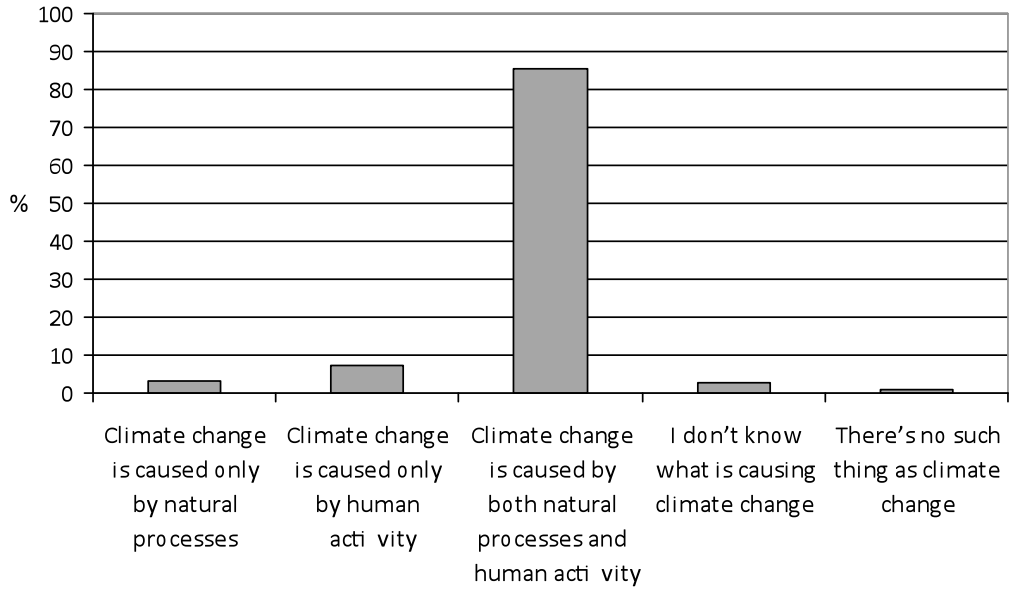


Understanding about the causes of climate change

While most people seem to accept that climate change is a product of both natural and human causes (Table 1), a sizeable minority continue to doubt whether human activities influence climate (Appendix 2). Further, there are important misperceptions about the relative contribution of different activities or

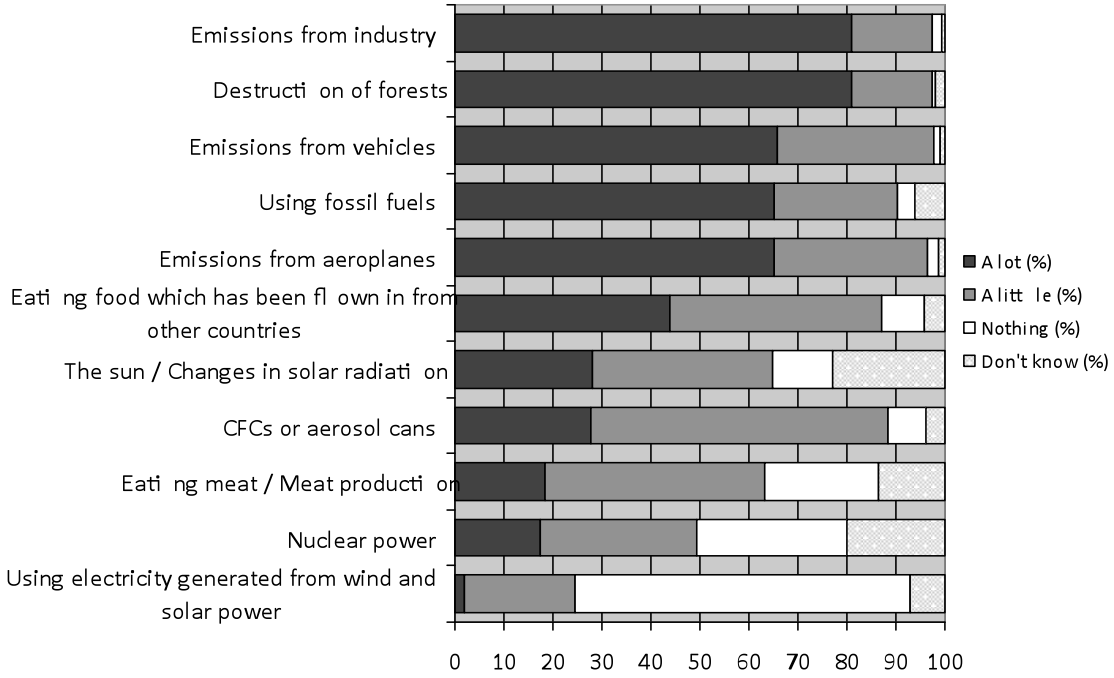
processes in causing climate change (Figure 2). In particular, there is an underestimation of the contribution of meat eating/production and an overestimation of the role of CFCs, and solar radiation. In general, people identify the causes of climate change with more 'distant' activities, namely industry and deforestation, rather than their own actions[2].

