

Climate Change Beliefs and Perceptions of Weather-Related Changes in the United Kingdom

Andrea Taylor,^{1,2} Wändi Bruine de Bruin,^{1,3,*} and Suraje Dessai^{2,4}

Public perception research in different countries has suggested that real and perceived periods of high temperature strengthen people's climate change beliefs. Such findings raise questions about the climate change beliefs of people in regions with moderate climates. Relatively little is known about whether public concerns about climate change may also be associated with perceived changes in other weather-related events, such as precipitation or flooding. We examine the relationship between perceived changes in weather-related events and climate change beliefs among U.K. residents at a time of below-average winter temperatures and recent flooding. National survey data ($n = 1,848$) revealed that heat waves and hot summers were perceived to have become *less common* during respondents' lifetimes, while flooding, periods of heavy rainfall, coastal erosions, and mild winters were perceived to have increased in frequency and cold winters were perceived to be unchanged. Although perceived changes in hot-weather-related events were positively associated with climate change beliefs, perceived changes in wet-weather-related events were found to be an even stronger predictor. Self-reported experience of "flooding in own area" and "heat-wave discomfort" also significantly contributed to climate change beliefs. These findings highlight the importance of salient weather-related events and experiences in the formation of beliefs about climate change. We link our findings to research in judgment and decision making, and propose that those wishing to engage with the public on the issue of climate change should not limit their focus to heat.

KEY WORDS: Climate change belief; experience; flood; heat; risk perception; weather

1. INTRODUCTION

The Fifth Assessment Report of the Intergovernmental Panel on Climate notes that global mean surface temperature "warmed strongly over the pe-

riod 1900–1940, followed by a period with little trend, and strong warming since the mid 1970s" and that "more than half of the observed increase in global mean surface temperature from 1951 to 2010 is very likely due to the observed anthropogenic increase in greenhouse gas concentrations."⁽¹⁾ In line with such expert assessments, public perception surveys have found that people in different countries commonly list "temperature increases" as a potential consequence of a changing climate.^(2,3) Perhaps as a result, perceptions of temperature increases play an important role in people's beliefs about climate change.^(4–6) Both perceived⁽⁷⁾ and directly measured^(8–11) fluctuations in temperature have been found to be significant predictors of climate change beliefs

¹Leeds University Business School, Centre for Decision Research, Leeds, UK.

²Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, UK.

³Carnegie Mellon University, Department of Engineering and Public Policy, Pittsburgh, PA, USA.

⁴ESRC Centre for Climate Change Economics and Policy, University of Leeds, Leeds, UK.

*Address correspondence to Wändi Bruine de Bruin, Leeds University Business School, Centre for Decision Research, Leeds, LS2 9JT, UK; W.BruinedeBruin@leeds.ac.uk.

and related concerns, as have experimentally manipulated variations in hot or cold indoor temperature.⁽¹²⁾⁵

This pattern of results is in line with research on the *availability heuristic*, which suggests that people tend to judge the likelihood of phenomena (such as climate change) by the ease with which relevant events (such as hot weather) come to mind.^(14,15) Because memory is biased toward events that are recent, unusual, and personally experienced, such events are most likely to drive people's likelihood judgments.⁽¹⁶⁾ For example, people tend to judge inflation by their recent personal experiences with unusually large price changes.⁽¹⁷⁾ As a result, we suspect that, when people are judging the extent to which climate change is happening, personal experiences with unseasonably hot temperatures are likely to receive the most attention.

A potential concern about such a focus on temperature increases is that people may become less concerned about climate change when the weather is not hot.⁽⁵⁾ It has indeed been suggested that, in addition to the economic crisis, the relatively low U.S. temperatures of 2008 may have reduced the strength of Americans' climate change beliefs.^(5,18) Moreover, individuals living in areas with colder climates may actually look forward to experiencing warmer summers as a result of climate change.⁽¹⁹⁾

However, climate change will likely not just bring temperature increases. Depending on the region, climate change may also contribute to other weather-related events.⁽²⁰⁾ For example, flooding is expected to become more common in specific regions such as the United Kingdom.⁽²¹⁾ Recent U.K. weather patterns appear to be inline with this prediction. Between 2007 and 2012, the United Kingdom experienced widespread flooding.⁽²²⁾ Though not a projected climate change impact for this region, during this time the country also experienced below-average winter and summer temperatures.⁽²³⁾ Hence, the question remains as to which weather experiences may inform the climate change beliefs of U.K. residents.

