Uncertainty, scepticism and attitudes towards climate change: biased assimilation and attitude polarisation

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Abstract

'Scepticism' in public attitudes towards climate change is seen as a significant barrier to public engagement. In an experimental study, we measured participants' scepticism about climate change before and after reading two newspaper editorials that made opposing claims about the reality and seriousness of climate change (designed to generate uncertainty). A well-established social psychological finding is that people with opposing attitudes often assimilate evidence in a way that is biased towards their existing attitudinal position, which may lead to *attitude polarisation*. We found that people who were less sceptical about climate change evaluated the convincingness and reliability of the editorials in a markedly different way to people who were more sceptical about climate change, demonstrating *biased assimilation* of the information. In both groups, attitudes towards climate change became significantly more sceptical after reading the editorials, but we observed no evidence of *attitude polarisation* – that is, the attitudes of these two groups did not diverge. The results are the first application of the well-established assimilation and polarisation paradigm to attitudes about climate change, with important implications for anticipating how uncertainty – in the form of conflicting information – may impact on public engagement with climate change.

Key words: Climate change, uncertainty, scepticism, biased assimilation, attitude polarisation

Introduction – Uncertainty, climate change & public engagement

Despite the well-established body of scientific evidence that the warming of the Earth over the last half-century has been caused largely by human activity (for a recent summary, see Royal Society, 2010), debates about climate change are characterised by an enormous amount of uncertainty (Zehr, 2000).[1] This is because climate change is a multi-facetted and complex phenomenon, founded on an extensive body of interdisciplinary science and with deeply challenging policy implications (e.g., Prins et al, 2010). While a great deal is known about the climate system (and the question of anthropogenic influence), many uncertainties remain. Some are quantifiable (albeit with sophisticated probabilistic statistics – e.g., UK Climate Impact Programme, 2009), but others are harder to pin down. As in any other scientific discipline, uncertainty is an inherent feature and a stimulus that drives progress rather than a weakness that holds it back.

But in debates about climate change, social and human issues are interwoven with scientific and technical ones (Wynne, 2010). This broader conception of climate change – as much more than just a scientific issue – introduces types of uncertainty that are much harder to quantify. People disagree about the reality, seriousness and consequences of climate change because it (socially) means very different things to different people (Hulme, 2009). These social uncertainties reflect differences in personal values and political ideologies, and are very different from the type of uncertainty that scientists typically encounter when formulating assessments of evidence (for a discussion of the way in which lay people conceptualise and experience uncertainty relating to environmental risks, see Powell, Dunwoody, Griffin & Neuwirth, 2007). Political and societal decisions about how (and indeed whether) to respond to climate change are fraught with uncertainties (Lorenzoni, Pidgeon & O'Connor, 2005; Oppenheimer, 2005) – and this is seen as a major barrier to public engagement with the issue (Lorenzoni, Nicholson-Cole & Whitmarsh, 2007 – where 'public engagement' is defined as a personal connection with climate change comprising cognitive, emotional and behavioural aspects).

[1] The research in this manuscript is predicated on the uncontroversial scientific position that human activity is the primary forcing of current observed climate change. We take the mildly normative position that public awareness of and engagement with the issue of climate change, and the significant negative impacts it has on human and natural systems, is a desirable goal. We do not discuss these issues further in the main body of the paper.

The everyday meaning of uncertainty is negative, as it is commonly equated with ignorance (Shome & Marx, 2009). Pollack (2005) has suggested that the media and non-scientists in general tend to infer that scientists do not know *anything* about a topic, just because they do not know *everything* about it. Corner and Hahn (2009) argue that the public perception of science, as a provider of knowledge and consistency, does not sit comfortably with the notion that scientific evidence may not always cohere. They reported an experiment in which people's evaluations of science arguments were compared with their evaluations of non-science arguments. Participants viewed uncertainty as more problematic for the science arguments, and they rated the sources of scientific arguments containing mixed evidence as especially unreliable.

Scientists are generally attuned to the difficulties of communicating uncertainty to the public. Frewer, Hunt, Brenna, Kuznesof and Ness (2003) found a widespread belief amongst scientists that the public are unable to conceptualize scientific uncertainties and that the communication of uncertainty would be interpreted as an 'admission' that their understanding of a subject was not complete. The communication of risk and uncertainty is a major challenge for the Intergovernmental Panel on Climate Change (IPCC), which has attempted (not always successfully) to quantify and communicate the uncertainties around climate science (Budescu, Broomwell & Por, 2009; Harris & Corner, 2010; Patt & Schrag, 2003; Patt & Dessai, 2005). However, the overwhelming majority of information that people receive about climate change comes not through formal IPCC reports (which are designed for policy makers), but through verbal or written summaries of risk information, typically consumed via the media (Carvalho & Burgess, 2005).

Among ordinary members of the public, there is a great deal of uncertainty about the reality and seriousness of climate change. A number of polls of public attitudes towards climate change have documented an increase in the degree of perceived uncertainty about anthropogenic climate change over the past three years (BBC, 2010; Gallup, 2009; Pew Research Centre, 2009; Spence, Venables, Pidgeon, Poortinga & Demski, 2010). Uncertainty about the impact of human activity on the climate is typically labelled 'scepticism', although the term is poorly understood. For example, Whitmarsh (2011) found that in the UK between 2003 and 2008 the belief that claims about climate change had been exaggerated almost doubled from 15% to 29%;

however, public uncertainty about climate change remained constant in most other respects. This suggests that an increase in scepticism about climate change may be manifested in quite specific attitudes about the way that climate change is communicated (rather than scepticism about climate science itself).