*Table 1. Human versus natural causes of climate change**



*Respondents were asked to select just one of the five statements shown in Table 1

Figure 2. Perceived contribution of different activities and processes to climate change



[2] It is worth noting a limitation with the measure we used here: we asked about the scale of contribution of different activities – i.e., 'a lot', a little', 'nothing' – but these are of course very broad response options and difficult to assess even by more expert groups. We suggest future research might focus instead on asking participants to *rank* the contributions of these activities to provide a better assessment of individuals' understanding.

Findings from this survey highlight the diverse meanings associated with the term 'carbon' (see Table 2). In order to prompt links between carbon and climate change, the survey asked 'When you hear statements such as "carbon emissions are increasing" or "the company is aiming to become carbon-neutral" what do you understand by the word "carbon"?' Although the most common response term (by 26.5% of respondents) was 'carbon dioxide' or 'CO2', many responses were less technical and suggested moral or cultural concepts. In particular, 'pollution' (8%) and environmental 'destruction' (4.9%) were fairly common responses – consistent with previous research on how the public conceive of climate change. Far fewer thought about carbon as natural, abundant and benign (e.g., the basis of life; cited by 4 people) than as an anthropogenic cause of climate change, harmful and toxic[3].

Responses also suggested a number of misperceptions exist in understanding about carbon emissions. For example, some indicated ozone depletion as caused by carbon emissions (a common misperception – see, e.g., Whitmarsh 2009a); others see carbon monoxide as a cause of climate change. Crucially, respondents used generic language and cited others' activities, indicating *little connection to personal choices or actions*.

Table 2. Situated meanings of 'carbon' (most popular; 10 or more references)

Category	**No. of references***	**Theme(s)**
Carbon dioxide / CO2	146	Technical language , cause of climate change
Emissions	89	Technical language , cause of climate change
Atmosphere	59	Technical language
Gaseous /a gas	50	Technical language
Burning/using fossil fuels	47	Technical language , cause of climate change
Pollution/pollutant	44	Non-technical language
Do not know anything/much	32	Uncertainty
Element/ chemical element	31	Technical language
Greenhouse gas	27	Technical language , cause of climate change
Damaging environment /destroying planet	27	Non-technical language , harmful
Vehicle emissions	23	Cause of climate change
Too much (e.g., emitted)	23	Non-technical language
Waste product / residue	22	
Fuel/energy consumption	21	Cause of climate change
Industrial emissions/activities	21	Cause of climate change
Uncertain response ('I think…', 'Not exactly sure, but…')	19	Uncertainty
Cause of global warming	17	Cause of climate change
Fossil fuels	17	Technical language
Carbon monoxide	16	*Misperception re. climate change*
Product of combustion/burning	15	
Poisons / toxic	14	Harmful
Harmful	13	Harmful
Cause of ozone depletion	12	*Misperception re. climate change*
Cause of climate change	11	Cause of climate change
Mitigation (general)	11	
Fumes / waste gas	10	Non-technical language
Coal	10	

*Total number of references is greater than the number of participants, as most participants' responses comprised several categories

[3] Again, we note a limitation with our measure: the wording of the question may have steered respondents to consider carbon as negative since we mention the concept of carbon neutrality.

