Public Engagement with Carbon and Climate Change: To what extent is the public 'carbon capable'?

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Abstract

The relevance of climate change for society seems indisputable: scientific evidence points to a significant human contribution in causing climate change, and impacts which will increasingly affect human welfare. In order to meet national and international greenhouse gas (GHG) emissions reduction targets, there is an urgent need to understand and enable societal engagement in mitigation. Yet recent research indicates that this involvement is currently limited: although awareness of climate change is widespread, understanding and behavioral engagement are far lower. Proposals for mitigative 'personal carbon budgets' imply a need for public understanding of the causes and consequences of carbon emissions, as well as the ability to reduce emissions. However, little has been done to consider the situated meanings of carbon and energy in everyday life and decisions. This paper builds on the concept of 'carbon capability', a term which captures the contextual meanings associated with carbon and individuals' abilities and motivations to reduce emissions. We present empirical findings from a UK survey of public engagement with climate change and carbon capability, focusing on both individual and institutional dimensions. These findings highlight the diverse public understandings about 'carbon', encompassing technical, social, and moral discourses; and provide further evidence for the environmental value-action gap in relation to adoption of low-carbon lifestyles. Implications of these findings for promoting public engagement with climate change and carbon capability are discussed.

Keywords: public understanding; climate change; carbon; low-carbon lifestyles

1 Introduction

The Kyoto Protocol provides an international framework for reducing GHG emissions. The Protocol set binding targets for 37 industrialized countries and the European community for reducing emissions of the six main greenhouse gases (GHG) by an average of five per cent against 1990 levels, by 2012. The Parties to the Convention decreed at Bali in 2007 that an 'ambitious and effective international response' to further the Protocol at the end of first commitment period would be agreed at Copenhagen in December 2009 (UNFCCC, 2009).

We focus here on the UK, which has taken the lead at a national level in setting mitigation targets. The UK Climate Change Bill calls for an 80% GHG emissions reduction by 2050 relative to 1990 (HM Government, 2008). This level of response to climate change has profound implications for individual choices and behavior, 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 a low-carbon society. Besides reducing their direct emissions (e.g., conserving gas or electricity in the home), an individual can act in several roles to promote a low-carbon society, including being a low-carbon consumer (e.g., buying energy-efficient appliances or local, seasonal food), a low-carbon employee (through professional decisions and workplace behavior), and a low-carbon citizen (e.g., voting for a 'green' policy; joining an environmental campaign or community action group). Indeed, individual behaviour change (encouraged primarily through economic and informational approaches) has been a key feature of recent UK government climate change and environmental policy (e.g., HM Government, 2009, Hinchliffe, 1996, Ockwell et al., 2009).

At the moment, however, public engagement with climate change in the UK (as elsewhere) is limited, with energy demand for both domestic uses and transport rising (Defra, 2006). Clearly, new

tools and approaches are required in order to achieve the sort of ambitious carbon-reduction targets being pioneered by the UK. One such proposal is 'personal carbon budgets' whereby individuals are issued with an annual carbon 'ration' (Roberts and Thumin, 2006), but this is only an extreme version of the generalized responsibility for carbon-reduction which is being placed at individuals' feet. Given the policy preference for voluntary action by individuals (as opposed to top-down regulation; e.g., Carter and Ockwell, 2007), what conditions would be most conducive to a successful policy implementation?

Policy proposals relying on individuals' voluntary carbon reduction highlight the need for at least some level of public understanding of the causes and consequences of carbon emissions, as well as the ability and motivation for individuals to reduce emissions. However, little has been done to consider the situated meanings of carbon and energy in everyday life and decisions. Seyfang et al. (2007) have proposed the concept of 'carbon capability' to capture the contextual meanings associated with carbon and individuals' ability and motivation to reduce emissions, but this model has not hitherto been empirically applied. This paper aims to address that knowledge gap by presenting an initial study of public carbon capability. The paper begins with a review of theoretical and policy contexts around public engagement with climate change, conceptualizing climate change and carbon, and an elaboration of the carbon capability model. It then presents empirical findings from a UK survey of public engagement with climate change and carbon capability, focusing on both individual and institutional dimensions. In so doing, we attempt a novel synthesis between psychological and sociological approaches to behavior change. We then discuss the findings and implications for policy, in terms of measures to increase carbon capability in the populace, and conclude with reflections on the limitations of individual-focused instruments to achieve lifestyle change in social context.

2 Background

2.1 Public engagement with climate change

Although there is widespread global recognition of climate change, there is a general lack of knowledge and emotional engagement with the issue (BBC World Service, 2007, Defra, 2007b, Lorenzoni et al., 2007). Surveys show that awareness and concern about climate change have increased over the past two decades (Defra, 2002, 2007b), but in the context of other, more immediate or tangible concerns (e.g., health, finances), climate change takes a low priority (e.g., Poortinga and Pidgeon, 2003). The low relative importance of climate change reflects a widespread perception amongst the public that the issue is a spatially and temporally remote risk, affecting future generations and other countries (O'Neill and Hulme, 2009). Whilst it is considered socially relevant, most individuals do not feel it poses a prominent personal threat (e.g., Bord et al., 2000). Furthermore, people tend to identify causes of climate change with other people or groups, such as SUV drivers, industry, the US or China (Lorenzoni and Pidgeon, 2006, Whitmarsh, 2009b).