⁵It should be noted that a recent U.S. study examining trends in public climate change concern across opinion polls did not find an effect of weather extremes on public opinion at a national aggregate level.⁽¹³⁾ However, as the study in question focused on aggregate trends rather than associations between individual-level weather experience, perception, and climate change belief amongst those sampled, it should not—as Brulle *et al.* point out—be interpreted to mean that experience and perceptions of weather do not impact on individuals' climate change beliefs.

Although the research that was discussed above suggested a link between perceptions of temperature increases and beliefs about climate change, most of that work has been conducted in the United States.^(6,8–11,24,25) One study did find that U.K. participants were most likely to list temperature increases in response to an open-ended question about what they knew about “climate change,” especially if it was referred to as “global warming.”⁽³⁾ However, when asked directly about the impacts of climate change, “temperature increases/heat” was only the ninth most popular response, with participants being more likely to mention flooding.

Another study that examined perceived consequences of climate change found that U.K. participants were less likely than U.S. participants to reference “heat” while only U.K. respondents mentioned “rain.”⁽²⁾ In part, these findings may have been due to the phrase “climate change” being used with U.K. participants and “global warming” with those in the United States. However, differences in climate between localities may also play a role. Another recent U.S. investigation examining perceived personal experiences of “global warming” among residents in one Michigan county found that the experiences reported by participants included perceived *reductions* in rainfall.⁽²⁶⁾ This perceived reduction in rainfall was consistent with meteorological records.⁽²⁶⁾ Thus, there is a need for a country-specific examination, focusing on public perceptions of those weather patterns that may be changing in the United Kingdom as a result of climate change, and their association with public climate change beliefs.

Moreover, there is reason to believe that between-country variations in perceptions of weather and climate change may reflect people's different experiences. Indeed, personal experience with specific hazards changes people's perceptions of these hazards.⁽²⁷⁾ Research on the *affect heuristic* additionally shows that events that trigger stronger negative affect are perceived as more risky.^(28,29) People who have experienced flooding in their own home tend to be more concerned about flooding and perceive greater flood risk.^(30,31) However, the relationship between experience with flooding and climate change beliefs is unclear, with one U.K. study finding no relationship⁽³²⁾ and another U.K. study finding that individuals with flood experience had more concerns about climate change,⁽³³⁾ suggesting the possibility of growing awareness that flooding events may occur as a result of climate change. Even the experience of environmental hazards such as air

pollution are positively correlated with climate change concern.⁽³²⁾ Overall, negative experiences with extreme weather-related events may lead to negative mental images about climate change and reduced psychological distance, which are associated with perceiving climate change as more dangerous.^(34–38)

This article examines perceptions of climate change and weather-related events among the British public during January/February 2013: a time during which central England temperature was below the 1983–2012 winter average,⁽²³⁾ and the nation had recently witnessed several highly publicized flooding events⁽²²⁾ as well as experienced below-average summer temperatures.⁽²³⁾ This article aims to provide new insights about whether people in the United Kingdom perceive different weather-related events to be changing, as well as how their perceptions and experiences of changes in these weather-related events contribute to their climate change beliefs. Our analyses control for pro-environmental values,^(32,39,40) as well as demographic factors such as age and gender,^(39,41,42) which have been associated with having stronger beliefs about climate change.

Based on the literature review presented above, we therefore sought to address the following research questions via a national U.K. survey conducted by Ipsos MORI:

- (1) Do our U.K. participants perceive the frequency of different weather-related events to have changed in their lifetime?
- (2) Are overall climate change beliefs associated with perceived changes in the frequency of weather-related events?
- (3) Is personal experience with the negative consequences of specific weather-related events (e.g., flooding, water restrictions, heat-wave-associated hazards) associated with perceived changes in the frequency of weather-related events and overall climate change beliefs?
- (4) What is the relative contribution of weather-related perceptions and experiences to beliefs about climate change?

2. METHOD

2.1. Participants

A national U.K. sample ($n = 2,007$) took part in an online survey conducted by Ipsos MORI.¹ The sample consisted of Ipsos MORI panel members who

had agreed to participate in online market and social research. Panel members were recruited via a two-stage “opt-in” process, whereby those wishing to become members first completed an online recruitment survey in which they provided demographic details and accepted the terms and conditions of membership. These individuals were then emailed a hyperlink, which they clicked to confirm acceptance.