Furthermore, uncertainty and lack of knowledge was a common theme in participants' understanding of carbon, consistent with respondents' attitudes to climate change (see Appendix 2). For example, 62% of respondents agreed 'I need more information to form a clear opinion about climate change' and 64% agreed 'It is difficult to know which products are better for the environment'. A sizeable minority evidently doubt that anthropogenic climate change is real and think expert opinion is divided on this; and most are sceptical about claims made in the media about climate change. When we compare these findings with a similar survey conducted in 2003 (Whitmarsh 209a), it appears that public uncertainty and scepticism about climate change has, in fact, *increased*.

Topics of information

The most common aspect of climate change or energy which participants indicated they are interested in (Table 3) is seasonal/weather change in the UK (73.2%). This is consistent with the conceptual association of climate (change) and weather noted in previous research (e.g., Whitmarsh 2009a). However, it is also likely that this is a relatively easy thing to monitor; in many other cases, seeking information requires more than simply looking out of the window! The next most common aspects which participants were interested in were: debates about the future of energy provision, availability of energy-efficient appliances, and actions individuals can take.

Table 3. Topics of information

Which, if any, of these things do you personally keep an eye on?	**%**
How the climate and seasons seem to be changing in the UK	73.2
Availability of more energy-efficient appliances for the home	61.3
Debates about the future of energy provision (e.g. nuclear power, renewables)	58.3
Actions I can take to reduce carbon emissions	57.5
New technologies to reduce carbon emissions	55.2
UK government policy on climate change	53.4
New scientific knowledge about climate change	40.7
Impacts of climate change on developing countries	40.3
International agreements on climate change	45.0
Which political parties have the strongest climate change policies	30.0
Which companies are doing the most to reduce carbon emissions	25.0
Indications of embedded carbon, e.g. carbon labels, 'by air' food labels	25.0
Other aspects of climate change or energy	8.9

Low-carbon actions taken

We also asked about whether respondents had taken actions to reduce their emissions. The results show that domestic energy conservation is relatively common, but changing travel and shopping habits are less popular (see Tables 4 and 5). For example, 67% claim they 'always' turn off lights they are not using, and 37% have installed home insulation products, whereas only 33% walk, cycle or take public transport for short journeys (i.e., trips of less than 3 miles) and 13% eat food which is organic, locally-grown or in season. Even fewer - 9% - avoid eating meat. Consistent with the widely-reported reluctance to change travel habits (e.g., Norton and Leaman 2004; Verplanken *et al.* 1998), most participants in our survey (62%) use a car at least 3 times per week; and 51% took at least one flight for social or leisure reasons in the past year.

Further, consistent with previous research (e.g., Lorenzoni *et al*. 2007), people are more willing to recycle (71% say they always do so) than to take any direct energy conservation actions. Least popular of all are political actions: over 90% have *never* written to their MP about an environmental issue, and the same proportion has never taken part in a protest about an environmental issue. It is worth pointing out that

political actions *about any issue* are relatively uncommon (Hansard, 2008), highlighting the general political disenfranchisement, distrust, and fatalism amongst the
British public noted elsewhere (e.g., Grove-White 1996).

Table 4. One-off pro-environmental actions

Please indicate the last time you took this action (if at all):	**In the last year (%)**	**1-3 years ago (%)**	**5 or more years ago (%)**	**Never (%)**
Bought a product to save water (e.g., water butt, water 'hippo', low-flush toilet)	17.4	20.9	19.2	42.5
Installed insulation products in your home	11.4	25.5	38.4	24.7
Installed a more efficient heating system	9.0	18.8	22.8	49.5
Bought a low-emission vehicle (e.g., hybrid, electric, biofuel, less than 1.4l engine)	5.3	7.9	5.9	80.9
Changed to a 'green' energy tariff for your home	4.7	5.3	3.9	86.1
Bought or built an energy-efficient home	2.2	3.5	6.1	88.2
Installed a renewable energy system (e.g., solar panels, wind turbine) in your home	1	2	0.8	96.2