Behavioral engagement with climate change is even more limited. Surveys indicate around a third of the public are making an effort to drive or fly less (Defra, 2007b). When asked what actions they would be willing to undertake (or are already undertaking) to address climate change, recycling and energy conservation in the home are the most frequently mentioned, while there is considerable resistance to changing travel habits (Defra, 2007b, Whitmarsh, 2009a). In relation to energy policies, incentives and technological solutions receive more support than taxes or higher bills (Defra, 2002, O'Connor et al., 1999).

One might assume that the low levels of energy conservation action are due to a lack of awareness on the part of individuals as to the most effective actions to take. Yet, while some misperceptions exist, it is striking that surveys suggest a high level of understanding amongst the public as to which

behaviors contribute to the problem. For example, a UK survey that polled over 3,600 individuals found more than 75% of respondents believed 'using a car less' and 'flying less' would have a 'medium or major impact' on reducing the UK's contribution to climate change (Defra, 2007b). The same survey, however, showed that less than a quarter of those polled believe that the UK public would be willing to take these actions.

The disparity between public awareness about climate change on the one hand, and the limited behavioral response on the other is consistent with the widely-reported 'value-action' gap (e.g. Blake, 1999). In other words, people often do not act in accordance with what they know or care about. The value-action gap points to the complex interactions of psychological, social and environmental factors in the production of behavior (e.g., Stern, 2000). Indeed, behavior is not always preceded by conscious deliberation at all, notably in the case of habits (van Vliet et al., 2005). This is particularly true in the case of travel behaviors (e.g., Verplanken et al., 1998). Furthermore, climate change in particular, as a complex, uncertain, global, and long-term issue, is particularly difficult to understand and relate to at the individual level. Various barriers exist to increasing public knowledge, interest, concern, and - above all - action in relation to climate change. These barriers occur at two interrelated levels - individual and social - and include lack of knowledge, skepticism and distrust of information, feeling disempowered, competing priorities and values, perceived inaction by others, social norms (to consume) and physical/infrastructural impediments (Lorenzoni et al., 2007). Clearly, then, there are structural constraints and disincentives to leading low-carbon lifestyles which militate against individuals acting in accordance with their awareness of climate change.

2.2 Understanding the unfamiliar: conceptualizing climate change and carbon

Climate change is an issue which poses major challenges to communicators and educators. It is a risk 'buried' in familiar natural processes such as temperature change and weather fluctuations (Ungar,

2000), and has low salience as a risk issue because it cannot be directly experienced. Since people are accustomed to considerable weather and temperature variation on a daily and seasonal basis they underestimate the effects of a predicted rise in global temperatures of a few degrees (Berk and Schulman, 1995, Kempton, 1991). The World Meteorological Organisation uses consecutive periods of weather over a period of 30 years to calculate a 'climate' average: and thus - unlike an individual weather event - 'climate' is not directly observable. Confidence in projections of climate change impacts decreases with scale - with regional, and especially local, impacts often poorly described (IPCC, 2001), meaning the risks posed by climate change to individuals are ill-defined. Furthermore, reliance on second-hand information about the reality and severity of the risk of climate change means the risk is defined and interpreted by both the information source and message recipient (cf. Petty and Cacioppo, 1986). Uncertainty about climate change can be exaggerated by the media, which tends to emphasize the scientific and political controversy surrounding the issue (e.g., Boykoff and Boykoff, 2004).

Given the intangibility, complexity and uncertainty of climate change, how do individuals learn about it, and in what ways (if at all) is this understanding integrated into existing knowledge and applied in daily decisions? Here, it is useful to refer to the cognitive and social psychology literatures relating to individual learning. Both highlight the relational and constructivist nature of learning, whereby individuals interpret new experiences in light of, and build new understanding around, existing concepts and beliefs (Marshall, 1995). One of the major social psychological theories of perception and social influence is Moscovici's (1988) Social Representations Theory, which identifies two key processes involved in understanding and evaluating changes in the social/physical environment: 'objectification' (translating the abstract into the concrete and tangible) and 'anchoring' (categorising according to pre-existing cognitive frameworks thus rendering familiar). Crucially, these cognitive frameworks arise from cultural, as well as psychological, origins and are often normative in nature: 'most of our reasoning in societies depends on categories of right or wrong more than those

of true or false' (Moscovici, 1993, p.166). This appropriation of new knowledge in turn changes it, through processes of assimilation and accommodation (Piaget, 1970). This theory has been applied to understand the interaction of science and society, and the evolution and communication of scientific knowledge (as a function of subject, object and contextual factors; Bauer and Gaskell, 2008), and is particularly appropriate for the area of risk, where concepts or issues are likely to be novel and unfamiliar (Breakwell, 1991).

Returning to the issue of climate change, we see these processes of assimilation, accommodation, objectification and anchoring at work in the language used to describe climate change and in the way new information about the issue is interpreted. Recent research sheds some light on how people integrate new concepts such as climate change into existing knowledge through linguistic constructivism. Nerlich and Koteyko (2009) have tracked the rise of lexical 'carbon compounds' used in the mass media to communicate climate change. The most prevalent carbon compounds they have identified relate to: finance (e.g., 'carbon tax', 'carbon budget'); lifestyle (e.g., 'carbon footprint', 'carbon diet'); and morality/religion (e.g., 'carbon sinner', 'carbon indulgences'). Whitmarsh (Whitmarsh, 2009b) found different terminology about climate change is understood in different ways and evokes different responses: 'global warming' is associated more readily with heat-related impacts, ozone depletion and human causes than 'climate change', which is more often seem as having natural causes and a range of impacts; furthermore, 'global warming' is seen as more important and concerning than 'climate change'.

