Energy Policy 120 (2018) 284–293

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Promoting low carbon behaviours through personalised information? Long-term evaluation of a carbon calculator interview

Milena Büchs[a,*], AbuBakr S. Bahaj[b], Luke Blunden[b], Leonidas Bourikas[b], Jane Falkingham[c], Patrick James[b], Mamusu Kamanda[d], Yue Wu[b]

[a] Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds LS2 9JT, United Kingdom
[b] Energy and Climate Change Division, Sustainable Energy Research Group, Faculty of Engineering and the Environment, University of Southampton, Southampton SO17 1BJ, United Kingdom
[c] Social Sciences, University of Southampton, Southampton SO17 1BJ, United Kingdom
[d] INDEPTH Network, 38 & 40 Mensah Wood Street, Accra, Ghana

ARTICLE INFO

Keywords:
Behaviour change
Energy reduction
Field experiment
Intervention
Personalised information
Sustainable cities

ABSTRACT

The UK needs to accelerate action to achieve its 80 per cent carbon reduction target by 2050 as it is otherwise in danger of lagging behind. A much discussed question in this context is whether voluntary behaviour change initiatives can make a significant contribution to reaching this target.

While providing individuals with general information on climate change or low carbon action is increasingly seen as ineffective, some studies argue that personalised information has greater potential to encourage behaviour change. This mixed methods study examines this claim through a longitudinal field experiment which tested the effectiveness of a carbon calculator interview. It finds that the intervention significantly raised awareness of ways in which participants could reduce their carbon footprint. However, this increased awareness did not translate into measurable behaviour changes in relation to home energy and travel. Qualitative analysis shows that participants refer to infrastructural, social and psychological barriers to change. This indicates that more ambitious government and corporate action is required to speed up carbon reduction.

1. Introduction

The Climate Change Act 2008 commits the UK to reduce CO_2 emissions by 80 per cent by 2050, compared to a 1990 baseline. While, by 2017, substantial reductions of 42 per cent have been achieved compared to 1990 levels, the Committee on Climate Change states in its most recent report (CCC, 2017) that progress is stalling because no new policies have been adopted more recently while emissions from transport and buildings continue to rise. Even though it is hoped that energy efficient technologies will provide considerable savings, the adoption of lower carbon lifestyles will also be required to reduce emissions in these areas (CCC, 2017: 47, 107). An important question is whether the public can be encouraged to change their behaviours voluntarily, or whether additional government policies and support for infrastructure change are required to achieve the UK's carbon reduction target. Much research has been conducted on ways in which people can be motivated to voluntarily reduce their direct and indirect carbon emissions. This includes research on the role that the provision of information on climate change or carbon reducing actions can play in this process. While providing individuals with *general* information on these topics is increasingly seen as ineffective, some studies claim that *personalised* information which is tailored to the recipient's situation, for instance feedback on their personal energy use or carbon footprints, or personalised energy saving tips, achieves better results in encouraging behaviour change (see Section 2 for details). Of course, the provision of personalised information is more resource and time-intensive than the provision of general information. In order to determine whether investing in developing and scaling up such strategies to the national level would be worthwhile, it is important to examine whether this has the potential to effectively support the uptake of low carbon behaviours in the long term. This paper examines this claim through a longitudinal field experiment which tests the effectiveness of a carbon calculator interview. For this study, we received permission from the climate change engagement initiative Carbon Conversations to employ a carbon calculator which they use in an initial interaction with their participants. Thus, it is a tool that is already in operation and (a version of which) could be scaled up to engage larger proportions of the population, possibly delivered through community groups. The carbon

* Corresponding author.
E-mail addresses: m.m.buchs@leeds.ac.uk (M. Büchs), A.S.Bahaj@soton.ac.uk (A.S. Bahaj), lsb1@soton.ac.uk (L. Blunden), L.Bourikas@soton.ac.uk (L. Bourikas), J.C.Falkingham@soton.ac.uk (J. Falkingham), P.A.James@soton.ac.uk (P. James), mamusu.kamanda@indepth-network.org (M. Kamanda), Phil.Wu@soton.ac.uk (Y. Wu).

https://doi.org/10.1016/j.enpol.2018.05.030
Received 5 February 2018; Received in revised form 10 May 2018; Accepted 11 May 2018

calculator interview can be regarded as a personalised information approach as it provides participants with their personal carbon footprint in various domains, and a comparison to UK averages. In a qualitative debriefing interview, participants were also taken through various options tailored to their situation through which they could reduce their carbon footprint, and asked which ones they would consider to adopt.

To properly test the effectiveness of the carbon calculator, it is important to use it on a broader sample of the population which does not only include those who are already highly engaged on climate change. To achieve this, the experiment participants were recruited from a random sample of the "city living" segment of the UK Office of National Statistics (ONS) Output Area Classification. Furthermore, it is important to test the effectiveness of the carbon calculator using actual energy use, which is possible for home energy and car travel, instead of self-reported behaviours, and to examine change over the long term. This is achieved in this study by comparing changes in measured energy use in the year before the intervention to the year after the intervention.

If one is interested in understanding the potential effectifeness of personalised information interventions for carbon reduction, it is important to compare their impact across different behavioural domains. A tool that informs participants how the carbon savings from different actions compare might encourage them to focus on the most effective actions. While several studies on comprehensive carbon calculators have already been conducted, they focus on carbon calculation methods (Birnik, 2013), or perceptions of user friendliness and potential for behaviour change (Brazil et al., 2013; Chatterton et al., 2009). To our knowledge it has not yet been tested whether completing a comprehensive carbon calculator has longer lasting effects on participants' awareness or actual behaviours. The results will be policy relevant because investment in personalised information strategies, which include carbon calculators, are only worthwhile if they achieve required behaviour changes. If they are ineffective, alternative government and corporate action will be required.

The next section reviews the literature on the provision of information and pro-environmental behaviour change, and formulates competing test hypotheses. Section 3 presents the data and methods, Section 4 reports results from quantitative and qualitative analysis, and Section 5 discusses the findings and concludes.

2. The provision of information and behaviour change

Much research has already been conducted on the effectiveness of providing people with information on environmental problems or with general advice on pro-environmental behaviours. There is a growing consensus that the provision of *general* information, i.e. information that is not tailored to the social background and/or the specific situation of the recipient, largely fails to encourage greater uptake of pro-environmental behaviours (Abrahamse et al., 2005; Owens and Driffill, 2008). Various studies show that gaps between people's attitudes and behaviours (or "values and actions") remain prevalent (Blake, 1999; Cohen et al., 2013; Kollmuss and Agyeman, 2002).

The explanation for the ineffectiveness of providing general information is that there are social, cultural, infrastructural and psychological factors which shape people's energy use, and which prevent them from changing their behaviours even though they might wish to do so 'in an ideal world'. Examples of social factors for energy use include family size, the presence of children, age or gender as they influence how much time is spent at home, which activities are undertaken in the home, how much people travel and how, and so forth (Lutzenhiser, 1993).