These data on public opinion about climate change can be contrasted with a recent survey of active and publishing climate scientists. Among this group, Doran and Zimmerman (2009) found 97% agree that human activity is contributing to climate change. On the basic question of whether human activity is influencing the global climate there is very little uncertainty among climate scientists; there is a much greater degree of uncertainty among the general public about the reality and seriousness of anthropogenic influence on the climate than there is in the scientific community. This demonstrates that scepticism cannot be reduced to an assessment of the climate science – and also warrants a psychological explanation.

Perceived uncertainty as a determinant of climate change scepticism

Several factors have been identified as being important determinants of scepticism about climate change, including political ideology (Pew Research Centre, 2009; Whitmarsh, 2011), age and level of education (DEFRA, 2007, Whitmarsh, 2011), and differences in values (Dunlap, Grieneeks & Rokeach, 1983; Nilsson, Borgstede & Biel, 2004) and 'worldviews' (Kahan, Braman & Jenkins-Smith, 2010). One of the most important factors, however, is perceived uncertainty (Poortinga, Spence, Whitmarsh, Capstick & Pidgeon, 2011).

Media-generated controversy is also often cited as a reason for scepticism about climate change (e.g. Antilla, 2005; Poortinga et al., 2011. Several analyses of media coverage of climate change have concluded that a discourse of uncertainty is unsuited to the typically adversarial style of English language journalism (Boykoff, 2007; Ward, 2008). Radio, television and newspaper reports have been criticised for interpreting too simplistically the notion of providing a 'balanced' set of views. This can lead to competing points of view on a scientific issue being presented as equally supported, when in fact they are not (Zehr, 2000; see also McCright & Shwom, 2010). There is some evidence that this trend is slowly changing (at least in the UK – Boykoff, 2007). However, Butler and Pidgeon (2009) have shown that people continue to view the media as offering a range of viewpoints on climate change,

creating the impression that the causes of climate change are more controversial than they actually are.

Corbett and Durfee (2004) have emphasised that the word 'uncertainty' need not be present in an article in order for the science to be portrayed as uncertain – all that is necessary is that 'duelling experts' are presented without any sense of how the weight of evidence is distributed. For scientists and non-scientists, it would seem that managing uncertainty is a demanding task. Both *prior attitudes* and the presence of *conflicting or opposing evidence* (perhaps amplified by the norm of journalistic 'balance') have been identified as contributing towards public uncertainty (or scepticism) about climate change. However, to date very few studies have yet sought to examine the effect of new information on people's existing attitudes about climate change (for an exception see Corbett & Durfee, 2004).

Biased assimilation and attitude polarisation

There is a considerable body of social psychological literature focused on the impact of persuasive messages on attitudinal change (for a recent summary, see Maio & Haddock, 2010). Important factors influencing the impact of arguments and evidence on people's attitudes include the perceived reliability of the source (Hahn, Harris & Corner, 2009), the level of personal involvement an individual has with a particular issue (Petty & Cacioppo, 1984) and personality characteristics such as the degree to which people are 'open to change' (Kruglanski, Webster & Klem, 1993). But one well-established and longstanding finding is that people with opposing prior attitudes process *uncertain* or *conflicting* evidence in a markedly different way.

In a series of experiments across a number of attitudinal domains, it has been shown that individuals with opposing prior attitudes assimilate new information in a way that is consistent with their existing attitudinal position (termed 'biased assimilation'); and that having assimilated information in a biased way, people with opposing attitudes may diverge in their opinions (known as 'attitude polarisation').[2] Lord, Ross and Lepper (1979) provided the most famous demonstration of biased assimilation and attitude polarisation. They gave the same arguments for and against the death penalty to both supporters and opponents of capital punishment. Study participants seemed

[2] The term 'biased' does not indicate a judgment about the validity of a particular opinion. It is a formal term for a process that has been well documented in the social psychological literature: the tendency of individual s to assimilate new information in a way that is consistent with their existing attitudes.

not only to assimilate evidence in a biased way (i.e. selectively accept evidence that confirmed their existing view, while discounting evidence against it), but also to become more convinced of their initial views – despite being exposed to identical evidence. While evidence for biased assimilation has steadily accrued, subsequent research has raised questions over the ubiquity of attitude polarisation (see Kuhn & Lao, 1996; Miller, McHoskey, Bane & Dowd, 1993; Munro & Ditto, 1997; Plous, 1991; Taber & Lodge, 2006), as it is more commonly found in measures of *reported* rather than *actual* attitude change.[3] This suggests that the biased assimilation of information may sometimes occur independently of attitude polarisation.

In summary, while actual attitude polarisation has been difficult to detect consistently in psychological studies, biased assimilation of information by individuals has been well documented across a number of attitudinal domains. No study has yet sought to apply the biased assimilation and polarisation paradigm to attitudes about climate change. Given that public uncertainty and scepticism has now become central to debates about climate change and is seen as a major barrier to public engagement (Lorenzoni et al, 2007), it seems important to establish whether attitudes about climate change also exhibit signs of biased assimilation and attitude polarisation. This was the goal of the experiment reported in the current paper – representing the first attempt to evaluate individual level attitude polarisation towards climate change in an experimental context.