Previous research also highlights the resistance to change of existing mental models of risks, such that novel information may be misinterpreted in light of these pre-existing ideas: Kempton (1991) found that individuals often link ozone depletion and climate change and that, even when presented with information about climate change which makes no reference to ozone, individuals continue to connect the two issues. In general, there is a tendency to conceptually integrate climate change and

other (similar) environmental phenomena or problems, notably weather, air pollution and ozone depletion (e.g., Whitmarsh, 2009b). Consistent with this, recent qualitative research on public understanding of energy consumption concluded that 'many participants were unable to distinguish terms such as the ozone layer, greenhouse gases and carbon emissions from the perceived "science babble"' (Brooke Lyndhurst, 2007, p.9). There is also a conflation of solutions to environmental problems: recycling tends to be seen as a panacea for all environmental problems, or is perhaps a tokenistic, symbolic gesture of environmental concern (Whitmarsh, 2009a).

There is low salience of climate change, energy and sustainability in individuals' day-to-day choices and actions (e.g., Macnaghten and Jacobs, 1997, Whitmarsh, 2009a). Growing awareness of environmental problems at an abstract or general level tends not to be translated into personally-relevant cognitions or motivating attitudes (Lorenzoni et al., 2007). Furthermore, neither energy consumption (including embodied energy and potential future energy savings) nor environmental impact are typically considered when buying appliances (for which initial cost is the primary motivating factor; Brooke Lyndhurst, 2007). Understanding about environmental issues tends to be limited to abstract or vague concepts; for example while most people are aware of the main causes of climate change, understanding about the relative contribution of different activities to causing climate change is lower and there is confusion associated with emissions-related terminology (e.g., carbon dioxide, carbon, carbon equivalent) and difficulty visualizing quantification of emissions (Anable et al., 2006, DfT, 2007).

Awareness of the concept of 'carbon footprints' and the use of carbon calculators are growing but are not yet widespread[1]. Nevertheless, exploratory research suggests they can help make carbon

[1] Defra's 2009 survey found 48% of the public claimed to know 'a lot' or 'a fair amount' about carbon footprints, compared to just 25% in 2007. Between 2008 and 2009, around 10% of the public claimed to use a carbon calculator to calculate their carbon footprint (up from 3% in the previous year), while around 40% were aware of advertising about carbon calculators or carbon footprints (TNS, 2009a). Evaluation of the latest UK government climate change campaign, 'Act on CO2', suggests use of the online campaign information (including a carbon calculator) is relatively low, compared to (passively) learning about low-carbon behaviours from advertising on television and other mass media (TNS, 2009b).

and climate change more personally relevant and link energy choices to environmental impact; there is particular value in providing comparative information, so that individuals understand the *relative contribution* of different activities and how their lifestyles *compare to others* locally, nationally and globally (DfT, 2007). In this sense, relevant information is individually and socially contextualized. Yet, these concepts and tools will not necessarily motivate behavior change where individuals are not motivated to change or perceive barriers to doing so. Indeed, amongst users of carbon calculators, many (though by no means all) use such tools to *offset* their emissions rather than to change their energy consumption behavior (DfT, 2007). In some cases, these tools only serve to highlight the lack of individual control over potentially major carbon saving actions (e.g., lack of insulation in rented accommodation), and the minimal effect of other, directly controllable, choices (e.g., using energy-efficient lightbulbs). Clearly, information provision of any kind, even packaged in a personally-relevant, user-friendly and contextualized form, cannot address competing values or the wider, structural barriers to low-carbon lifestyles mentioned above. Furthermore, as Hargreaves (2010) shows in relation to smart energy meters in the home, this type of information provision may even be counter-productive if it results in individuals feeling guilty about consumption they feel unable to reduce, or otherwise disempowered, disinterested or cynical about such attempts by government to 'educate' the public by locating responsibility for climate action with individuals.

2.3 Carbon capability

There is some convergence of findings from the (primarily quantitative) work around public engagement with climate change (section 2.1), and the (primarily qualitative) work on learning about climate change and carbon (2.2). In particular, these two literatures demonstrate that both individual and institutional dimensions of engagement are vital to understanding (barriers to) adoption of low-carbon lifestyles. Furthermore, they highlight the need to understand the 'situated' meanings associated with carbon; that is, how individuals translate and apply knowledge about

carbon and climate change to their daily lives (for example through processes of objectification and anchoring).

Seyfang et al. (2007) have proposed the concept of 'carbon capability' to capture the contextual meanings associated with carbon and the individual ability and motivation to reduce emissions. Carbon capability is defined as: 'The ability to make informed judgments and to take effective decisions regarding the use and management of carbon, through both individual behavior change and collective action' (Whitmarsh et al., 2009). We identify three core dimensions of carbon capability:

(1) decision-making (knowledge, skills, motivations and judgments),
(2) individual behavior or 'practices' (e.g., energy conservation), and
(3) broader engagement with systems of provision and governance (e.g., lobbying, voting, protesting, creating alternative social infrastructures of provision).