Cultural factors are also important because people attach specific meanings to their activities. Therefore, how energy is used in the home, for instance, will be influenced by what people consider 'normal' and adequate, as exemplified in studies on the importance of bathing routines in Japan, the importance of heating the whole home to create "cosiness" in Norway (Wilhite et al., 1996), or the establishment of showering practices (Shove, 2003).

In addition, infrastructures shape consumers' choices and can 'lock' them into specific patterns, for instance through the level of efficiency of electrical appliances, the energy mix in the electricity grid, or the quality of public transport provision (Van Vliet et al., 2005).

Finally, psychologists have identified perceptions of 'helplessness', or lack of 'outcome efficacy' (Bandura, 1977) (the perception that the behaviour one chooses to engage in can bring about desired outcomes, sometimes also subsumed under the concept of self-efficacy) as one of the barriers to the take-up of low carbon behaviours (Lertzman, 2015: 125–6; Norgaard, 2006). This is an important challenge for action against climate change as many people perceive their individual actions to only make a minute difference relative to the impacts that other individuals, corporations and countries have across the globe. In this context, some studies maintain that non-engagement can be countered with the idea that "many drops can fill the bucket" (Bonniface and Henley, 2008); or through self-transcending, universal values which can encourage people to behave in certain ways because the action is 'valuable in itself', not because it is expected to bring about a desired outcome (Crompton and Kasser, 2010; de Groot and Steg, 2009; Schultz et al., 2005).

While there are plausible reasons why the provision of *general* information is largely ineffective in encouraging people to reduce their carbon footprint, especially in the long-term, several studies found that the provision of *personalised* information which was more tailored to recipients' social background or life situation achieved some behavioural effects (see for useful overviews Abrahamse et al., 2005; Abrahamse et al., 2007). Some of the studies in this field build on the nudge approach which, by utilising insights from behavioural economics, seeks to influence behaviours in a 'soft' way, e.g. by changing 'choice architectures' or the provision of information (Thaler and Sunstein, 2008). Based on "libertarian paternalism", this approach seeks to make people 'better off' whilst preserving their freedom and avoiding "coercion" (legislation) (Thaler and Sunstein, 2003). So far, most studies on providing personalised information focus on specific areas of energy use / emissions, such as electricity consumption or car travel.

For instance, several studies examined the effectiveness of home energy monitors which provide people with instant feedback on how much electricity specific activities or appliances are consuming. They found that some participants changed habits in response (Hargreaves et al., 2010) and reduced electricity use (Darby, 2008; van Dam et al., 2010). Other experiments focused on the effectiveness of social comparison feedback on electricity use and report significant initial reductions (Allcott and Rogers, 2014). Other studies examined the effectiveness of personalised information in relation to travel behaviours, for instance through travel carbon calculators and/or personalised travel planning programs. Several studies find that these tools reduced car travel or increased use of public transport (Fujii et al., 2009; Fujii and Taniguchi, 2005, 2006; Meloni et al., 2011; Möser and Bamberg, 2008; Rose and Ampt, 2001; Taniguchi and Fujii, 2007; Tight et al., 2007).

The literature provides three main explanations of why personalised information is more effective than general information. The first relates to "norm activation theory" which states several conditions that need to be in place so that people can act on a personal norm (for instance an environmental norm to reduce their carbon footprint). One of these conditions is the "awareness of consequences" of their actions (Klockner, 2013). While this usually refers to consequences for the person, e.g. in terms of rewards or sanctions, it has been broadly applied in this literature to argue that the provision of personalised information or feedback can make people more aware of the ways in which their actions impact on energy use or carbon emissions (Abrahamse et al., 2005: 278; Benders et al., 2006: 3614; McCalley and Midden, 2002). The underlying assumption is that people are often

unaware of the connection between their actions and energy use/emissions because in many ways the latter remain "invisible" (Burgess and Nye, 2008).

The second explanation is that personalised approaches can provide people with information that is relevant to their situation, thus avoiding information overload, and with behaviour change advice that takes the recipient's situation into account, making it more applicable and realistic (Abrahamse et al., 2005: 277; Benders et al., 2006: 3614).

The third explanation highlights that personalised information can encourage people to keep up or intensify desired behaviours if it shows them how much progress they have already made in achieving a goal (McCalley and Midden, 2002: 591). While this especially applies to behaviours with clearly set goals, for instance weight loss or fitness targets, it can be regarded as broadly relevant for this study, too, if participants have a general interest in reducing or maintaining a 'reasonably sized' carbon footprint.

Which hypotheses can be derived from this review of theories on the provision of (personalised) information and behaviour change and previous studies? We formulate two competing hypotheses here which we will test, the first is the 'effectiveness hypothesis', the second the 'null hypothesis'. The 'effectiveness hypothesis' is based on the following considerations. The comprehensive carbon calculator applied in this study relates to all three elements of the theories on personalised information provision that we just presented: it made participants aware of the ways in which their behaviours are connected to emissions because it calculates emissions based on a range of behavioural questions, e.g. whether they take a shower or bath, how far/often they travel by car or train, etc.; the debriefing interview provided participants with personalised advice on ways in which they could reduce their carbon footprint; and the carbon calculator results present a comparison between participants' carbon footprints and UK averages for every behavioural domain, thus showing participants where they 'stand' (e.g. in relation to a hypothetical goal of not having a higher-than-average carbon footprint). In addition, since the carbon calculator covers emissions from different behavioural domains, it also shows participants which types of actions would be more effective in reducing their carbon footprint, for instance by highlighting the carbon intensity of flights compared to switching off lights. This could encourage action in areas in which more visible results can be achieved, especially if it can counter perceptions of helplessness or activate participants' self-transcendent values. Based on these features, and on positive findings from previous empirical studies, one can formulate the 'effectiveness hypothesis' according to which intervention group participants would a) gain an increased awareness of what they could do to reduce their carbon footprint and b) act on this awareness and reduce their carbon footprints by more (or increase them less) in the second year of the study following the carbon calculator intervention.

An alternative 'null-hypothesis' can be based on evidence regarding the limited long-term effectiveness of personalised information shown in some studies; as well as the theories discussed further above which highlight barriers to behaviour change. Several studies examined the long-term effectiveness (after one or two years) of providing tailored information or feedback on the reduction of home energy use. While one study showed an increased effect over time (Hirst and Grady, 1983), several others concluded that behavioural effects had disappeared in the long-term (Allcott and Rogers, 2014; Darby, 2008; Hargreaves et al., 2013; McDougall et al., 1982; van Dam et al., 2010; Winett et al., 1985). This also fits with evidence that personalised information was most effective the more frequently it was given (Abrahamse et al., 2005: 281). The main explanation that these studies provide for the limited long-term effects of personalised information is that the novelty of the monitoring equipment and/or intervention was wearing off over time while contextual and habitual factors regained importance in shaping behaviour.