Experiment

Studies of biased assimilation and attitude polarisation have typically provided participants with opposing arguments about a topic and measured their attitudes towards this topic before and after evaluating the arguments. Following this well-established paradigm, we conducted an experiment at Cardiff University to examine whether individuals who expressed different attitudes about climate change would assimilate conflicting evidence about climate change in a biased way, and whether their attitudes towards climate change would subsequently become polarised. In order

[3] We discuss the difference between *reported* and *actual* attitude change in detail later in the paper – but *actual* attitude change would typically be measured by a 'before-and-after' method, where participants respond to a question asking them to state their current attitude towards a topic. *Reported* attitude change would typically be measured only once, after the provision of some information or stimuli, and would require participants to state whether their attitudes had changed since before the experiment was administered (i.e., a self-assessed change in attitudes).

to achieve this, we measured people's scepticism about climate change before and after reading two 'editorials' that offered opposing arguments about climate change.

Drawing on Hulme's distinction between the science of climate change and its social, political and moral implications (Hulme, 2009), we created two newspaper editorials that presented conflicting views about climate change. In one condition, the two opposing articles focussed on climate science (creating scientific uncertainty). In the other condition, the two opposing articles focussed on the political/moral dimensions of climate change (creating political/moral uncertainty – see Appendix 1 for the editorials). Patt (2007) has also distinguished between 'model-based' and 'conflict-based' uncertainty – e.g., the difference between a 20% model confidence in an effect and 2 out of 10 experts expressing confidence in an effect. There are many other typologies of uncertainty (see, e.g., Tanner, Elvers & Jandrig, 2007), but our selection of Hulme's distinction was motivated by our interest in the sorts of uncertainty one might encounter in a typical media editorial.

The experiment was designed to answer the following questions:

1) Do individuals with opposing attitudes towards climate change assimilate novel, conflicting information about climate change in a biased way and exhibit attitude polarisation?

2) Do people respond differently to scientific versus political/moral uncertainty about climate change?

Method

Participants

A total of 173 undergraduate students (155 female,[4] age range 18-33, mean age = 19.6) from the School of Psychology at Cardiff University took part in the experiment in exchange for course credit. Participants took part in groups of between 1-15 people, and were seated at individually screened stations. Participants were randomly

[4] **A great deal of experimental psychology utilises 'convenience samples' – which typically means the undergraduates studying in the Psychology department where the researchers are based. In the UK, the gender ratio of Psychology undergraduates is almost always heavily skewed towards females, and this is reflected in our sample.**

assigned to one of two experimental conditions (88 in the scientific uncertainty condition, 85 in the political/moral uncertainty condition).

Design, Materials & Procedure

The experiment was conducted using personal computers situated in a group laboratory. We recorded participants' responses on a battery of measures before and after reading two editorials about climate change (described below).

First, participants answered basic demographic questions, indicating their age, gender, political affiliation (if any) and membership of any environmental organisations. Next, using the 15-item New Ecological Paradigm (NEP; Dunlap et al., 2000) scale, known to be highly predictive of attitudes towards climate change (e.g., Bord et al., 2000; Whitmarsh, 2011), participants indicated their views about the environment in general. This was measured on a seven-point scale from 'Strongly Disagree' (-3) to 'Strongly Agree' (+3), where higher scores indicate a more pro-environmental worldview.

Climate change scepticism was measured using a set of 17 statements on a five-point Likert scale from -2 'Strongly Disagree' to +2 'Strongly Agree' (see Table 1). This measure is an extended version of the scale developed by Whitmarsh (2011), where high scores indicate greater scepticism about climate change. The same scale was also administered after participants had read the newspaper editorials, in order to establish a 'before-and-after' measure of climate change scepticism.

Table 1 about here

Next, participants read the two editorials (printed on white A4 paper), before answering a second battery of measures. The editorials were constructed for the purpose of the study (see Appendix 1). In order to maximise the realism of the editorials, we presented them to participants as web-page printouts using the logos, formatting and font from two genuine newspapers - the Irish Times and the Scotsman. They were selected following pre-testing that established that these newspapers were

recognised, but not associated with any particular political views or position on climate change.

There were two versions of the editorials. In one experimental condition, the two opposing articles focussed on climate science (one headline read 'We are as certain about climate change as we are about anything', the other read 'If we can't predict the weather, how can we predict the climate?'). These editorials were designed to generate *scientific* uncertainty. In the other condition, the two opposing articles focussed on the political/moral dimensions of climate change – one headline read 'US politicians are committing treason against the planet', while the other read 'Why are environmentalists exaggerating claims about climate change?' These editorials were designed to generate *political/moral* uncertainty, and were carefully constructed to be broadly equivalent on key dimensions such as overall length (between 220-240 words), and the number of sources identified in the editorial (one per editorial), as message length and source attribution are factors known to be important determinants of message persuasiveness and argument strength (Hahn, Harris & Corner, 2009; Petty & Cacioppo, 1984).

After reading both editorials, participants were required to indicate how *convincing* and how *reliable* they considered each article to be on five point scales from 'Very Unconvincing' (-2) to 'Very Convincing' (+2), and from 'Very Unreliable' (-2) to 'Very Reliable' (+2) respectively. After evaluating the editorials, participants completed for the second time the set of questions designed to measure scepticism about climate change. Finally, participants were asked directly whether their attitudes towards climate change had altered after reading the editorials (a measure of 'reported change') on a nine-point scale from 'Less convinced about climate change' (-4) to 'More convinced about climate change' (+4) with 'My beliefs did not alter' at the midpoint (0). The entire experiment took between 20-30 minutes for participants to complete.

Results

Prior attitudes

Political affiliation was split fairly equally between the three main UK parties, with 25% supporting Labour, 25% supporting the Liberal Democrats and 21% supporting the Conservatives. Almost 8% identified themselves as Green Party voters, while 5%

were a member of an environmental organisation. Reliability analysis of the NEP scale showed it to be internally consistent (Cronbach's $\alpha = 0.73$). The mean NEP score was 0.73 (SD = 0.60).