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, the concept of carbon capability implies an understanding of the limits of individual action and where these encounter wider societal institutions and infrastructure, and so prompt the need for collective action and other governance solutions. The notion also suggests an appreciation 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 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 three dimensions of carbon capability (mapped onto the social practices model of sustainable consumption; Spaargaren, 2003), which comprise decision-making, behavioral and structural aspects. As mentioned, people face considerable obstacles to low-carbon lifestyles (Lorenzoni et al., 2007). Therefore, fully 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. This key point about carbon capability contrasts with the current policy emphasis on achieving behavioral change (dimension 2) through efforts to influence actors' cognitive and motivational processes (dimension 1) (e.g., Ockwell et al., 2009). Our contribution is to integrate a consideration of the sociological factors which influence practices (dimension 2), and so to direct attention towards broader issues around institutional carbon governance (dimension 3).

- Insert Figure 1 about here -

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) and includes: managing money, planning ahead, choosing products and staying informed (Atkinson et al., 2007). 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 (Seyfang et al., 2007).

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; witness also the current 'credit-crunch'–driven recession). 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-materialize energy use in day-to-day activities and choices (Burgess and Nye, 2008). Carbon capability is about transforming understandings of carbon from an inevitable (invisible and overlooked) waste product of modern lifestyles, to 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 (e.g., 'facts' about GHG emissions) is interpreted in diverse ways by different individuals - according to their prior beliefs, knowledge, emotions, and situational factors. Furthermore, abstract scientific information may not be useful to inform individual decision-making: 'While there may be no particular need for the public to engage at the deepest level of understanding, clearly there is a need for the public to better understand *their individual contribution* to climate change. This is especially true for those participants that expressed

a desire to contribute more personally to climate change reduction' (emphasis added; DfT, 2007, p.32).

As illustrated in section 2.2, 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 criticized 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 (indeed, carbon capability implies that agents have specific knowledge pertaining to, for example, the relative associated emissions of particular behaviors); 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 to transform the structural constraints on practice choice sets.

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, dramatization, politicization, etc.) than of schism within mainstream scientific opinion (Boykoff and Boykoff, 2004, Hargreaves et al., 2003). 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, 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;
- which carbon-reduction activities require collective action and infrastructural change;
- managing a carbon budget;
- information sources - and their reliability (in terms of bias, agenda, uncertainty, etc.) - for achieving a carbon capable lifestyle; and
- the broader structural limits to and opportunities for sustainable consumption.

While the research reviewed above begins to shed light on these dimensions of carbon capability, there is much more work to be done to determine the nature and extent of carbon capability amongst the public. Initial research evaluating the evolution and application by individuals, households and communities of new carbon concepts and tools (e.g., 'carbon footprints', 'carbon calculators') has been conducted with relatively small samples (DfT, 2007); we have sought to expand the scale and scope of this exploratory work through a UK survey of public engagement with climate change and carbon capability, focusing on both individual and institutional dimensions.

3 Methods

As an initial investigation of the nature and extent of carbon capability amongst the public, 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 (see Supplementary Material). The eight-page questionnaire included both closed and open questions, and addressed knowledge, understanding, attitudes, values and behaviors, as well as demographic variables. Several of the measures used, including behavioral measures (see Defra, 2008), were adapted from previous studies. (In addition to questions about carbon capability, attitudes to climate change and carbon offsetting were also measured; these findings are reported elsewhere, see e.g., Whitmarsh et al., 2009). Questionnaires were piloted and revised according to feedback from pilot respondents.

In total, we received 551 responses from the postal survey (representing a response rate of 18.4%). Participants in the postal survey were broadly demographically representative of the total population sampled (see Supplementary Material), although somewhat more qualified (26% have a degree, slightly more than the national average of 20% according to 2001 census data). Quantitative data was analyzed in SPSS; and qualitative data was coded thematically in NVivo.

4 Exploring the three dimensions of carbon capability

4.1 Individual decision-making

4.1.1 Awareness and knowledge about climate change

Consistent with previous research, we find that awareness of climate change is very high. Less than 1% has not heard of climate change at all; and the largest proportion (56%) says they know 'a fair amount' about it. A further 10% say they know 'a lot', and 29% know 'just a little'.

Furthermore, most people (85.6%) agree with the statement 'climate change is caused by both natural processes and human activity'. However, this proportion seems rather high when compared

with responses to other questions in this survey on skepticism and uncertainty about climate change, which suggest a sizeable minority continue to doubt whether human activities influence climate. For example, 25.2% of the sample agreed that 'Climate change is just a natural fluctuation in earth's temperatures' and 22.4% agreed that 'I am uncertain about whether climate change is really happening'; furthermore, most participants are skeptical about claims made in the media about climate change and feel they need more information to form a clear opinion about it (see Whitmarsh et al., 2009).

Participants evidently recognize the main causes of climate change, including emissions from deforestation, industry, transport and (more generally) fossil fuel use (Figure 2). However, misperceptions exist in respect of the relative contribution of different activities or processes in causing climate change. An important misperception occurs in the lack of recognition of the contribution of meat eating/production contributing to greenhouse gas emissions. McMichael et al. (2007) note how agricultural and especially livestock-based activities account for around a fifth of emissions globally, in their proposal for a restriction in the production and consumption of red meat. In general, people identify the causes of climate change with more 'distant' activities, namely industry and deforestation, rather than their own actions[2]. Participants' perceptions of climate change as a non-salient issue are also reflected in their beliefs about the impacts of climate change, with only 53% agreeing 'climate change is something that is affecting or is going to affect me, personally'.