Furthermore, while information about the relative carbon footprint of different activities can be regarded as a necessary first step for people to concentrate on actions that yield the greatest carbon savings, it is not guaranteed that they will be able or willing to make these changes due to prevalent social norms, infrastructures, or perceptions of lacking outcome efficacy. Results from some studies suggest it is unrealistic to expect carbon calculators to support behavioural changes in 'difficult', high carbon areas as participants were only prepared to make 'small', convenient changes in response to carbon feedback programs (Chatterton et al., 2009; Tight et al., 2007). Based on these points, the alternative null-hypothesis would lead us to expect that while the personalised information approach may still increase awareness, it will not result in significant carbon savings in the intervention group in the long-term. Sections 4 and 5 will reveal whether this study supports the 'effectiveness' or the 'null' hypothesis.

3. Data and methods

This mixed methods study first conducts a field experiment method to test whether participating in a carbon calculator interview increases participants' awareness of carbon reduction options, their climate change concern, and carbon reducing behaviours. Qualitative analysis of the interviews is then applied to examine possible explanations for the test results. Field experiments have become increasingly popular in the social sciences over the last few years because they facilitate testing the effectiveness of interventions by comparing a treatment (receiving the intervention) and a control group (not receiving the intervention), who are otherwise identical. This facilitates the isolation of causal effects, i.e. the intervention, by holding other factors such as socio-demographic characteristics, attitudes, etc., constant across the control and the intervention groups (Baldassarri and Abascal, 2017; Harrison and List, 2004; List and Metcalfe, 2014).

In contrast to laboratory experiments, field experiments take place in a natural setting. While it is not possible to control external factors that might affect the outcomes of a field experiment, for instance price rises, weather, or policy changes, an advantage is often regarded to be that people behave more 'naturally' in their usual environment, compared to a lab setting (Harrison and List, 2004: 1010; List and Metcalfe, 2014: 588). Furthermore, as long as changes in external circumstances apply equally to the intervention and control group, outcomes following an intervention can still be attributed to it with high levels of confidence.

The fieldwork for the experiment, designed and coordinated by the corresponding author, involved an initial sample of 335 individuals in 218 households, recruited from the "city living" category of the 2001 ONS Output Area Classification (Vickers and Rees, 2007) in Southampton. Area classification is a geodemographic method that allocates small areas to classes of a typology based on clustering analysis. The UK 2001 ONS Output Area Classification consisted of seven categories to which 223,060 output areas were allocated (ibid.). Clustering was based on a set of 41 variables selected to represent the main dimensions of the 2001 census: demographic characteristics, household composition, housing, socio-economic characteristics and employment (Vickers and Rees, 2007). The city living[1] segment is characterised by, relative to the UK average, a higher proportion of people aged 25–44, higher ethnic diversity and population density, higher proportion of single person households, higher proportion of people living in flats and renting, higher proportion of people with higher education qualifications, lower proportions of children under 14 and people over the age of 65, single parent households, lower number of rooms per household, and a lower proportion of households providing unpaid care (Vickers et al., 2005: 55). The 'city living' category was selected because it matched the focus of the overall EPSRC project "Transforming the Engineering of Cities to Deliver Societal and Planetary Wellbeing" (or short "Liveable Cities").

[1] 'City living' is not a term used by the ONS, but was coined by the authors of the ONS classification.

Table 1
Survey waves and response rates.

Wave	Period	HH participants	Response %	IND participants	Response %
1	Jul 14 – Nov 14	218		336	
2	Oct-14 – Jan 15	198	90.8	306	91.3
3	Jan 15 – Apr 15	200	91.7	307	91.6
4	Apr 15 – Jun 15	199	91.3	303	90.4
Intervention	*Carbon Calculator Interviews May 15 – Jun/Jul 15*	*95*		*143*	
5	Jul 15 – Oct 15	196	89.9	301	89.9
6	Oct 15 – Jan 16	184	84.4	283	84.5
7	Jan 16 – Mar 16	187	85.8	285	85.1
8	May 16 – Jul 16	192	88.1	291	86.9

Recruitment proceeded in summer 2014 through a postal invitation to 6000 randomly selected addresses from the 'city living' segment obtained from the National Address Gazetteer provided by Southampton City Council. To incentivise participation in this long term project which required regular completion of surveys, all participants were offered a Love2Shop voucher of £100 at the start, and again at the end of the project, provided they had completed the final survey. Invitation letters included a freepost response postcard which recipients could send back to express interest in participation. From the 384 households (response rate of 6.4 per cent) who initially responded, we admitted 218 to the study (response rate of 3.6 per cent) as they kept responding to communication, had stated that they are not intending to move house within the coming two years, and had internet access.

Over the course of two years, between summer 2014 and summer 2016, respondents took part in quarterly surveys, that is eight survey waves over the duration of the project (see Table 1 for timing and response rates for each wave). The first survey round was delivered face to face, all others online through the University of Southampton's isurvey platform. Invitations to participate in the online survey were emailed to the participants, and followed up by reminders to non-completers, during the survey window.

Data collection was split into two separate surveys, first the 'household surveys', completed in each wave by a designated household representative, which covered electricity, gas and vehicle mileage meter readings. Second, 'individual' surveys were completed in each wave by all participating household members over the age of 16. 'Individual' surveys included, amongst others, questions on climate change attitudes, frequency, and change of frequency, of walking, cycling, bus, train and plane journeys, environmental behaviours, and socio-demographic characteristics such as income, highest qualification, and employment status. To minimise the burden on participants, only the first (wave 1) and last (wave 8) survey rounds included all of the questions. Each wave included travel behaviours and number of flights so that they could be monitored over the whole course of the study, and some of the attitudinal questions were also repeated in wave 5.

Recruitment letters had been randomly split 50/50 into intervention and control group invitations. This yielded a sample in which roughly half of the participants, 164 individuals (~49 per cent of 335) in 108 (~50 per cent of 218) households, belonged to the intervention group, the remainder to the control group. A comparison of important demographic characteristics shows that the households in the intervention group do not significantly differ from those in the control group (see Table 2). This confirms that households were randomly allocated to the two experiment groups.

143 individuals in 95 households that had been allocated to the intervention group responded to the invitation to take part in a face-to-face carbon calculator interview between waves 4 and 5 in spring 2015. The carbon calculator employed in this study had been designed by the Centre for Alternative Technology, in collaboration with, and for use by, the Carbon Conversations initiative (in its latest version from summer 2014).[2] Carbon Conversation is a grassroots climate change engagement program which encourages and supports participants to reduce emissions in all areas of their lives. Participants take part in six small group sessions which cover the following topics: climate change, home energy, travel, food and water, consumption and waste, and a debriefing session. Carbon Conversation uses this carbon calculator in its first session to raise people's awareness of the relative carbon implications of different areas of their lives and to discuss people's views on climate change. The calculator contains 36 questions, divided into eight sections – space heating, water heating, lightening and electrical appliances, car travel, other surface travel, air travel, and household goods. After the first year of the study, intervention group participants took part in a carbon calculator interview, delivered face to face by a team of interviewers. The interviews were introduced by stressing that the exercise is not about generating a very detailed, accurate carbon footprint, but rather to provide insight into the relative size of the carbon implications of different areas of our lives. Interviewers also emphasised that the exercise does not intend to judge anyone's views or behaviours, to minimise potential interviewer bias and experience of guilt. Participants were then taken through the carbon calculator excel sheet on a laptop screen. The interviews ended with debriefing questions on how participants had experienced this exercise, in which areas they would find it easy, and which areas difficult, to reduce their emissions, and what their views of climate change were – whether they think it is happening, whether human action is contributing to it, who might be affected by it and what kinds of emotions they experience thinking about climate change. This style of interviewing was based on key Carbon Conversations principles, designed to draw attention to the issue of climate change and current generations' responsibility to mitigate it, thus appealing to self-transcendent, environmental values. They also provide a space for participants to acknowledge potentially difficult emotions around climate change such as guilt, hopelessness and helplessness, assuming that acknowledgement can make it easier to 'move on' and take action (Randall, 2015; Randall and Brown, 2015). All stages of the research were approved by the Faculty of Social, Human and Mathematical Sciences Ethics Committee of the University of Southampton.