The items on the scepticism about climate change scale formed a reliable measure of climate change scepticism (Cronbach's $\alpha = 0.92$; identical to that reported in Whitmarsh, 2011). Taking the sample as whole, the mean score was -0.24 (SD = 0.62), indicating that the sample were marginally non-sceptical about climate change (higher scores – above 0 – indicate scepticism about climate change). A simple linear regression was conducted in order to establish which of the demographic or value variables predicted scepticism about climate change (see Table 2). The model accounted for 30% of the variance in scepticism scores, although only NEP score was a significant predictor of scepticism. Political affiliation, membership of environmental organisation, age and gender were non-significant predictors of climate change scepticism in this model.

Table 2 about here

Editorial evaluation: biased assimilation

For the purpose of subsequent analyses, we divided participants into two groups on the basis of their median scores on the *scepticism about climate change scale*. Using a median split, we created a 'sceptical' group and a 'non-sceptical' group.[5] The mean score in the non-sceptical group (n = 88) was - 0.75 (SD = 0.35), while the mean score in the sceptical group (n = 85) was 0.29 (SD = 0.36).

Participants in the sceptical and non-sceptical groups evaluated the editorials in a markedly different way. Mean convincingness ratings are displayed in Figure 1 (data from both experimental conditions). Mean reliability ratings are displayed in Figure 2 (data from both experimental conditions).

Figure 1 and Figure 2 about here

[5] Despite the loss of statistical power associated with transforming a continuous variable into a categorical one, a median split (and the corresponding use of statistical Analyses of Variance) permitted us to observe evidence of polarization more clearly than continuous data and regression analyses. We repeated the analyses presented here using a different split (around the 'absolute' value of 0 on the scepticism scale). The results did not differ, suggesting that a median-split was an appropriate way of analysing the data.

We conducted a repeated-measures ANOVA with level of scepticism (sceptical vs. non-sceptical) and experimental condition (scientific vs. political/moral uncertainty) as between-group variables, editorial type (Irish Times vs. Scotsman) as the within-groups variable, and ratings of editorial convincingness as the dependent variable. We found no main effect of scepticism level, or editorial type. Crucially, there was a highly significant interaction between scepticism level and editorial type, $F(1, 169) = 41.24$, $p < .001$. T-tests of the simple effects showed that non-sceptical participants rated the pro-climate change Irish Times editorial as significantly more convincing ($M = .45$, $SD = .90$) than the sceptical Scotsman editorial ($M = -.36$, $SD = 1.12$), $t(171) = 3.00$, $p < .01$, while sceptical individuals rated the Scotsman as significantly more convincing ($M = .46$, $SD = 1.10$) than the Irish Times ($M = .01$, $SD = 1.04$), $t(171) = -4.89$, $p < .001$.

There was also a significant main effect of experimental condition, with the science-based editorials rated as significantly more convincing than the editorials that focussed on moral/political uncertainty, $F(1, 169) = 8.35$, $p < .01$. There were no significant interactions between experimental condition and either of the other variables, however, suggesting that the same pattern (i.e. biased assimilation) of convincingness ratings was observed in both experimental conditions. Follow-up analysis confirmed that this was the case (statistical analyses included in Appendix 2).

The same analysis was conducted using ratings of the reliability of the editorials as a dependent variable. There was no main effect of level of scepticism, but there was a main effect of editorial type, with the Irish Times rated as significantly more reliable overall than the Scotsman, $F(1, 169) = 13.66$, $p < .001$. Once again there was a highly significant interaction between level of scepticism and editorial type, $F(1, 169) = 26.56$, $p < .001$. T-tests of the simple effects showed that non-sceptical participants rated the pro-climate change Irish Times editorial as significantly more reliable ($M = .41$, $SD = .94$) than the sceptical Scotsman editorial ($M = -.39$, $SD = 1.01$), $t(171) = 3.07$, $p < .01$, while sceptical individuals rated the Scotsman as significantly more reliable ($M = .09$, $SD = .92$) than the Irish Times ($M = -.04$, $SD = .95$), $t(171) = -3.27$, $p < .001$.

Similarly to the convincingness ratings, there was a main effect of experimental condition, with the science-based editorial rated as significantly more reliable overall than the moral/political editorials, $F(1, 169) = 8.63$, $p < .01$.[6] There was no significant interaction between experimental condition and level of scepticism, although there was an interaction between experimental condition and reliability ratings, $F(1, 169), = 6.01$, $p < .05$. Follow-up analysis (statistical analyses included in Appendix 2) showed that in the political/moral uncertainty condition, the expected pattern of biased assimilation occurred. In the scientific uncertainty condition, however, sceptical participants attributed almost identical ratings of reliability to the pro-climate change and sceptical editorials. In fact, the pro-climate change editorial was rated as marginally more reliable by the *sceptical* group, providing the only exception to the pattern of biased assimilation in the editorial evaluation measures.