- Insert Figure 2 and Table 1 about here -

[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, and add a timescale element to the question to both provide a better assessment of individuals' understanding, such as: 'How much do you think the following activities have contributed to causing climate change over the last 100 years? Please rank them in order (1 = biggest contribution, 10 = least contribution)'.

When asked about aspects of climate change and energy which participants are interested in, the most popular response was seasonal/weather change in the UK (73.2%; see Table 1). This is consistent with the conceptual association of climate (change) and weather noted in previous research (e.g., Whitmarsh, 2009b). However, it is also likely that this is relatively easy to monitor; in many other cases, seeking information requires more than simply looking out of the window! Most participants also indicate they keep an eye on the availability of energy-efficient appliances (61.3%), and actions individuals can take to reduce their emissions (57.5%).

4.1.2 Awareness and knowledge about carbon

Moving from climate change in general to more specific knowledge around 'carbon', we find levels of awareness and engagement decrease (Figure 3). A minority of the sample state they know 'nothing' about 'climate change' (5%) or 'CO2/carbon dioxide emissions' (7%), rising to 12% of participants for the term 'carbon footprint'. Whilst over half of the sample indicates they know 'a lot' or 'a fair amount' about the term 'carbon footprint', only one in ten of those surveyed had actually used a carbon calculator to work out their carbon footprint.

- Insert Figure 3 about here -

Findings from this survey highlight the diverse meanings associated with the term 'carbon'. 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"?' The most common response term (by 26.5% of respondents) was 'carbon dioxide' or 'CO_2'. Similar, *technical* or scientific framings include:

> *'Element (atomic no.12) essential in organic compounds and acidic gas emissions […]' (P13)*
>
> *'Carbon in organic compounds and CO2 + CH4' (P134)*

However, many responses were less technical or suggested moral or cultural framings (or social representations). 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 (Whitmarsh, 2009b) and the environment in general (e.g., Douglas, 1992). In some cases, these framings implied some normative conception of how humans *should* relate to the natural environment and that the human-nature relationship is currently dysfunctional. Typical moral framings include:

'a toxic substance, a polluting gas that clogs up the air and rips off the ozone layer' (P400)

'The irreversible impact humans have on planet' (P67)

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 suggest a number of *misperceptions* exist in understanding about carbon emissions. For example, some indicated ozone depletion is caused by carbon emissions (a common misperception – see, e.g., Whitmarsh, 2009b). We also find confusion around carbon monoxide as a cause of climate change, which has not previously been mentioned in the literature. Examples of both of these types of misperceptions include:

'The emissions that are potentially damaging the ozone layer' (P183)

'Carbon monoxide that is omitted [sic] into the atmosphere' (P465)

Furthermore, uncertainty and lack of knowledge is a common theme in participants' understanding of carbon, consistent with respondents' attitudes to climate change. Typical responses include:

'A compound found in gases that MAY be bad for the environment' (P61)

'Not a great deal, but do know it is damaging the environment' (P36)

[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.

Last, as others have also noted (e.g., Lorenzoni et al., 2007, O'Neill and Nicholson-Cole, 2009), we find respondents' qualitative responses generally make little connection between carbon and personal choices or actions, with the role of industry in producing emissions often highlighted[4]:

'Polluting substances going into the air, primarily from fossil fuels' (P25)

'A substance that accelerates global warming' (P471)

'A by-product that industry is producing' (P503)

4.2 Individual behaviors or practices

We asked whether respondents had taken actions to reduce their emissions. The results show domestic energy conservation is relatively common, but changing travel and shopping habits are less popular (see Table 2 for frequent actions; Whitmarsh et al., 2009 report findings relating to infrequent actions, such as installing insulation). For example, 67% claim they 'always' turn off lights they are not using, 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., Defra, 2007b), most participants in our survey (62%) use a car at least 3 times per week; and 51% have taken 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.

- Insert Table 2 about here -

[4] However, we acknowledge that the question wording may have influenced responses to some extent here, since one of the example statements given ("the company is aiming to become carbon-neutral") was an industrial framing.

4.3 Engagement with systems of provision and governance[5]

As Table 2 demonstrates, a large proportion of respondents undertake some individualized pro-environmental actions. There is some evidence of engagement beyond these individualized contexts within systems of provision: for example, 58.3% of participants state they keep abreast of debates on energy futures, such as on the role of nuclear power (Table 1). Yet more active engagement activities, such as keeping an eye on embedded carbon indicators or 'by air' labels were only undertaken by a quarter of participants.

A lack of participation and engagement with systems of governance was found throughout the survey. Although over half of participants state they are interested in national government climate policy, only a quarter of participants actually keep an eye on which political parties have the strongest climate policies, indicating that, as others have found, the environment remains a low priority issue at election time (Whiteley et al., 2005). As shown in Table 2, over 90% of participants 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).