Owing to missing or “don’t know” responses on key summary measures of pro-environmental values (Section 2.3.1), beliefs regarding changes in weather (Section 2.3.2), and climate change beliefs (Section 2.3.4), 158 members of the sample were excluded from our analyses. Of the remainder ($n = 1,848$), 953 were female (51.6%). Participants’ ages ranged from 16 to 94, with a mean of 47.5 ($SD = 18.1$). With respect to education 751 (40.6%) participants reported having a bachelor’s degree or higher. According to U.K. mid 2012 population estimates,⁽⁴³⁾ the gender composition of the U.K. population aged 16+ was 51.3% female. For people aged 16–89, mean age was 46.1 ($SD = 19.0$). Thus, our sample (of which only three members were aged over 89) can be said to be similar to that of the general population 16–89 in terms of gender composition and average age. With respect to education, data from the 2011 census⁽⁴⁴⁾ indicated that 27% of the population 16+ held a higher education qualification. Our sample therefore contains a greater proportion of highly educated individuals than the population as a whole.

The participants who were retained in the final sample and those who were excluded due to missing responses did not differ with respect to gender ($X^2 = 1.13$; $p > 0.05$) or education ($X^2 < 0.01$; $p > 0.05$). However, there was a significant difference in age ($t(2,005) = 4.59$; $p < 0.01$), with those who were retained having a higher average age than those who were not.

2.2. Dates and Weather Context

Between January 30, 2013 and February 5, 2013, an online survey was conducted by Ipsos MORI with the purpose of gauging the British public’s perceptions of climate risk.

The survey was conducted shortly after a cold snap (January 16–23), during which eight consecutive days of negative temperatures were recorded in central England.⁽²³⁾ At 3.8 °C, mean central England winter temperature for 2012–2013 was below the 1981–2010 mean of 4.55°C.⁽²³⁾ Central England temperature for spring, summer, and

autumn of 2012 was also below the 1981–2010 average.⁽²³⁾ Mean precipitation for winter 2012–2013 in the United Kingdom was above the 1981–2010 mean, as was mean precipitation for the summer of 2012, with the year as a whole being one of the wettest on record for the United Kingdom.⁽⁴⁵⁾ In the year preceding the data collection the country experienced several flooding events, with some of the most highly publicized occurring in November 2012.⁽²²⁾

2.3. Measures

The authors of this article had an advisory role in the design of the measures for this survey. Below, we discuss the assessment of the control variables (Section 2.3.1) and our focal measures (Sections 2.3.2–2.3.4) in the survey. With the exception of the demographic control variables, which were either prerecorded by Ipsos MORI or appeared at the very end of the survey, measures are reported in the order in which they were presented to participants.

2.3.1. Control Variables

Our participants reported the degree to which they held pro-environmental values on a short form of the New Ecological Paradigm Scale.⁽⁴⁶⁾ Agreement with six statements (e.g., “Humans are severely abusing the planet”) was measured on a five-point scale (1 = “strongly agree”; 5 = “strongly disagree”), with an additional “don’t know” option. Responses to these items were coded so that a higher score corresponded with greater concern for nature while “don’t know” responses were coded as missing. A summary score was derived by calculating the scale mean. Internal consistency is reported in the Section 3.4.

The demographic variables of age, gender (0 = male, 1 = female), and education (0 = no higher education, 1 = higher education) are also controlled for. At the time of the survey, age and gender had been prerecorded by Ipsos MORI. Participants were asked for their highest level of educational attainment at the end of the survey.

2.3.2. Beliefs Regarding Changes in Weather

Participants were asked to state whether they thought that nine different weather-related events had become more (or less) frequent during their lifetime. The events were: snow, cold winters, mild winters, dry periods without rain, heat waves, flooding,

periods of heavy rainfall, hot summers, and coastal erosion. Responses were provided on a five-point scale (1 = “a lot more frequent”; 5 = “a lot less frequent”). For our analyses, we reverse coded these responses so that a higher score reflected greater perceived frequency. An additional “don’t know” response was available. The internal consistency of these items is examined in Section 3.1.