'Actual' attitude change – no attitude polarisation

A repeated-measures ANOVA was conducted to establish whether attitudes towards climate change altered after reading the editorials. Mean scores on the scepticism scale (before vs. after reading the editorials) were entered as the within-groups variable, while experimental condition (scientific vs. political/moral uncertainty) and scepticism group (sceptical vs. non-sceptical) were included as between-groups variables. There was a significant within-group effect, as overall scepticism about climate change increased after reading the editorials, $F(1, 169) = 11.28$, $p < .001$. Interestingly, however, they did not cross the threshold into "scepticism territory" (i.e. a mean score greater than 0 on the scepticism scale). Taking the sample as a whole, the mean post-editorial scepticism scale score increased to -0.16 (SD=0.67), from -0.24 (SD=.63) pre-editorial. There was also a main effect of level of scepticism, indicating that a significant difference between the sceptical and non-sceptical groups was maintained across the pre and post scepticism scores, $F(1, 169) = 356.05$, $p < .001$. There was no main effect of experimental condition, nor any interactions between experimental condition and the other variables – attitude change was not impacted by the *type* of editorials participants read. Crucially, there was no interaction

[6] In both convincingness and reliability ratings, the scientific editorials were rated more highly than the editorials that focussed on moral/political uncertainty. This indicates that the two experimental conditions were not equivalent. However, we were not seeking to construct editorials of equivalent strength (which would be challenging for multiple reasons), but to compare participants' responses to the different types of uncertainty – scientific and moral/political – generated through the conflicting articles.

between level of scepticism and pre/post scepticism scores. As Figure 3 shows, we observed no evidence of polarisation in attitudes.

Figure 3 about here

While the scepticism scale as a whole showed that participants shifted uniformly towards greater scepticism, analysis by individual questions suggested some interesting variation between items on the scale (see Table 3). In fact, there were only a few items which showed significant changes, including significant increase in agreement with the item "I do not believe climate change is a real problem". Strikingly, significant changes in pre/post ratings of individual items were evident for items about the reliability of scientific evidence, complexity and expert disagreement – suggesting that these are the specific attitudes about climate change that are most susceptible to perceived uncertainty.

Table 3 about here

'Reported' attitude change – some evidence of polarisation

A between-groups ANOVA was conducted with experimental condition and level of scepticism as the independent variables, and degree of reported change as the dependent measure. There was no effect of experimental condition. However, participants in the non-sceptical group reported becoming marginally but significantly ($F (1, 172) = 16.08$, $p < .001$) more convinced about climate change after reading the editorials ($M = .17$, $SD = 1.00$), while participants in the sceptical group reported becoming less convinced ($M = -.45$, $SD = .1.01$). Thus, in the measure of self-reported change (and in keeping with previous research on attitude polarisation) there was some evidence of attitude polarisation.

Discussion

The current research was designed to address two key questions. Firstly, whether individuals with opposing attitudes towards climate change would assimilate novel, conflicting information about climate change in a biased way and exhibit attitude polarisation, and secondly whether people would respond differently to different types of conflicting evidence about climate change (i.e. scientific or political/moral uncertainty). The results represent the first attempt to apply the well-established

biased assimilation and attitude polarisation paradigm to the practically important topic of attitudes about climate change.

With regard to the first question, our results provide strong evidence that individuals with opposing attitudes towards climate change assimilate novel, conflicting information about climate change in a biased way. When participants were split into two groups ('sceptical' and 'non-sceptical'), they evaluated two editorials positing opposing arguments about climate change in a markedly different way. Participants seemed to evaluate the convincingness and reliability of the editorials according to their existing attitudes: those with greater prior scepticism about climate change rated the sceptical editorial as more convincing and more reliable than the pro-climate change editorial (and vice versa for less sceptical participants). This finding is consistent with the large body of literature that has previously demonstrated the biased assimilation of evidence by people with opposing views on a number of different topics (see, e.g., Kuhn & Lao, 1996; Lord et al, 1979; Munro & Ditto, 1997), and suggests that attitudes about climate change are likely to be subject to the same psychological demands and tensions as other 'controversial' subjects.

We observed only limited evidence of attitude polarisation. The sample as a whole became slightly (but significantly) more sceptical about climate change after reading the editorials. However, this shift was fairly uniform – there was no evidence from participants' pre- and post- editorial attitudes that individuals with opposing attitudes about climate change had diverged even further (the signature of attitude polarisation). Using a measure of 'reported' change (i.e. when participants were asked to indicate whether they thought their attitudes had changed), we found some evidence of polarisation – again, in keeping with the existing literature on assimilation and polarisation. Theoretically, our results add to the body of evidence that suggests biased assimilation and attitude polarisation may be independent constructs – as biased assimilation can often be found without strong evidence of polarisation (Kuhn & Lao, 1996).

With regard to the second question – whether people would respond differently to scientific or moral/political uncertainty – we observed no impact of experimental condition on actual or reported attitude change. In the reliability ratings of the science-based editorials, we observed the only exception to the pattern of biased

assimilation – sceptical participants did not perceive the sceptical science-based editorial as more reliable than the pro-climate change editorial. This finding suggests that the biasing influence of prior attitudes may be less powerful when the information under consideration is based on (relatively objective) facts and figures, rather than political opinion and conjecture.

A limitation of the current paper is the convenience sample used – like many experimental psychology studies the sample was skewed towards female participants, and was comprised exclusively of undergraduate students studying Psychology. The use of such a sample was borne out of practical constraints on resources for conducting the research – but the risk of relying on a sample of Psychology students is that they may have knowledge about the experimental task, or anticipate a level of deception that other participants would not (see Corner, Harris & Hahn, 2009, for a discussion of the 'pragmatics' of experimental participation). It is not possible to eliminate this risk entirely, but qualitative measures were included in the battery of questions administered during the experiment, providing space for participants to indicate more general thoughts about the materials, and their reasons for changing their attitudes in response to the newspaper editorials. Although for reasons of space we do not report an analysis of these data, there was no indication that participants anticipated the deception or the aim of the experiment.