5 Discussion and Implications for Developing Carbon Capability

The research findings presented here on the three dimensions of carbon capability reinforce earlier research that indicates little connection (or 'objectification') between individuals and climate change. Carbon emissions are rarely linked to personal actions and lifestyles choices, and consistent

[5] We should note that the survey did not ask about involvement with community groups, which would need to be considered for a more complete analysis of carbon capability.

with previous studies, we find that few people are taking significant steps to lead a low-carbon lifestyle. The research offers new insights into how individuals learn about (the causes of) climate change, particularly how 'anchoring' occurs in relation to other (similar) environmental issues, such as ozone depletion and carbon monoxide (cf. Kempton, 1991, Whitmarsh, 2009b); and how understanding about carbon and climate change may form part of larger cultural framings or discourses about the dysfunctional human-nature relationship and 'pollution' (cf. Douglas, 1992). Furthermore, whilst some engagement with systems of provision was noted in the survey, it rarely extends into more active engagement activities, which may reflect the widespread political apathy and mistrust amongst the UK public noted in other research (e.g., Hansard, 2008).

What does this mean for policy? We argue that these findings show that public carbon capability is below the levels required for active citizen engagement with climate change which would lead to carbon-reduction activities. However, we do not principally (or solely) blame individuals' lack of knowledge and understanding for their low levels of pro-environmental behavior. Rather, our findings are consistent with substantial existing evidence (e.g., Stern, 2000, Lorenzoni et al., 2007, Whitmarsh, 2009a) that current systems of provision are often not conducive to such practices; and that contextual barriers contribute to the widely-reported 'value-action gap' (Blake, 1999). For example, we found that knowledge about the contribution of car use and flying to climate change is high (over 90% acknowledging that vehicle and aeroplane emissions are a cause of climate change), but that change in relation to these transport behaviors is much lower (6-36%, depending on the particular transport behaviour). We therefore cannot exclude considerations of the social meanings and institutions associated with driving and flying (e.g., Barr et al., 2008), and the availability or otherwise of practical low-carbon alternative systems of transport provision (e.g., Lorenzoni et al., 2007). We conclude that there are likely to be interlinked deficiencies along all three dimensions of carbon capability (decision-making, practices, and structural engagement), which undermine the foundations of a carbon-reduction policy context requiring voluntary action by individuals. Given this

context, we argue that raising levels of carbon capability is a necessary but not sufficient condition for increasing carbon-reduction lifestyle changes. Furthermore, achieving policy targets for individual carbon-reduction will require measures to improve these capabilities by addressing all three aspects simultaneously. This integrative policy approach is all the more vital given the potential for information on households' carbon-emitting activities to be counter-productive under unsupportive institutional conditions; that is, where recommended actions are unfeasible or unappealing, or responsibility for action located elsewhere, information may induce guilt, disinterest or disempowerment (O'Neill and Nicholson-Cole, 2009; Hargreaves, 2010). Below, we outline what some of the policy measures might look like, mapped onto Spaargaren's model which illustrates the dialectical relationships between structure and agency, resulting in particular sets of social practices.

The first dimension of carbon capability comprises knowledge, understanding and motivations to act. The survey findings show that certain misperceptions continue to prevail and that there is limited awareness of the relative contribution of different activities to causing climate change. This suggests a role for communication and education to provide relevant information to guide effective mitigative action. We stress, however, that this communication effort should be grounded in situated contexts and social meanings, and needs to be cognizant of the ways that individuals learn. Social Representation Theory (Moscovici, 1988) suggests that there is a need for objectification - making carbon tangible and concrete. This could be achieved through effective informational approaches that effectively rematerialize energy and carbon (e.g., carbon labeling, smart meters, etc.; Burgess and Nye, 2008, HM Government, 2009). The Theory also suggests anchoring within pre-existing frameworks is needed in order to render the unfamiliar, familiar. So for example, the concept of 'carbon' could be anchored within existing frames of lifestyle, finance or morality (Nerlich and Koteyko, 2009). Such tailored informational approaches may also help address the evident limited public motivation to adopt low-carbon lifestyles (and, particularly, to change travel, shopping and eating habits). By highlighting personal (e.g., health, financial) as well as social and

environmental benefits of action, individuals may be persuaded to move away from carbon-intensive choices (e.g., eating meat, driving) towards low-carbon alternatives (e.g., vegetarianism, cycling; see Lorenzoni et al., 2007). Motivation is also, of course, closely connected to the availability and attractiveness of low-carbon options, which are addressed through structural change, as we now discuss.

Moving from the actor to the structure side of the social practices diagram, and the third dimension of carbon capability (broader engagement with systems of provision and governance), we can identify two complementary courses of action. The first is for individuals to influence the rules and resources which comprise the governance structures of carbon, for instance through civic engagement (e.g., voting, lobbying, protesting, deliberative participation in policy-making). These new rules might take the form of carbon pricing, carbon allowances (for citizens, businesses or both), emissions regulation (e.g., carbon-capping of energy companies), low-carbon planning and transport policies, renewable energy policies, and so on. These measures would set quite different frameworks for potential repertoires of action, which would filter through systems of provision to influence the sets of social practices which are possible. Secondly, there is scope for the public to shape systems of provision directly, through engagement in environmental activism at the community level. For example, the Transition Towns movement seeks to create alternative, low-carbon systems of provision to replace existing infrastructures (Haxeltine and Seyfang, 2009) and is just one of many 'grassroots innovations' which aim to achieve system-wide change through collective community-based action (Seyfang, 2009). Clearly, the impacts and influence of such initiatives are currently limited as they are working in opposition to many societal institutions (e.g., externalizing environmental costs), and would be enormously enhanced by structural changes such as those mentioned above. Improvements in the social practices element of carbon capability should arise naturally out of a combination of the other two elements providing greater understanding and

motivation to act, within an enabling structural framework of systems of provision and governance which offer practical options for low-carbon social practices and individual choices.