Data analysis, carried out by the corresponding author, proceeded as follows. For the purpose of conducting tests on the effectiveness of the carbon calculator, the intervention group was defined to include participants who had received the carbon calculator intervention, and the control group everyone else - including those who had been invited to the exercise but not taken part. This was based on the assumption that the invitation to the carbon calculator exercise would have had a much more minor effect on participants' attitudes and behaviours compared to actually taking part. The effectiveness of the carbon calculator intervention was tested through difference in differences tests. This is a common approach in experimental studies which compares the before/after intervention difference between intervention and control group. To perform these tests, we created variables that represent the difference of the outcome of interest for each individual or household before and after the intervention. T-tests for household data, or bivariate random effects regressions which take clustering of individuals in households into account (see Table 3 for an overview of outcome variables and tests) were then performed to examine whether the

[2] http://www.carbonconversations.co.uk/, last accessed 16 May 2018.

Table 2
Randomisation Check: Intervention vs. Control Group.

Variable	Intervention Mean/proportion	Control Mean/proportion	Type of test	Test statistic	p-value
Household level					
Household income (10 bands)	£34,194.88 (1441.50)	£34,001.70 (1310.43)	Wilcoxon-Mann Whitney test	z = −0.013	0.989
Household size	2.23 (0.14)	2.13 (0.09)	Wilcoxon-Mann Whitney test	z = 0.048	0.962
Resident status (dummy 1 = rented, 0 = owned)	0.31 (0.05)	0.33 (0.04)	Chi Squared test	Pearson chi2(1) = 0.1569	0.692
Type of property (dummy 1 = house, 0 = flat)	0.52 (0.05)	0.51 (0.05)	Chi Squared test	Pearson chi2(1) = 0.0028	0.958
Number of cars in household	1.22 (0.05)	1.16 (0.05)	Wilcoxon-Mann Whitney test	z = −1.070	0.285
No car in household (dummy)	0.23 (0.04)	0.20 (0.04)	Chi Squared test	Pearson chi2(1) = 0.2543	0.614
Individual level					
Age	46.53 (1.45)	46.67 (1.24)	*t*-test (2-sided)	t = 0.0748	0.940
Gender (dummy, 1 = female)	0.55 (0.04)	0.54 (0.04)	Chi Squared test	Pearson chi2(1) = 0.0064	0.936

Note: The tests are based on 218 households / 336 individuals who participated in wave 1. Standard errors are provided in parenthesis in the columns on means or proportion.

Table 3
Response variables and tests.

	Type of variable	Time	Difference in differences test
Difference in climate change attitudes and awareness	Continuous. Agreement statements on scale from 1 (not at all) to 5 (very much): "The effects of climate change are too far in the future to really worry me" and "Human induced climate change is happening"; "I feel well informed about ways in which I can reduce my personal emissions"[a]	Wave 5 minus wave 1 Wave 8 minus wave 1	OLS regression, random effects
Difference in daily electricity consumption kWh (excluding economy 7)[b]	Continuous	Average of waves 5–8 minus average of waves 1–5	*t*-test
Difference in daily gas consumption kWh	Continuous	Average of waves 5–8 minus average of waves 1–5	*t*-test
Difference in daily vehicle mileage	Continuous	Average of waves 5–8 minus average of waves 1–5	*t*-test
Change in mean number of return flights per wave	Continuous. a) including respondents without flights, b) excluding respondent without flights	Average of waves 5–8 minus average of waves 1–5	OLS regression, standard errors account for clustering[c]
Increased agreement "would walk for short distances instead of using car"	Dummy variable. 1 = increased or same rating in wave 8 compared to wave 1, 0 = decreased rating, based on statement "How often do you walk or cycle for short journeys less than 2 or 3 miles" – scale from 1 "never" to 5 "always".	Wave 8 minus wave 1	Logistic regression, random effects

[a] The questions on awareness of how to reduce one's carbon footprint and on climate change concern ask respondents to state their agreement on a scale from 1 to 5. If necessary, variables were recoded after survey completion to ensure that high values always represent high concern about climate change. Even though they are ordinal variables, responses are roughly normally distributed in the awareness variable and the composite climate change awareness variable which justifies using regressions. The number of flights per wave is top coded to 5 return flights because we asked for up to 5 destinations per wave to ease participant burden.

[b] Due to a high proportion of missing or incorrect values, electricity consumption data exclude households with economy 7 metres (which distinguish between day and night tariffs and are common in homes with electric storage heaters).

[c] To test the difference of differences in the number of flights, we used an OLS regression in which clustering is taken into account in the calculation of standard errors because we assume that several members of the same households often go on holiday together and will thus have reported the same number of flights, i.e. random effects assumptions do not apply to this situation.

intervention and control group significantly differ in these changed outcomes following the intervention.

The qualitative debriefing questions of the carbon calculator interviews were also analysed to learn more about possible motivators and barriers of behaviour change. The interview transcripts were coded using the qualitative data analysis software NVivo (version 11). Codes were applied in two stages. The first stage applied broad codes of 'reaction to carbon footprint', 'changes easy to implement', 'changes difficult to implement' and 'climate change attitudes'. The second round of coding applied lower level codes which distinguished different types of behaviours such as home energy, car travel, air travel, and views on climate change.

4. Findings

4.1. Carbon calculator summary

The mean annual carbon footprint of intervention group participants was 15.18 t of CO_2 (standard error 0.43). (Since control group participants did not take part in the intervention exercise, we do not have data on their estimated carbon footprints). The carbon footprint figures include direct emissions from home energy and car travel, as well as indirect emissions from other forms of travel and consumption. This figure closely corresponds to the UK annual mean of 15 t of CO_2 that the calculator assumes. The standard deviation was 5.08 t; the lowest carbon footprint was 8.05 t and the highest 35.06 t. Average consumption-based emissions are thus still considerably above the 80 per cent UK reduction target of 2.4 t per person (Fig. 1).[3]

4.2. Changes in awareness

Agreement with the statement "I feel well informed about ways in

[3] This figure is based on estimated consumption based UK emissions of 943.67 Mega tonnes of greenhouse gases (CO_2e) in 1990 (Barrett et al., 2018), scaled down by a factor of 0.74, taken from the relationship between UK territorial greenhouse gases and CO_2 (BEIS, 2015) and a population estimate of 57,237,500 in 1990 (ONS, 2017).