Table 5. Regular pro-environmental actions

Please indicate how often you take each action:	**Always (%)**	**Often (%)**	**Occasionally (%)**	**Never (%)**
Recycle	70.7	23	5.1	1.1
Turn off lights you're not using	67.2	28.8	3.4	0.6
Turn off the tap while you brush your teeth	55.1	24.2	10.2	10.6
Drive economically (e.g., braking or accelerating gently)	36.2	40	12.6	11.3
Compost your kitchen waste	35.8	10.2	14.8	39.3
Walk, cycle or take public transport for short journeys (i.e., trips of less than 3 miles)	33.3	37	21.8	7.9
Reuse or repair items instead of throwing them away	31.7	39.6	25.1	3.7
Save water by taking shorter showers	30.2	28.6	22	19.3
Cut down on the amount you fly	23.8	17.6	23.2	35.4
Eat food which is organic, locally-grown or in season	12.6	50.3	28.6	8.6
Buy products with less packaging	11	41.9	37.8	9.3
Avoid eating meat	8.7	9.8	24.3	57.2
Share a car journey with someone else	8.3	22.4	44.6	24.8
Buy environmentally-friendly products	8.3	42.1	43.4	6.2
Use an alternative to travelling (e.g., shopping online)	6.1	24.6	30.5	38.8
Take part in a protest about an environmental issue	0.6	1	7.7	90.7
Write to your MP about an environmental issue	0.4	1.5	7.1	91

Table 6. Travel behaviours

a) How often do you personally use a car or van to travel, either as a driver or as a passenger? (%)	
6-7 days a week	29.7
3-5 days a week	31.8
1-2 days a week	21.4
Once or twice a month	5.7
Less often	5.5
Never	6.0

b) Did you take any flights in 2007 for leisure, holidays or visiting family or friends? (%)	
Yes	51.0
No	48.8
Don't know	0.2

Empirical results and the three dimensions of carbon capability

Cognitive: knowledge, skills and motivations
In sum, these findings reinforce earlier research that indicates little connection between individuals and climate change. The ways in which people talk about carbon is in very abstract and impersonal terms, and others (e.g., industry) are blamed for causing climate change. Carbon emissions are rarely linked to personal actions and lifestyles choices; in particular, few people are aware of the significant climate impact of eating meat. Other misperceptions also exist, for example conflation of ozone depletion, carbon monoxide and climate change. Also, very few people have used a carbon calculator.

Individual behaviour
Similarly, few are taking significant steps to lead a low-carbon lifestyle. In general, action does not extend beyond recycling and domestic energy conservation. This is despite a majority claiming to be interested in actions individuals can take to address climate change. It is also apparently inconsistent with most participants' belief that vehicle emissions contribute 'a lot' to causing climate change.

Structural engagement
Importantly, few citizens consider political action (e.g. writing to their MP) a valid response to tackling climate change.

Importantly, this research represents an *initial* investigation of carbon capability, and as such includes only indicative measures. Further work should build on this study by incorporating a more complete set of carbon capability measures. This should include, for example, individuals' evaluation of different information sources (in terms of bias, agenda, uncertainty, etc.) about carbon and climate change; their ability to budget and plan energy use; and engagement in community action to reduce carbon emissions.

Promoting carbon capability

Together this evidence indicates that individuals would benefit from *education to promote understanding and skills* to manage their carbon emissions, as well as structural measures to *enable and encourage* carbon capability. Our survey showed that misperceptions exist which may be addressed through informational approaches (e.g., highlighting the contribution of meat production to climate change). However, the low uptake of alternatives to driving and flying, and of political actions, likely reflects broader structural and cultural impediments to behaviour change noted elsewhere (Lorenzoni *et al.* 2007).