6 Conclusions

Achieving ambitious policy targets for carbon reduction depends on societal engagement with climate change and GHG mitigation. In the current policy context which places considerable responsibility for carbon reduction with individuals, we have here considered the extent to which the public is appropriately equipped to engage in (voluntary) GHG mitigation, that is how 'carbon capable' they are. The construct of 'carbon capability' delineates the skills, situated knowledge, motivation, and capacity to cut carbon. In order to elucidate the dimensions of carbon capability, we have attempted to synthesize psychological and sociological considerations of the factors influencing public engagement in individual, community and civic action to help mitigate climate change. These considerations include processes of individual learning (e.g., objectification, anchoring) and construction of situated knowledge, as well as engagement with systems of provision and governance and the complex agency-structure dialectic that co-produces social practices.

Our survey shows that carbon capability is limited along all three dimensions of this construct, namely decision-making (knowledge, skills, motivation, judgment); individual behavior or practices; and broader civic and community engagement. Consistent with previous literature on public engagement with climate change and carbon, we find that carbon is not a salient consideration in everyday decision-making, that misperceptions exist, and that the disparity between knowledge and behaviour (the 'value-action gap') would suggest certain barriers constrain the ability of even knowledgeable and motivated individuals to act. The low uptake of alternatives to driving and flying, for example, likely reflects structural and cultural barriers to behavior change (Lorenzoni et al., 2007), while limited civic and community engagement point to a perceived lack of opportunities for,

and efficacy of, individual participation in social change (e.g., Grove-White, 1996) or climate change mitigation (Poortinga and Pidgeon, 2003). While carbon education may remove informational (and to a lesser extent, motivational) barriers to behavior change, structural measures are also required to encourage lifestyle change and enable participation in broader social change.

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 and contextual set of carbon capability indicators, as well as exploring the links between carbon capability and sustainability literacy (see Stibbe, 2009). This could 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; motivations for and barriers to engagement in community action to reduce carbon emissions; and individuals' consideration of carbon in everyday decisions and actions (e.g., through ethnographic approaches). Through this research agenda, we may better understand the public's (actual and potential) role in tackling climate change and achieving carbon-reduction targets.

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Table 1. 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

Table 2. Regular pro-environmental actions

Please indicate how often you take each action:	Always (%)	Often (%)	Occasionally (%)	Never (%)
Conservation and consumer actions				
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
Political actions				
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

Figure 1. The three individual and structural dimensions of carbon capability (mapped onto the social practices model of sustainable consumption; Spaargaren, 2003)

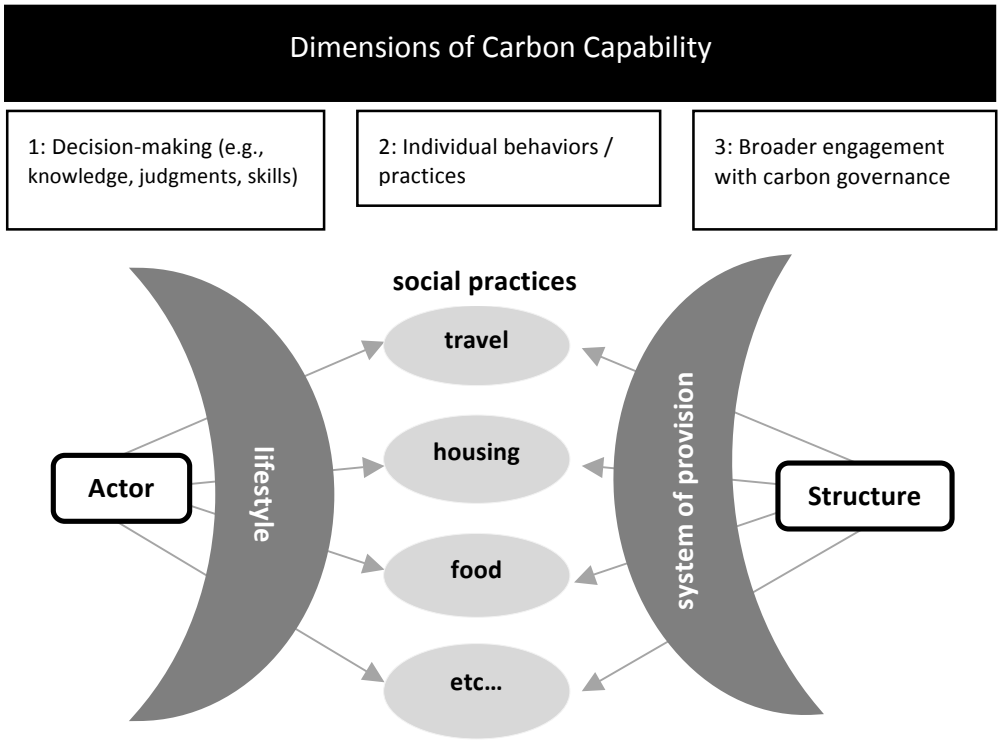


Figure 2. Perceived contribution of different activities and processes to climate change