2.3.3. Climate Change Beliefs

Climate change beliefs were measured with three questions taken from previous research.⁽⁴⁷⁾ Specifically, we asked: (1) How convinced are you, if at all, that climate change is currently affecting the planet? (2) How convinced are you, if at all, that climate change is currently affecting the United Kingdom? (3) How concerned, if at all, are you about climate change? Four response options ranged from “totally convinced” (= 1) to “not at all convinced” (= 4) for the first two questions, and from “very concerned” (= 1) to “not at all concerned” (= 4) for the third. Additional “don’t know” and “no opinion” response options were provided. Responses were reverse coded so that higher scores reflected stronger climate change beliefs, treating “don’t know” or “no opinion” as missing responses. A summary scale of climate belief was computed by calculating the mean of the three items. See Section 3.2 for details of internal consistency.

2.3.4. Personal Experience of Specific Weather-Related Hazards

Personal experience of weather-related hazards was measured by six items that recorded (on a binary experienced/not experienced scale) whether participants had personally experienced: flooding in own home, flooding in local area, water restrictions, discomfort due to a heat wave, illness due to a heat wave, or transport disruption due to a heat wave.

3. RESULTS

3.1. Do Our U.K. Participants Perceive the Frequency of Different Weather-Related Events to Have Changed in Their Lifetime?

Table I shows mean perceived change in the frequency of nine weather-related events. Because responses were given on a five-point bipolar scale

Table I. Mean (*SD*) and Factor Analysis for Perceived Changes in Nine Weather-Related Events

| Weather-Related Event | Mean (<i>SD</i>) Perceived Change ^a | Factor Analysis ^b | | |
|---------------------------|--|------------------------------|-------------|--------------|
| | | Hot Events | Wet Events | Cold Events |
| Flooding | 4.38 (0.69)*** | -0.09 | <u>0.83</u> | 0.04 |
| Periods of heavy rainfall | 4.16 (0.77)*** | -0.13 | <u>0.80</u> | 0.08 |
| Coastal erosion | 3.86 (0.76)*** | 0.04 | <u>0.72</u> | -0.05 |
| Mild winters | 3.36 (1.00)*** | 0.28 | 0.26 | <u>-0.73</u> |
| Cold winters | 3.05(1.05) | 0.13 | 0.11 | <u>0.86</u> |
| Snow | 3.00 (1.09) | 0.22 | 0.15 | <u>0.79</u> |
| Dry periods without rain | 2.97 (1.07) | <u>0.73</u> | 0.05 | -0.02 |
| Heat waves | 2.48 (1.06)*** | <u>0.85</u> | -0.09 | 0.06 |
| Hot summers | 2.26 (1.02)*** | <u>0.83</u> | -0.17 | 0.10 |
| Eigen value | - | 2.1 | 2.0 | 1.9 |
| Variance explained | - | 23.4% | 22.1% | 21.3% |

^aPerceived changes in weather-related events were assessed on a scale from 1 (= definitely decreased) to 5 (= definitely increased); one-sample *t*-tests examined difference from midpoint (= no change); a Bonferroni correction adjusts for multiple tests (adjusted $\alpha = 0.01$).

^bThe highest factor loadings are underlined.

*** Significant at the 0.001 level.

going from definitely decreased to definitely increased, the scale midpoint of 3 indicated perceiving no change in frequency. A series of one-sample *t*-tests with Bonferroni correction were used to examine whether perceived change in frequency significantly diverged from the midpoint. Our analyses suggest that, over their lifetime, our U.K. participants perceived increases in flooding, periods of heavy rainfall, coastal erosion, and mild winters—as seen in mean ratings being significantly above the scale midpoint. Participants perceive no change in cold winters, snow, and dry periods of rain, as seen in mean ratings that were not significantly different from the scale midpoint. Heat waves and hot summers were perceived to have decreased over participants' lifetime, as seen in mean ratings that were significantly below the scale midpoint.