Carbon capability is a capacity pertaining to people, but not necessarily exclusive to individuals. As discussed, understanding and skills to manage carbon emissions are insufficient without enabling contexts and facilitating environments in which to act on that knowledge. This perspective ensures that we focus as much on social institutions and organisations as we do on individual choices and action. One such potential change to the 'rules and resources' infrastructure of greenhouse gas emissions was the recent policy proposal for tradable Personal Carbon Allowances (Miliband 2006; Fleming 2005). While technically as well as politically ambitious, this proposed system of allocating all citizens an equal share of the national carbon budget highlighted the need for carbon capability (and a strong sense of the common good) among the populace in order to successfully adapt to de-facto rationing (Seyfang *et al.* 2008). While this proposal has since been sidelined (DEFRA 2008b), it prompted considerable interest and preliminary research into the component aspects of such a scheme and the skills and capabilities required to successfully and equitably use one (see, e.g., Fawcett *et al.* 2007; Roberts and Thumim 2006; RSA 2007; Seyfang *et al.* 2008). It is within this policy context of personalising and managing carbon budgets that we explore the issue of promoting carbon capability, although we acknowledge that these are foundation-laying exercises which are exploratory and possibly limited in their scope to achieve significant reductions, in the absence of top-down carbon governance changes.

How then, might carbon capability be promoted in society? There are two strands of work currently being developed, relating to 'materialising' and 'budgeting' carbon emissions:

Materialising carbon emissions *tools and techniques which make carbon emissions more tangible in daily activities*	***Budgeting carbon emissions*** *concepts relating to the management of personal carbon quotas*
• provide direct feedback on everyday consumption activities • work to make carbon emissions visible and accountable • raise the profile of carbon emissions • encourage awareness of carbon costs associated with particular actions • allows development of enabling contexts in which people are motivated and able to act on their knowledge about carbon and its impacts *Examples:* Smart electricity meters (e.g., Burgess and Nye 2008) • can be used throughout the home to display real-time energy usage • makes intangible electricity usage tangible through rematerialising energy and economic costs • savings of 5-10% of consumer energy demand (2% of UK emissions) Carbon labelling consumer products (e.g., Upham and Bleda 2009): • a label displays the product's carbon footprint • informs consumers of the carbon emissions associated with the product's manufacture and use	• provide information for assessing personal carbon emissions • involve community engagement with like-minded people • involve goal-setting and support networks to help achieve goals • people voluntarily accept new 'rules and resources' governing their energy consumption *Examples:* Royal Society of Art's CarbonDAQ (RSA 2007): • participants report personal carbon emissions within a 'personal budget' framework • carbon allowances bought and sold for virtual money in a virtual market • embedded social networking tools enable participation of communities, teams, etc. Carbon Reduction Action Groups (CRAGs) : • community-based voluntary groups ('craggers') adopt a 'weight-watchers' approach to cutting carbon footprints • regular meetings provide support for reducing carbon emissions • a 'weigh-in' calculates actual emissions against personal carbon allowances (reduced each year)

So what is the next step in developing carbon capability? Again, in the absence of policy intervention to shape our systems of provision, the immediate next steps are likely to involve voluntary efforts by groups of individuals – either pre-figuring future governance changes, or demonstrating that such policies would be effective and welcomed. In order to move beyond the simplest energy-conservation measures, interventions are needed at a larger scale than the household level: schemes such as car share clubs and sustainable energy schemes (Prescott 2008). Prescott also found public enthusiasm for voluntary schemes which link personal emission-reductions with community benefits.

Conclusions

This brief exploration of carbon capability suggests a need for improved communication and public education in this area, which takes account of individuals' context and concerns and seeks to encourage individual and structural engagement. Yet, information provision alone is not enough to encourage lifestyle change or promote public acceptance of policy (e.g., Lorenzoni *et al*. 2007). We argue for the need to explore situated meanings of carbon and energy in everyday life and decisions - within the broader context of structural opportunities for, and barriers to, low-carbon lifestyles. More research is needed on the specific components of carbon capability, and the skills needed to become carbon capable, as well as the links between carbon capability and engagement with climate change and sustainability. Carbon capability must retain a focus on helping people to resist - and create alternatives to - broad social pressures to increase consumption, in order that carbon budgets can be effectively managed.