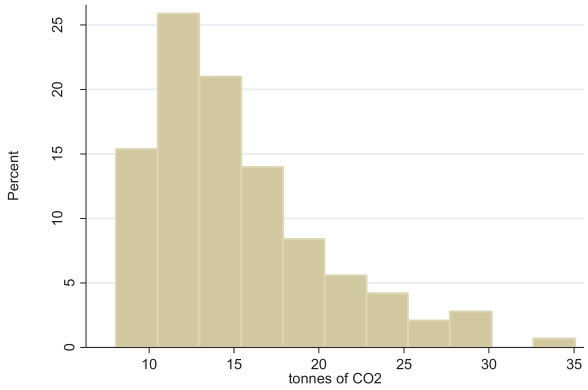

Fig. 1. Total carbon footprint of intervention group participants. Note: The carbon footprint sample consists of 143 intervention group participants.

which I can reduce my personal emissions" increased significantly in the intervention group, compared to the control group, following the carbon calculator intervention. Between waves 1 and 5 (around two weeks after the intervention), it had increased by 0.50 points more in the intervention group than in the control group ($p = 0.001$). This gap narrowed slightly when we compare waves 1 and 8 (around one year after the intervention), as the intervention group's agreement with this statement increased by 0.41 points more compared to the control group ($p = 0.005$) over this period (Table 4).

In addition, we tested whether the intervention influenced climate change concern. Results show that climate change concern also significantly increased among intervention group participants in the second half of the study. Agreement with the statement "The effects of climate change are too far in the future to really worry me" had increased significantly more in the intervention group in the second half of the study. Between waves 1 and 5, it had increased by 0.47 points more than in the control group ($p = 0.006$), and between waves 1 and 8 by 0.40 points more ($p = 0.018$). Agreement with the statement "Human induced climate change is happening" had also significantly increased by 0.35 points between waves 1 and 8, $p = 0.042$, in the intervention group compared to the control group (Table 4).

4.3. Behaviours

Average daily kWh of electricity and gas use decreased in both groups in the second year of the study compared to the first year. While home energy use decreases slightly more in the intervention group than in the control group, these differences are not statistically significant at the 5 per cent level. Equally, differences in changes between the two groups in the mean vehicle mileage per day, and mean number of flights per wave are not significant with all p-values above 0.05 (Table 5).

We also tested whether the self-reported frequency of undertaking carbon reducing actions increased more in the intervention group than in the control group between waves 1 and 8 (see the methods section for the types of behaviours included here). These frequencies did not change significantly for any of the behaviours (however, the p-value of 0.055 for the increase of walking or cycling for short journeys instead of using the car is just above the 5 per cent threshold) (Table 5).

The carbon calculator interviews provide some insights into possible reasons why the intervention failed to motivate intervention group participants to significantly change behaviours and reduce emissions. After we had taken participants through the changes they could make to reduce their carbon footprint, we asked which of them they would find easy or difficult to make and which ones they would be prepared to consider. In response to these questions, many participants stated they would find it difficult to make additional changes as they felt they were already reducing their emissions as much as possible. Here are typical examples of these statements:

Table 4
Climate change attitudes and awareness.

	Mean change C	Mean change I	Difference of mean change I - C	z	p	N
"I feel well informed about ways in which I can reduce my personal emissions"						
Wave 1–5	0.22 (0.10)	0.72 (0.14)	0.50	3.45	0.001	295
Wave 1–8	0.05 (0.10)	0.46 (0.15)	0.41	2.80	0.005	288
"The effects of climate change are too far in the future to really worry me"						
Wave 1–5	−0.27 (0.11)	0.20 (0.17)	0.47	2.76	0.006	295
Wave 1–8	−0.12 (0.12)	0.28 (0.17)	0.40	2.36	0.018	288
"Human induced climate change is happening"						
Wave 1–5	0.02 (0.12)	0.33 (0.17)	0.31	1.81	0.070	295
Wave 1–8	0.03 (0.12)	0.38 (0.17)	0.35	2.03	0.042	287

Note: OLS regression with random effects which accounts for clustering of individuals in households. C = Control group, I = Intervention group. Standard errors in parentheses.

> Respondent: I think we already do quite a lot of stuff (…) we've got to the point where we're down to the marginal stuff like not using the toaster which isn't going to save the world (laughs) frankly. (241 − 1)

> Respondent: No, I don't think so [that they are able to make any additional changes]. I think that we are probably as careful as we want to be now. You know? We're not going to scrimp and save. (255 − 1)

> Respondent: I don't think we could change any more than what we're changing now (…). I don't honestly think that we could be any tighter or meaner than what we have. (269 − 0)

> Respondent: [As with heating], the same with the water heating and lighting and stuff; those I'd struggle to… yeah, I don't think I would want to go too much lower on that, might be a bit of a push. (319 − 1)

Some participants did identify areas in which they could make some changes without much difficulty. Unsurprisingly, participants in this group mainly mentioned 'small' changes which would, in all likelihood, not have made a detectable difference to their carbon footprints, such as walking more for short distances instead of using the car (which corresponds to the results from the self-stated behaviour change, see above Table 5), switching off appliances or turning the heating down a little as stated in the following examples:

> Interviewer: So thinking then about your own (...) emissions and how they broke down by these different categories and the different options we picked as you were going through, was there anything that, sort of, jumped out at you as being quite an easy area for you to reduce your emissions on?

> Respondent: Possibly on the heating side, where I could go and put more clothes on and turn it down a couple of notches, turn it to 18° instead of 20°, yeah.

> Interviewer: So sort of, just generally reducing the temperature?

> Respondent: Yes, slightly. I mean, not significantly, but slightly. (294 − 0)

> Respondent: I'd be happy to (…) walk more – I know I need to walk more because I need to do more exercise. (293 − 0)

> Interviewer: So how practical do you think it would be to cut down on your car mileage?

> Respondent: I could cut down. When I'm going to the local shops I could walk there and get myself a bit fitter into the bargain. (295 − 1)

Table 5
Differences in energy use / behaviour before and after the intervention.

	Change C	Change I	Difference of change I - C	Test statistic	p	N
Mean change electricity kwh/d	−0.11 (0.31)	−0.50 (0.44)	−0.39	t = 0.75	0.45	129
N	71	58				
Mean change gas kwh/d	−3.63 (1.39)	−3.99 (0.98)	−0.36	t = 0.21	0.83	129
N	66	63				
Mean change miles/d	−0.74 (1.75)	1.14 (1.09)	1.89	t = −0.87	0.39	128
N	70	58				
Mean change n flights/wave (top coded, excluding zero flights)	0.16 (0.06)	−0.005 (0.06)	−0.16	t = −1.74	0.08	180
N	90	90				
Mean change n flights/wave (top coded, including zero flights)	0.11 (0.04)	−0.004 (0.05)	−0.11	t = −1.59	0.11	237
N	129	108				
% increase walking statement dummy	65.13%	75.56%	10.43% Odds ratio 1.65	z = 1.92	0.055	287
N	152	135				

Note: C = Control group. I = Intervention group. Standard errors in parentheses. Tests for electricity, gas and vehicle miles relate to households, all other tests to individuals.