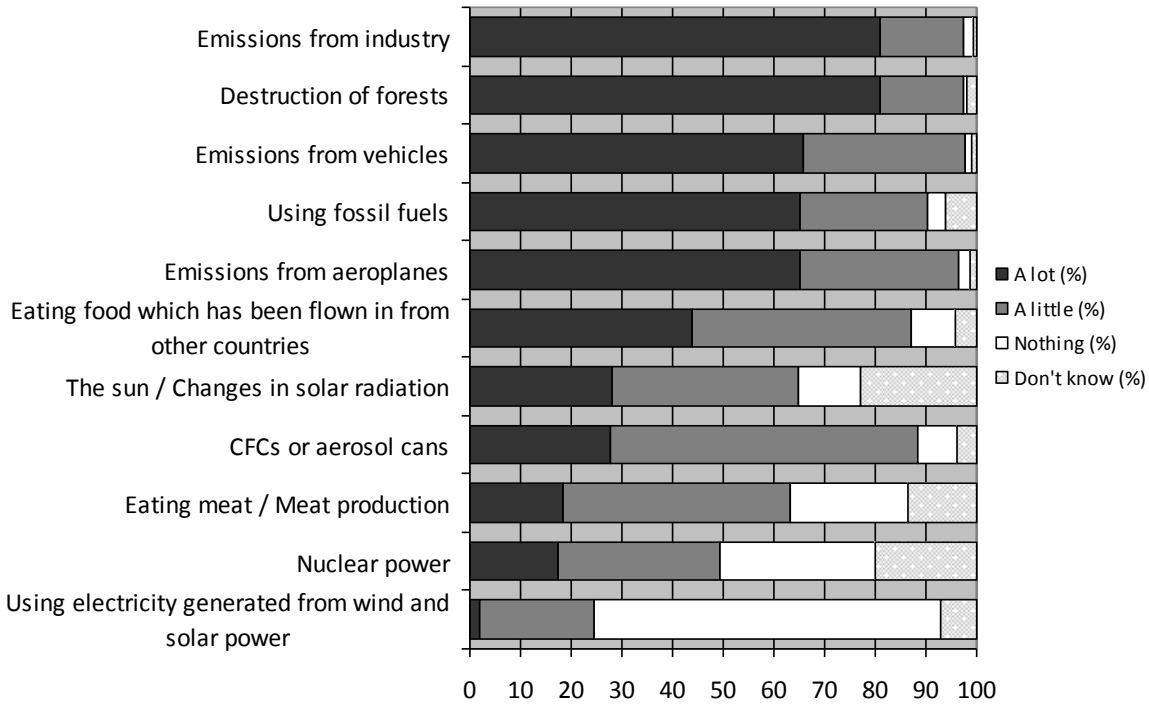
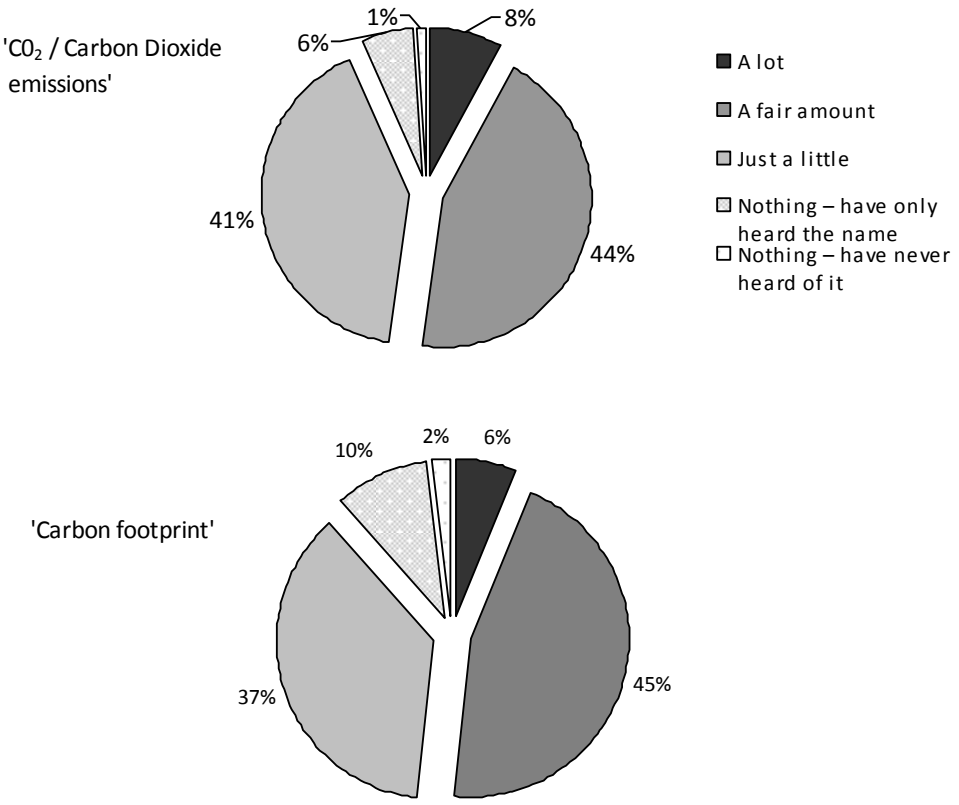


Figure 3. Knowledge about emissions-related terminology*



*Respondents were asked 'How much, if anything, would you say you know about the following terms: CO2 / carbon dioxide emissions; carbon footprint'

Supplementary material

Table 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

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

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