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Appendix 1. Demographic characteristics of survey sample

Gender	%
Female	53.4
Male	44.9
Prefer not to say	1.7

Age	%
16-24	7.3
25-44	28.7
45-64	38.2
65 and over	25.5
Prefer not to say	0.4

Household income (before tax)	%
Up to £9,999 per annum	12.4
£10,000 - £19,999 per annum	13.9
£20,000 - £29,999 per annum	11.8
£30,000 - £39,999 per annum	10.8
£40,000 - £49,999 per annum	7.8
£50,000 - £74,999 per annum	11.4
£75,000 or more per annum	7.4
Don't know	7.0
Prefer not to say	17.5

Political party most likely to support	%
Labour	16.1
Liberal Democrats	13.4
Conservative	28.7
Green	11.8
Other / Prefer not to say	21.3
Would not vote	8.7

Qualifications	%
No formal qualifications	19.9
GCSE/ O-Level	12.1
A-Level/ Higher/ BTEC	10.7
Vocational/ NVQ	14.2
Degree or equivalent	26.1
Postgraduate qualification	14.6
Other	2.5

Qualifications in science-related subject	%
No formal qualifications	40.3
GCSE/ O-Level	27.2
A-Level/ Higher/ BTEC	12.1
Vocational/ NVQ	2.7
Degree or equivalent	12.1
Postgraduate qualification	5.0
Other	0.6

No. of adults (incl. you) living in your house	%
1	25.3
2	55.4
3	12.2
4 or more	7.1

No. of children (ie., under 16) living in your house	%
0	77.3
1	9.8
2	9.1
3 or more	3.9

Area density	%
City	59.3
Town	12.0
Village or hamlet	28.6

County	%
Norfolk	63.7
Hampshire	36.3

Appendix 2. Attitudes to climate change

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
Climate change is too complex and uncertain for scientists to make useful forecasts	8.2	32.0	21.9	32.4	5.5
Claims that human activities are changing the climate are exaggerated	6.9	25.1	16.0	39.4	12.7
I do not believe climate change is a real problem	3.2	10.1	14.0	47.5	25.2
Floods and heat-waves are not increasing, there is just more reporting of it in the media these days	3.4	18.0	26.1	40.6	11.9
Recent floods and heat-waves in this country are due to climate change	6.0	31.6	47.7	11.7	3.0
I need more information to form a clear opinion about climate change	14.4	47.2	20.5	15.2	2.6
The media is often too alarmist about issues like climate change	19.6	37.4	20.4	18.6	3.8
Climate change is just a natural fluctuation in earth's temperatures	7.1	18.1	30.3	37.5	6.9
There is too much conflicting evidence about climate change to know whether it is actually happening	8.7	27.2	20.4	36.5	7.3
I am uncertain about whether climate change is really happening	3.3	19.1	15.7	49.0	13.0
Many leading experts still question if human activity is contributing to climate change	4.7	39.2	26.8	25.2	4.1
The evidence for climate change is unreliable	4.8	22.8	29.0	35.3	8.1
Climate change is too complicated for me to understand	2.4	19.9	29.0	41.2	7.5
It is too early to say whether climate change is really a problem	4.3	18.9	22.4	40.2	14.2
It is difficult to know which products are better for the environment	8.9	55.3	15.3	19.1	1.4
The effects of climate change are likely to be catastrophic	13.7	37.0	34.1	12.7	2.4
The thought of climate change fills me with dread	6.7	24.1	35.7	25.2	8.3
Climate change is something that frightens me	10.1	34.9	33.7	16.6	4.7
I consider climate change to be an unacceptable risk	10.5	35.2	35.4	16.0	2.9
I feel a moral duty to do something about climate change	13.1	50.9	24.4	9.3	2.2
Too much fuss is made about climate change	4.2	13.7	19.8	44.6	17.7
I often talk about climate change to family or friends	3.8	39.3	27.5	24.3	5.1
Talking about climate change is boring	2.8	8.9	27.1	45.5	15.8

	Very important	Quite important	Not very important	Not at all important
How important is the issue of climate change to you personally?	27.0	51.6	18.6	2.8

	Yes	No	Don't know
Do you think climate change is something that is affecting or is going to affect you, personally?	53.0	28.3	18.7

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