We are following up the experimental data reported here using a nationally representative sample – and the results of this will provide an important test of the validity of our initial investigation into climate change attitude polarisation. Other work conducted by the authors (e.g., Lorenzoni et al., 2007; Whitmarsh, 2011) has also sought to 'triangulate' different research methodologies (qualitative as well as quantitative) to provide even stronger evidence for the existence of patterns and trends in climate change scepticism. But even on the basis of the current findings, there are several implications for understanding how the public may respond to uncertain or conflicting information about climate change – whether it is scientific or moral/political in nature.

Firstly, the provision of conflicting evidence – both scientific and moral/political uncertainty – had the effect of *increasing* scepticism (albeit marginally) among both groups of participants. In keeping with the perception (expressed by scientists in

Frewer et al., 2003) that the communication of uncertainty is often interpreted as evidence that a subject is poorly understood, single item analyses found that participants in both experimental groups showed a significant decrease in the extent to which they perceived scientists to be in agreement, and a significant increase in the belief that climate change evidence is unreliable. This poses something of a dilemma for those seeking to communicate uncertainty: an increased focus on the areas in which uncertainties remain may be interpreted as evidence that the case for anthropogenic climate change is weaker than it actually is. Thus, although the message may be technically more *accurate*, it may simultaneously be *less accurately interpreted* (from the perspective of the intended audience).

A pertinent practical example of this 'uncertainty dilemma' is the ongoing UK Climate Impacts Programme which produces regional and national projections of climate change for the UK. The latest report (UKCIP, 2009) is meticulous in its treatment of uncertainty, even incorporating a short tutorial in interpreting Bayesian (probabilistic) data. But while the inclusion of uncertainty information is designed to act as a communication aid, the evidence reported in the current paper suggests that this may not always be the outcome. One response to the uncertainty dilemma is provided by Morton, Rabinovich, Marshall and Bretschneider (2010): they found that when uncertainty was used to indicate that losses *might not* happen if cautious action is taken to prevent them (i.e. a positive framing of the uncertainty information), then people were more likely to indicate stronger intentions to act in a pro-environmental way. Morton et al concluded that uncertainty is not an inevitable barrier to action, provided communicators frame climate change messages in ways that trigger cautious action in the face of uncertainty (rather than avoidance or inaction).

Secondly, although more and more information about climate change is being disseminated, this information is unlikely to be assimilated in the same way by people who initially differ in their assessment of the reality and seriousness of climate change. This means that while the evidence for anthropogenic climate change grows stronger, uncertainty remains on the social, economic, moral and political aspects of climate change. The challenge for climate change communicators will be to ensure that scientific uncertainties and political uncertainties are, as far as possible, not conflated, since it is the latter domains where the effects of biased assimilation and attitude polarisation seem to be most dominant (see also Pidgeon & Fischhoff, 2011,

for a discussion on non-persuasive communication). The current research examined one distinction between types of uncertainty – scientific and moral/political – but there are clearly others that would also warrant investigation (extending, for example, the work of Patt, 2007 on the difference between perceptions of model-based and conflict-based uncertainty in science; or of Poortinga et al. (2011) who distinguish trend, attribution, and impact uncertainties within a UK public sample).

Finally, our results suggest that as more entrenched positions are taken up on the topic of climate change by members of the public, message-based campaigns to engage the public with climate change may have less value. Given the value basis of climate change perceptions, evident from our regression analysis and several previous studies (e.g., Whitmarsh, 2011), constructive climate change communication should promote dialogue and focus on exposing and discussing values and trade-offs between them (Shwom, Bidwell, Dan & Dietz, 2010). Deliberative fora are more appropriate than unidirectional communication for achieving this deeper level of debate and discourse; furthermore, by encouraging systematic (rather than superficial) processing of information (Petty & Cacioppo, 1984), deliberation is more likely to lead to the durable attitudinal and behavioural changes that are crucial for increasing public engagement with climate change.

Future work should seek to further disentangle the factors that determine *how* uncertainty impacts on perceptions of climate change. Testing additional examples of 'moral/political' and 'scientific' uncertainty (as well as exploring different typologies of uncertainty) would provide important evidence of the generalisability of the current results. Of course, the frequent blurring of the distinction between the different types of uncertainty associated with debates about climate change may explain *why* reasoning about climate change is vulnerable to the effect of biased information processing – the science and the political/social implications of climate change are often, but unhelpfully, presented as interchangeable in the communication of climate change messages.

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Table Captions

Table 1: Items in the climate change scepticism scale

Table 2: Standardised coefficients from a linear regression analysis of scores on the scepticism scale (R^2=.30).

Table 3: Mean pre/post scores for selected items from the scepticism scale. Only those items with significant changes (amongst either group, or both) are shown (in bold typeface), and significance is indicated by t-statistics.

Figure Captions

Figure 1: Mean convincingness ratings assigned to the editorials by ‘non-sceptical’ and ‘sceptical’ groups (data from both experimental conditions).

Figure 2: Mean reliability ratings assigned to editorials by ‘non-sceptical’ and ‘sceptical’ groups (data from both experimental conditions).

Figure 3: Attitude change amongst ‘non-sceptical’ and ‘sceptical’ groups (data from both experimental conditions).