These quotes also imply that participants were mostly willing to consider changes which would either bring them a personal benefit (e.g. getting fitter by walking more) or which would not affect their lifestyles too much. Several participants stated this explicitly, exemplified by the following two quotes:

Interviewer: Are there any areas maybe you think it might be easy to change?

Respondent: I suppose walking not driving for short distances, using the line instead of the tumble drier when I can.

Interviewer: Why do you think those areas are easy?

Respondent: It doesn't really impinge on your lifestyle as such. (251 − 1)

Respondent: I think it is more just for me, it is just an awareness if we come across something else that we can do, that isn't going to have a mega impact on us, but would make a difference, then we would probably chose that option. (252 − 1)

When it comes to behaviour changes that would have a larger impact on individuals' carbon footprints, the interviews speak a very clear language. The majority of participants stated they would find it difficult to reduce car or air travel, or change their eating habits.

The difficulties in car travel are primarily related to a mixture of infrastructural and social barriers, expressed in concerns about impracticality, inconvenience, unreliability and higher cost that participants associate with public transport. The following quotes are typical examples:

Interviewer: Are there any areas where you would find it difficult to make a change in particular?

Respondent: At the moment with car travel just because it's, you know it is getting to my work and public transport to where it is, is so poor that there's just no chance. (…) There's just no way. It would add on a super amount of time a day. (210 − 0)

Interviewer: The other category for you regarding emissions, so again it's things like car travel but like you say you'd either have to change your job or change where you live in order to reduce that any further.

Respondent: (…) Exactly. If I try to rely on the train to get me to [place of work] it would increase my working day and then getting from the train station here, and also the cost of the tickets, I did have a look at it and it is more expensive that what I'm paying on fuel. (290 − 1)

Interviewer: So would you go as far as considering public transport to get to work?

Respondent: I would if it was consistent, better priced or better sold to me. But it is not, and it frustrates me. (294 − 0)

Interviewer: What do you think would be very difficult to stop doing?

Respondent: (…) I think it would be the car, again. Yeah, it'd be the car again. If we didn't have the car at all and had to try to move onto public transport, god, I don't think we'd survive. (318 − 0)

While lack of adequate public transport infrastructures is an important reason why people do not feel able to switch away from car travel, lifestyle considerations dominate the rejection to reduce or even give up flying, or consuming meat. The following quotes are just a small number of similar statements about the unwillingness to reduce air travel that many of our participants made:

Interviewer: Are there particular areas that it would be difficult for you to change anything in?

Respondent: Well is suppose we like our holidays. Yeah. I don't think we'd want to change our holiday position at the moment. (206 − 1)

Interviewer: Would [air travel] be something that you would be willing to try and either reduce or even sacrifice?

Respondent: No because I've only just started to be able to afford to travel again. I travelled a lot when I was younger and I've only just started doing it again, so no. I don't think one holiday in [Greek island] is actually excessive. (289 − 1)

Interviewer: So how about things like air travel? Do you feel that would be something that you could perhaps reduce your emissions on, or would that be…?

Respondent: No. And that's being selfish, but no. (…) It's a lifestyle choice I enjoy. (294 − 0)

Respondent: I think the [air] travel would be difficult. I think that would be hard for both of us, yeah. I think it's just something we both enjoy and want to see the world so I think it would be a tough thing to give up. (310 − 0)

Interviewer: And do you think you might fly more or less? Is that something in your life you would…

Respondent: I don't think that would change. Yeah, because you know I like going to see different places so I don't think I would worry as much about that. (317 − 1)

Lifestyle considerations are also an important factor for the diets

that people choose. The following quotes provide typical examples of participants who express how difficult they would find, or have found in the past, giving up eating meat:

> Respondent: I wouldn't want to change the food (laughing)! I like my meat (…)!
>
> Interviewer: You think that would really impact if you had to change that?
>
> Respondent: Yes! (251 – 1)
>
> Respondent: I did go vegetarian – I can't remember, a few years back, just a couple of years and… but I think it was the smell of bacon, I liked the smell of bacon (laughter). But no I won't give up meat and we could have a lot – it's chicken mainly I think, roast chicken. (269 – 0)
>
> Respondent: The only other thing that could be… you know, I could go veggie, but… and I did try that once, but it didn't work (laughs). I gave it up for Lent this year actually, and I missed meat quite a lot, and went back afterwards. (298 – 0)

The interviews also confirmed assumptions regarding important psychological barriers to low carbon action, for instance that perceptions of helplessness are widespread and reduce the motivation for individual action. Coherent with this view, many participants expressed support for additional government action, exemplified in the last quote of this set:

> Respondent: But at the same time, as well as being pessimistic I kind of think, well, what can I do? There's not a lot that I can do as just one person, so in a way, you can't worry about it too much because there's nothing you can really do. So it is what it is, I suppose. (235 – 1)
>
> Respondent: I feel like there's only little small things that I can do, I feel quite powerless in the face of some of the other things that are contributing to climate change. (…) Like the Shell example that I was giving you just now. You know? What can people like us do about that? And it's [the] feeling of helplessness that people who actually do not give a rat's arse are… are in the majority. Or they have the majority of power. (256 – 0)
>
> Respondent: There is nothing that I can really do now is there? I mean except for turning the light off (laughter) so it is a pressing matter, obviously I care, but there is not obviously much I can do right now is there? (301 – 0)
>
> Respondent: I think individuals have a responsibility to contribute to it [tackling climate change]. But I think the behaviour won't change until… I think that behaviour won't change unless kind of forced to, in essence. And the only way to do that is [for the government] to legislate. (242 – 0)

Taken together, the qualitative interview data provide insights into the continuing importance of infrastructural, social, cultural and psychological barriers that people experience in voluntarily reducing their carbon footprints in meaningful ways.

5. Discussion, conclusions and policy recommendations

The results from the experiment show that participation in a carbon calculator interview significantly increased participants' awareness of things they could do to reduce their carbon footprint, as well as their climate change concern. However, another important, policy-relevant finding is that the intervention did not result in measureable reductions in residential and travel related energy use. This confirmed the null-hypothesis which is coherent with results from some previous studies that show that personalised information interventions tend not to be effective in encouraging low carbon behaviour changes in the long-term, especially not for behaviours that people perceive as 'difficult' to undertake (Allcott and Rogers, 2014; Darby, 2008; Hargreaves et al., 2013; van Dam et al., 2010). It also confirms a range of previous studies which have demonstrated attitude-behaviour gaps, again especially for 'difficult'-to-change behaviours such as air travel (Barr et al., 2010; Cohen et al., 2013).