Table I also shows the factor loadings for the principal-components analysis with varimax rotation across the perceived changes reported for the nine weather-related events, highlighting the highest loading for each item onto each factor. The highest loadings onto the first factor appeared to be hot-weather-related events, including dry periods without rain, heat waves, and hot summers. The highest factor loadings onto the second factor appeared to be wet-weather-related events, including flooding, periods of heavy rain, and coastal erosion. The highest loadings onto the third factor appeared to be cold weather related, including mild winters, cold winters, and snow—with mild winters loading negatively onto the construct and requiring reverse cod-

ing before computing a summary measure. Summary measures for each factor were computed by taking the mean across reported ratings. Our subsequent analyses will use these summary scores. Their internal consistency was sufficient, as is seen in Cronbach's α of 0.74 for perceived changes in hot-weather-related events, 0.70 for perceived changes in wet-weather-related events, and 0.72 for perceived changes in cold-weather-related events after reverse coding mean rated changes for mild winters.

3.2. Are Overall Climate Change Beliefs Associated with Perceived Changes in the Frequency of Weather-Related Events?

The internal consistency of the three climate change belief items was high ($\alpha = 0.93$), thus supporting their incorporation into a single summary scale. The mean score on the climate belief summary scale was 2.8 ($SD = 0.8$), which was slightly above the feelings of "indifference" reflected by the scale midpoint of 2.5 ($t(1,847) = 18.24; p < 0.001$). A significant positive association was found between climate change belief and perceived change in wet-weather-related events ($r = 0.35; p < 0.001$), indicating that those who had stronger climate change beliefs tended to perceive a stronger increase in the frequency of wet-weather-related events. Climate change belief was also positively correlated with perceived change in cold-weather-related events ($r = 0.06; p < 0.05$) and hot-weather-related events ($r = 0.11; p < 0.001$),

Table II. Correlations Between Reported Experience with the Negative Consequences of Specific Weather-Related Events, Perceptions of Changes in the Frequency of Weather-Related Events, and Climate Change Beliefs

| Experience | Percent with Experience | Pearson's Product Moment Correlations | | | |
|---|-------------------------|---------------------------------------|------------|-------------|--------------------------------|
| | | Hot Events | Wet Events | Cold Events | Overall Climate Change Beliefs |
| Discomfort related to heat wave | 40.4% | 0.15*** | 0.06 | 0.00 | 0.20*** |
| Water restrictions | 34.5% | 0.13*** | 0.03 | -0.02 | 0.12*** |
| Flooding in area | 21.3% | -0.01 | 0.09*** | 0.03 | 0.14*** |
| Transport disruption related to heat wave | 7.1% | 0.14*** | 0.02 | 0.06 | 0.10*** |
| Illness related to heat wave | 6.3% | 0.11*** | 0.05 | 0.02 | 0.08*** |
| Flooding in own home | 4.7% | 0.07 | -0.02 | 0.04 | 0.02 |

Note: Due to the large number of tests, we only report significance at the 0.001 level. This is in line with a Bonferroni correction for multiple tests, (adjusted $\alpha = 0.002$).

***Significant at the 0.001 level.

even though wet-weather and hot-weather-related events were negatively associated with one another ($r = -0.15$; $p < 0.001$).

3.3. Is Personal Experience with the Negative Consequences of Specific Weather-Related Events Associated with Perceptions of Changes in the Frequency of Weather-Related Events and Overall Climate Change Beliefs?

Table II shows that the most commonly reported experiences associated with specific weather-related events were discomfort related to a heat wave, followed by water restrictions and flooding in one's area. Fewer than 10% reported experience with transport disruption related to a heat wave, illness related to a heat wave, or flooding in one's own home.

Table II also shows that participants who reported hot-weather-related experiences such as discomfort due to heat waves, water restrictions, transport disruption due to heat waves, and illness related to heat waves were significantly more likely to have perceived increases in hot-weather-related events. Correlations of reported experiences with flooding in one's own area were significantly related to perceived increases in wet-weather-related events, but flooding in one's own home was not—perhaps as a result of the low number of participants who experienced the latter. Participants who reported the specific experiences also show relatively stronger overall climate change beliefs—except, again, for flooding in one's own home, which may not have been experienced by enough people to discover any relationship.

3.4. What is the Relative Contribution of Weather-Related Perceptions and Experiences to Overall Beliefs About Climate Change?

Table III shows the results of a linear regression analysis examining the relative contribution to overall climate change beliefs of (1) perceived change in the frequency of hot-, cold-, and wet-weather-related events, and (2) reported experience of the negative consequences of weather-related events—excluding “flooding in own home” as it was uncorrelated with climate change belief. Model 1 contained the control variables only and found that climate belief was positively associated with higher environmental values as measured on the New Environmental Paradigm Scale ($\alpha = 0.73$), higher education, and being female. A negative association between age and climate change belief was also found.