Table 1

1	Climate change is too complex and uncertain for scientists to make useful forecasts
2	Claims that human activities are changing the climate are exaggerated
3	The media is often too alarmist about issues like climate change
4	I do not believe climate change is a real problem
5	Floods and heat-waves are not increasing, there is just more reporting of it in the media these days
6	Climate change is just a natural fluctuation in Earth's temperatures
7	It is too early to say whether climate change is really a problem
8	There is too much conflicting evidence about climate change to know whether it is actually happening
9	Too much fuss is made about climate change
10	The evidence for climate change is unreliable
11	Many leading experts still question if human activity is contributing to climate change
12	I am uncertain about whether climate change is really happening
13*	There is solid evidence that the Earth is warming because of human activities
14*	Recent floods and heat-waves in this country are due to climate change
15*	I am convinced that climate change is really happening
16*	Experts are agreed that climate change is a real problem
17*	Changes in climate over the last 100 years are mainly caused by human activities

* reverse scored

Table 2

	B	Std. Error	β
Gender	0.05	0.13	0.03
Age	-0.01	0.02	-0.02
Politics (Conservative)	0.06	0.12	0.04
Politics (Liberal Democrat)	0.01	0.12	0.01
Politics (Green)	0.17	0.17	0.07
Politics (Would Not Vote)	0.12	0.13	0.07
Politics (Other or Prefer not to Say)	-0.09	0.19	-0.03
Member of environmental organisation	-0.30	0.19	-0.11
Mean score on NEP Scale	-0.53	0.07	-0.51*

Politics (Labour) excluded from regression model due to exceeding collinearity tolerance

* p > .001

Table 3

	'Non-sceptical' group (N=89)					'Sceptical' group (N=88)				
	Means					Means				
	Pre	**Post**	**SD**	**t**	**Sig. (2-tailed)**	**Pre**	**Post**	**SD**	**t**	**Sig. (2-tailed)**
Climate change is too complex and uncertain for scientists to make useful forecasts	-.29	-.35	.93	-.57	.57	.49	.69	.95	2.02	**.05**
I do not believe climate change is a real problem	-1.34	-1.17	.63	2.54	**.01**	-.40	-.17	.84	2.54	**.01**
Experts are agreed that climate change is a real problem[1]	-.93	-.47	1.14	3.82	**.00**	-.27	-.06	1.01	2.00	**.05**
The evidence for climate change is unreliable	-.87	-.55	.94	3.17	**.00**	.38	.70	.89	3.46	**.00**
Mean score on Scepticism Scale	-.75	-.65	.34	2.65	**.01**	.28	.37	.31	2.62	**.01**

[1] Reverse scored

Figure 1

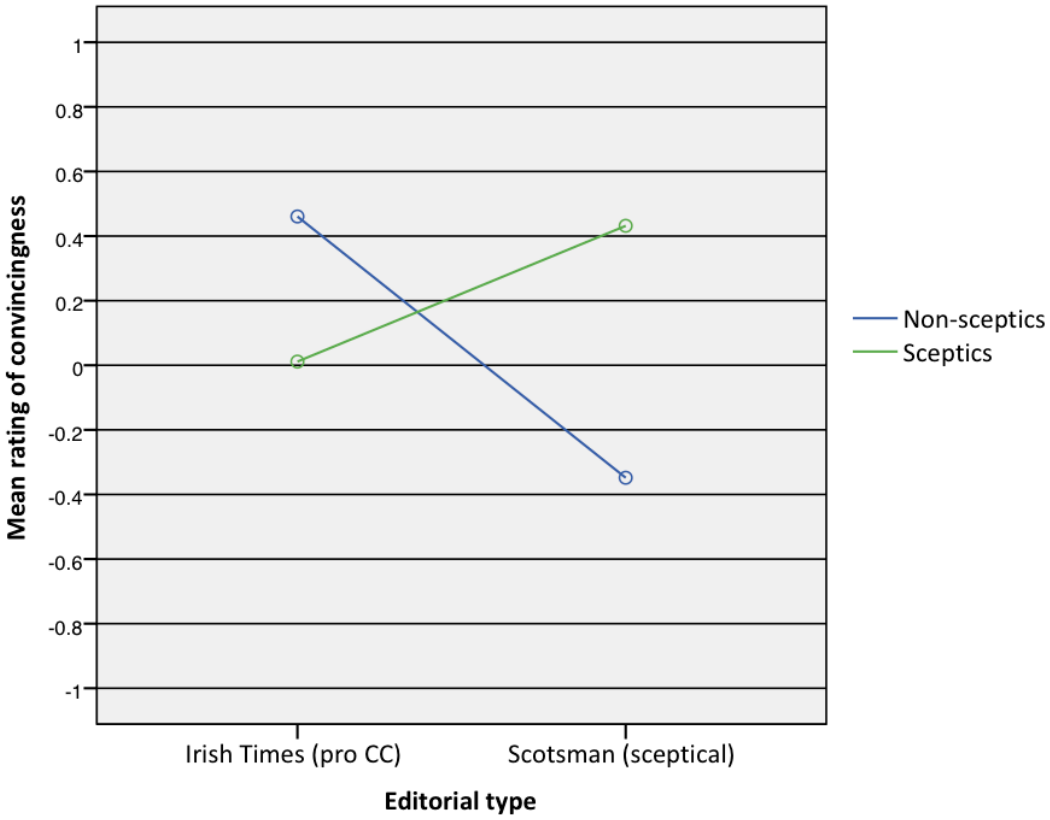

Mean rating of convincingness
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Irish Times (pro CC)
Scotsman (sceptical)
Editorial type
Non-sceptics
Sceptics