The analysis of the carbon calculator interviews generated further policy-relevant insights. They support the finding of the non-effectiveness of the carbon calculator as the majority of intervention group participants were only willing to undertake changes that did not have a considerable impact on their lifestyle. These types of changes included actions such as turning appliances off standby, slightly reducing the temperature setting on the heating thermostat, or walking for some short journeys instead of using the car. If participants did implement these changes, this has not made a measureable difference to their carbon footprints.

Especially in relation to home energy, many respondents felt they could not reduce consumption any further. People have a clear financial incentive to save home energy, and tips on saving energy in this domain are now likely to be generally well-known due to various home energy saving campaigns in recent years. It thus seems plausible that many people will already have adopted easily achievable behavioural changes in this domain (without compromising levels of comfort) such that further savings can likely only be realised with additional investments to further improve the energy efficiency of the housing stock.

The interviews also confirmed theoretical assumptions established in social and psychological research on low carbon behaviour change: infrastructural and socio-cultural contexts (Shove, 2003; Van Vliet et al., 2005), as well as perceptions of helplessness (Lertzman, 2015: 125–6; Norgaard, 2006), constitute barriers to the uptake of more impactful low carbon behaviours such as reducing car and air travel, or meat consumption. People consider changes in these areas as difficult and undesirable. Public transport is widely perceived to be inconvenient, unreliable, and more expensive than car travel. In addition, it is especially families with children who find it challenging to co-ordinate their complex lives, often combined with considerable time pressures. They therefore find the car is the only means of travel that helps them navigate these challenges. From a policy perspective, wide-ranging changes to the public transport infrastructures would need to be made to reduce people's dependency on the car.

Socio-cultural expectations and social settings are more relevant for air travel. Many people perceive holidaying abroad as a right, perhaps almost as a necessity to be able to enjoy life and fit in with social norms. As globalisation has contributed to a greater spatial spread of family members and company networks, many people also see a need to fly to conduct business or maintain close family relationships. The vast majority in our sample of those who regularly engaged in air travel thus explicitly stated they were unwilling to reduce it. And those who regularly consume meat often perceive it as a necessary part of their diet, or enjoy it so much, that they cannot imagine to reduce it or even give it up.

These results do not confirm alternative assumptions that the comprehensive carbon calculator interview can be effective because its debriefing questions on climate change attitudes might activate self-transcendent, environmental values (Crompton and Kasser, 2010); because the exercise makes people more aware of behaviours that are associated with especially large carbon emissions, and thus of actions that are most effective in reducing their personal carbon footprints; or because it was delivered face-to-face which might exert more 'pressure' on or provide support for participants to take behaviour change messages on board compared to, for instance, an online tool. This study did not compare face-to-face and online interventions, so we cannot say whether face-to-face delivery is more effective than light-touch (e.g. online) delivery. However, even if it was, the time and associated cost implications of face-to-face delivery – each carbon calculator interview visit lasted between 60 and 90 min per person – would likely be a barrier to policy adoption and large-scale roll out.

One limitation of this study relates to its generalisability. Participants were sampled from the “city living” segment of the ONS area classification. Strictly speaking, results can only be generalised to this segment in other places in the UK. Carbon footprints of other segments of this classification are likely to be composed slightly differently, and might diverge more from the UK average (to which our sample was very close). Similarly, opportunities for behavioural changes (and ways in which they are perceived) are also likely to differ for other segments; for instance, people in rural areas can be expected to struggle even more to reduce car travel. On the whole, however, we believe that our main results regarding the difficulties that participants experience to make more impactful changes to their carbon footprints is not likely to differ considerably across other segments.

In addition, the response rate to our study invitation is relatively low with 6.4% of initial responses, and 3.6 per cent of households who completed the first survey round (with further attrition over the two-year period of the study as set out in Table 1). Possible explanations are the required high level and long-term engagement by potential participants and the fact that the invitation letters could not greet invitees by name as we only had addresses. It might be possible that those who were included in the study, and kept responding to survey requests, were more environmentally-conscious than those who did not (however, there is no data available to examine this). If this was the case, it might have limited the effectiveness of the carbon calculator intervention because this group might already have taken a range of energy saving measures before the start of the study. Having said this, any ‘real world’ voluntary behaviour change intervention on carbon reduction might also suffer from a pro-environmental response bias, especially if it involved more in-depth or longer-term interaction, and would hence also be similarly limited in its effectiveness.

Taken together, this study is novel because it tests the long-term effectiveness of providing personalised information through a comprehensive carbon calculator interview, based on measured energy and using a random sample of UK city dwellers, and gains deeper insights into results through qualitative interviews. Its findings have important policy implications. If personalised information approaches are ineffective in motivating people to voluntarily reduce their emissions, there is an urgent need for additional government and corporate action to enable people to do so. In the current circumstances it appears that the UK would not be able to meet its 80 per cent reduction targets by 2050 without such measures being taken. Our interviews demonstrate that people would welcome such action as they perceive voluntarism, which puts the main responsibility on individuals, as futile.

Acknowledgements

This project was funded by UK Engineering and Physical Research Council grant “Transforming the Engineering of Cities to Deliver Societal and Planetary Wellbeing”, EP/J017698/1.

References

Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T., 2005. A review of intervention studies aimed at household energy conservation. J. Environ. Psychol. 25, 273–291.
Abrahamse, W., Steg, L., Vlek, C., Rothengatter, T., 2007. The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. J. Environ. Psychol. 27, 265–276.
Allcott, H., Rogers, T., 2014. The short-run and long-run effects of behavioral interventions: experimental evidence from energy conservation. Am. Econ. Rev. 104, 3003–3037.
Baldassarri, D., Abascal, M., 2017. Field experiments across the social sciences. Annu. Rev. Sociol. 43 (null).
Bandura, A., 1977. Self-efficacy - toward a unifying theory of behavioral change. Psychol. Rev. 84, 191–215.
Barr, S., Shaw, G., Coles, T., Prillwitz, J., 2010. ‘A holiday is a holiday’: practicing sustainability, home and away. J. Transp. Geogr. 18, 474–481.
Barrett, J., et al., 2018. Exploring the UK’s carbon footprint, 〈http://www.emissions.leeds.ac.uk/index.html〉, last accessed 14 January.
BEIS, 2015. 2015 UK greenhouse gas emissions: final figures - data tables. London: Department for Business, Energy & Industrial Strategy, available from 〈https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2015〉, (Accessed 31 January 2018).
Benders, R.M.T., Kok, R., Moll, H.C., Wiersma, G., Noorman, K.J., 2006. New approaches for household energy conservation - In search of personal household energy budgets and energy reduction options. Energy Policy 34, 3612–3622.
Birnik, A., 2013. An evidence-based assessment of online carbon calculators. Int. J. Greenh. Gas Control 17, 280–293.
Blake, J., 1999. Overcoming the ‘value-action gap’ in environmental policy: tensions between national policy and local experience. Local Environ. 4, 257–278.
Bonniface, L., Henley, N., 2008. 'A drop in the bucket': collective efficacy perceptions and environmental behaviour. Aust. J. Soc. Issues 43, 345–358.
Brazil, W., Caulfield, B., Rieser-Schussler, N., 2013. Understanding carbon: making emissions information relevant. Transp. Res. Part D.-Transp. Environ. 19, 28–33.
Burgess, J., Nye, M., 2008. Re-materialising energy use through transparent monitoring systems. Energy Policy 36, 4454–4459.
CCC, 2017. Meeting Carbon Budgets: Closing the policy gap. 2017 Report to Parliament. London: Committee on Climate Change.
Chatterton, T.J., Coulter, A., Musselwhite, C., Lyons, G., Clegg, S., 2009. Understanding How Transport Choices are Affected by the Environment and Health: Views Expressed in a Study on the Use of Carbon Calculators. Public health, pp. 123.
Cohen, S.A., Higham, J.E.S., Reis, A.C., 2013. Sociological barriers to developing sustainable discretionary air travel behaviour. J. Sustain. Tour. 21, 982–998.
Crompton, T., Kasser, T., 2010. Human identity: a missing link in environmental campaigning. Environ.: Sci. Policy Sustain. Dev. 52, 23–33.
Darby, S., 2008. Energy feedback in buildings: improving the infrastructure for demand reduction. Build. Res. Inf. 36, 499–508.
de Groot, J.I.M., Steg, L., 2009. Mean or green: which values can promote stable pro-environmental behavior? Conserv. Lett. 2, 61–66.
Fujii, S., Bamberg, S., Friman, M., Garling, T., 2009. Are effects of travel feedback programs correctly assessed? Transportmetrica 5, 43–57.
Fujii, S., Taniguchi, A., 2005. Reducing family car-use by providing travel advice or requesting behavioral plans: an experimental analysis of travel feedback programs. Transp. Res. Part D: Transp. Environ. 10, 385–393.
Fujii, S., Taniguchi, A., 2006. Determinants of the effectiveness of travel feedback programs—a review of communicative mobility management measures for changing travel behaviour in Japan. Transp. Policy 13, 339–348.
Hargreaves, T., Nye, M., Burgess, J., 2010. Making energy visible: a qualitative field study of how householders interact with feedback from smart energy monitors. Energy Policy 38, 6111–6119.
Hargreaves, T., Nye, M., Burgess, J., 2013. Keeping energy visible? Exploring how householders interact with feedback from smart energy monitors in the longer term. Energy Policy 52, 126–134.
Harrison, G.W., List, J.A., 2004. Field Experiments. J. Econ. Lit. 42, 1009–1055.
Hirst, E., Grady, S., 1983. Evaluation of a Wisconsin utility home energy audit program. J. Environ. Syst. 12, 303–320.
Klockner, C.A., 2013. A comprehensive model of the psychology of environmental behaviour-A meta-analysis. Glob. Environ. Change-Hum. Policy Dimens. 23, 1028–1038.
Kollmuss, A., Agyeman, J., 2002. Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? Environ. Educ. Res. 8, 239–260.
Lertzman, R., 2015. Environmental Melancholia: Psychoanalytic Dimensions of Engagement. Routledge, Hove / New York.
List, J.A., Metcalfe, R., 2014. Field experiments in the developed world: an introduction. Oxf. Rev. Econ. Policy 30, 585–596.
Lutzenhiser, L., 1993. Social and behavioral-aspects of energy use. Annu. Rev. Energy Environ. 18, 247–289.
McCalley, L.T., Midden, C.J.H., 2002. Energy conservation through product-integrated feedback: the roles of goal-setting and social orientation. J. Econ. Psychol. 23, 589–603.
McDougall, G.H.G., Claxton, J.D., Ritchie, J.R.B., 1982. Residential home audits - an empirical-analysis of the enersave program. J. Environ. Syst. 12, 265–278.
Meloni, I., Spissu, E., Bhat, C.R., 2011. The effect of personal cap-and-trade mileage policies on individual activity-travel patterns: the activity locator project. Transp. Lett.- Int. J. Transp. Res. 3, 293–307.
Möser, G., Bamberg, S., 2008. The effectiveness of soft transport policy measures: a critical assessment and meta-analysis of empirical evidence. J. Environ. Psychol. 28, 10–26.
Norgaard, K.M., 2006. “People want to protect themselves a little bit”: emotions, denial, and social movement nonparticipation. Sociol. Inq. 76, 372–396.
ONS, 2017. United Kingdom population mid-year estimate, London: Office for National Statistics, 〈https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/timeseries/ukpop/pop〉, (Accessed 15 January 2018).
Owens, S., Driffill, L., 2008. How to change attitudes and behaviours in the context of energy. Energy Policy 36, 4412–4418.
Randall, R., 2015. The Carbon Conversations Facilitators' Guide. Carbon Conversations.
Randall, R., Brown, A., 2015. In time for tomorrow? The Carbon Conversations Handbook. Carbon Conversations.
Rose, G., Ampt, E., 2001. Travel blending: an Australian travel awareness initiative. Transp. Res. Part D: Transp. Environ. 6, 95–110.
Schultz, P.W., Gouveia, V.V., Cameron, L.D., Tankha, G., Schmuck, P., Franěk, M., 2005. Values and their relationship to environmental concern and conservation behavior. J. Cross-Cult. Psychol. 36, 457–475.
Shove, E., 2003. Comfort, Cleanliness and Convenience. The social organization of normality, Oxford: Berg.

Taniguchi, A., Fujii, S., 2007. Promoting public transport using marketing techniques in mobility management and verifying their quantitative effects. Transportation 34, 37–49.
Thaler, R.H., Sunstein, C.R., 2003. Libertarian paternalism. Am. Econ. Rev. 93, 175–179.
Thaler, R.H., Sunstein, C.R., 2008. Nudge: Improving Decisions About Health, Wealth, and Happiness. Yale University Press, New Haven, Conn.
Tight, M.R., Vicat, A., Bristow, A.L., Pridmore, A., May, A.D., 2007. An exploration of household response to personal travel carbon-reduction targets. Int. J. Sustain. Transp. 1, 143–159.
van Dam, S.S., Bakker, C.A., van Hal, J.D.M., 2010. Home energy monitors: impact over the medium-term. Build. Res. Inf. 38, 458–469.
Van Vliet, B., Chappells, H., Shove, E., 2005. Infrastructures of Consumption. Environmental Innovation in the Utility Industries. Earthscan, London.
Vickers, D., Rees, P., 2007. Creating the UK National Statistics 2001 output area classification. J. R. Stat. Soc.: Ser. A (Stat. Soc.) 170, 379–403.
Vickers, I., Rees, P., Birkin, M., 2005. Creating the National Classification of Census Output Areas: Data, Methods and Results. School of Geography Working Paper 05/2. Leeds: University of Leeds.
Wilhite, H., Nakagami, H., Masuda, T., Yamaga, Y., Haneda, H., 1996. A cross-cultural analysis of household energy use behaviour in Japan and Norway. Energy Policy 24, 795–803.
Winett, R.A., Leckliter, I.N., Chinn, D.E., Stahl, B., Love, S.Q., 1985. Effects of television modeling on residential energy-conservation. J. Appl. Behav. Anal. 18, 33–44.