Figure 2

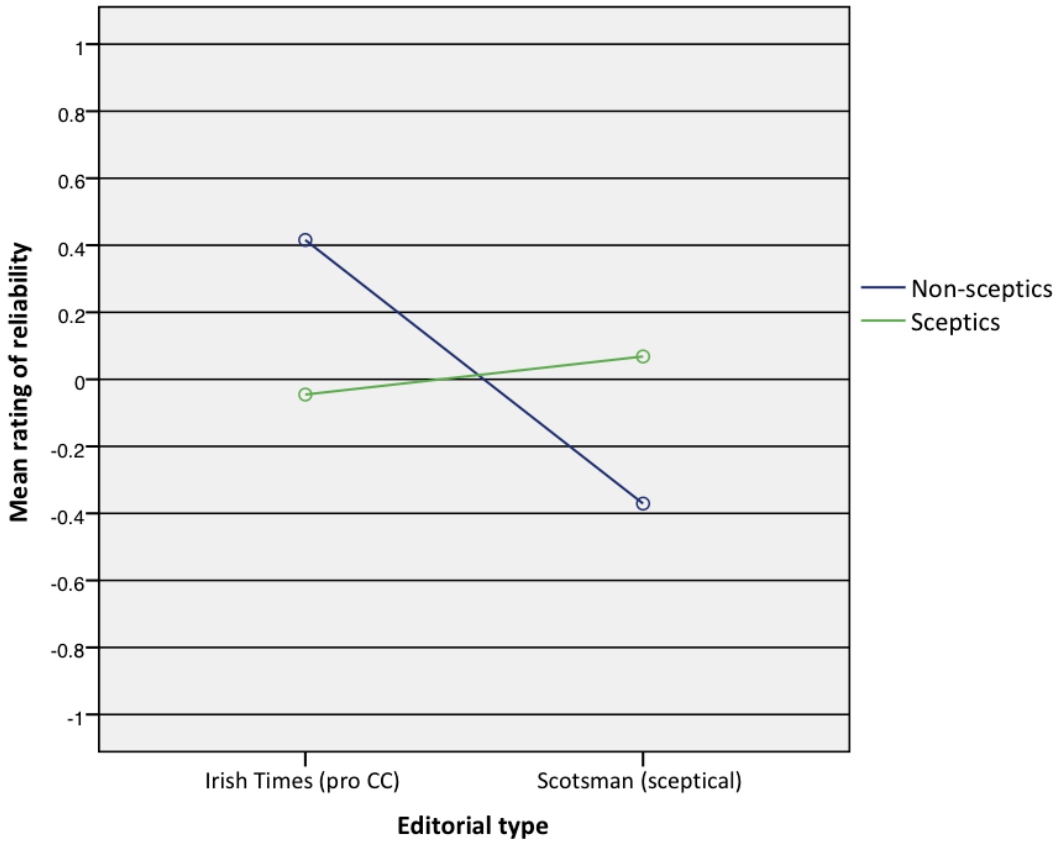
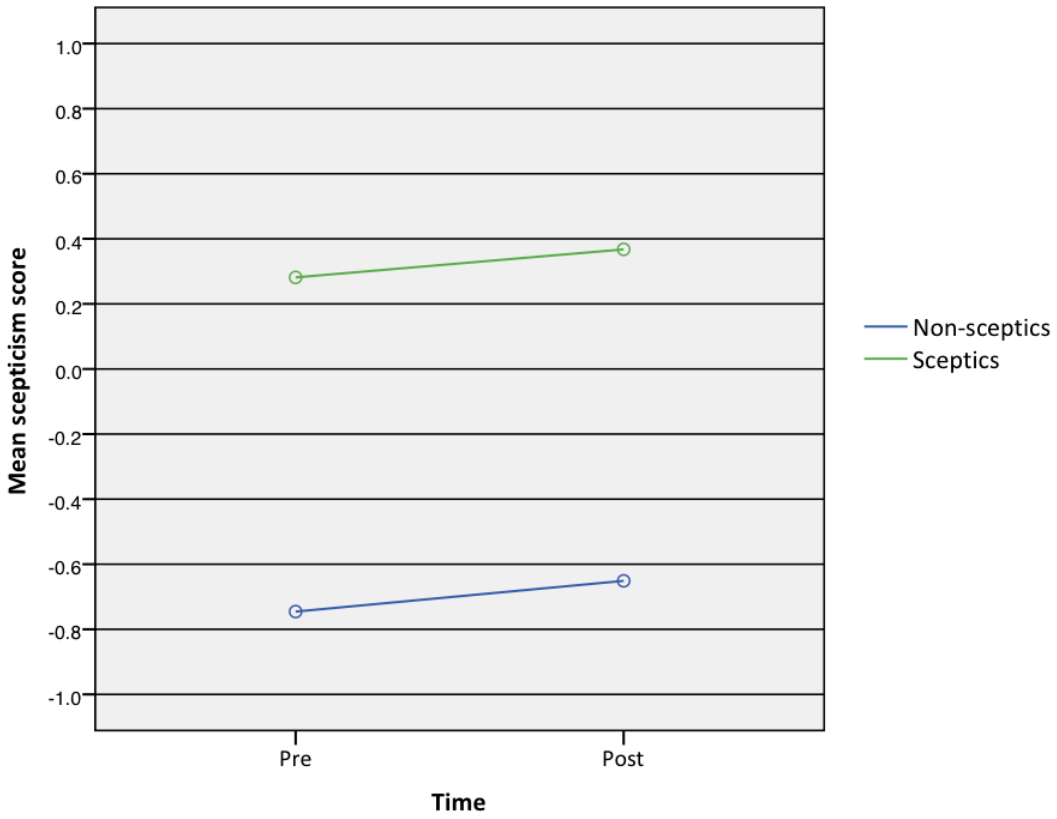

1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
Mean rating of reliability
Irish Times (pro CC)
Scotsman (sceptical)
Editorial type
Non-sceptics
Sceptics

Figure 3


1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
Mean scepticism score
Pre
Post
Time
Non-sceptics
Sceptics