Model 2 controlled for Model 1 variables whilst adding perceived change in the frequency of weather-related events (hot, wet, and cold) and experience of the negative consequences of weather events (flooding in local area, water restrictions, heat-wave-related discomfort, heat-wave-related illness, and heat-wave-related transport disruption). All control variables remained significant in Model 2, except for female gender. More importantly, Model 2 showed that perceived change in the frequency of both wet-weather-related events and hot-weather-related events both had independent positive relationships with climate change beliefs. Perceived change in cold-weather-related events, however, made no additional contribution. Of the five negative consequences of weather-related events, only experienced “flooding in area” and “heat-wave discomfort” emerged as having an independent association with

Table III. Predictors of Climate Change Belief (Standardized B and Unstandardised Coefficient β)

| | Model 1 | | Model 2 | |
|--|------------------------------|----------|------------------------------|----------|
| | β | B | β | B |
| Control variables | | | | |
| Pro-environmental values ^a | 0.52*** | 0.45*** | 0.42*** | 0.37*** |
| Higher education | 0.19*** | 0.12*** | 0.20*** | 0.12*** |
| Gender (female) | 0.10** | 0.06** | 0.06 | 0.04 |
| Age | -0.01*** | -0.14*** | -0.01*** | -0.13*** |
| Perceived change in weather events | | | | |
| Perceived hot events | - | - | 0.12*** | 0.13*** |
| Perceived wet events | - | - | 0.36*** | 0.27*** |
| Perceived cold events | - | - | 0.02 | 0.02 |
| Reported experiences | | | | |
| Experienced flooding in area | - | - | 0.12** | 0.06** |
| Experienced water restrictions | - | - | 0.02 | 0.01 |
| Experienced heat-wave discomfort | - | - | 0.14*** | 0.00*** |
| Experienced heat-wave illness | - | - | 0.00 | 0.00 |
| Experienced heat-wave transport disruption | - | - | 0.07 | 0.02 |
| R^2 | 0.25 | | 0.34 | |
| ANOVA of full model | $F(4, 1,843) = 154.25^{***}$ | | $F(12, 1,835) = 81.36^{***}$ | |
| ANOVA of change | $F(4, 1,843) = 154.25^{***}$ | | $F(8, 1,835) = 33.90^{***}$ | |

^aMeasured with the New Environmental Paradigm Scale (see Section 2.3.1).

***Significant at the 0.001 level; **significant at the 0.01 level; *significant at the 0.05 level.

climate change belief. Together, perceived change in the frequency of weather-related events and reported experience of the negative consequences of weather-related events accounted for 9% of the variance in climate change belief.⁶

4. DISCUSSION

Public perception research in different countries has suggested that real and perceived periods of high temperature increase people's climate change beliefs. Such findings raise questions about the climate change beliefs of people in regions with moderate climates, such as the United Kingdom. Relatively little is known about whether public concerns about climate change may also be associated with changes in other weather-related events, such as precipitation or flooding. We therefore used national survey data to examine the relationship between perceived weather changes and climate change belief among U.K. res-

idents, at a time of below-average winter temperatures and recent flooding.

We report on the following main findings. First, we found heat waves and hot summers were actually perceived to have become *less common* over respondents' life time, with flooding, periods of heavy rainfall, coastal erosion, and mild winters being perceived as more common, and cold winters being perceived as unchanged. Second, climate change beliefs were positively correlated with perceptions of changes in each of these types of events. Third, self-reported experiences with adverse consequences of hot-, cold-, and wet weather-related events were also positively correlated with climate change beliefs.

Perhaps most importantly, our analyses indicated that, of the perceptions and experiences of weather-related events examined, climate change beliefs were most strongly associated with perceived increases in wet-weather-related events, followed by hot-weather-related events, with additional independent contributions from experiences with flooding in one's own area and heat-wave discomfort. These findings hold after controlling for other factors that have been shown to be associated with climate change beliefs, such as younger age,⁽³⁹⁾ higher education,⁽⁴¹⁾ and stronger pro-environmental beliefs.^(32,39,40)

⁶Separate analyses of the contribution of perceived change in the frequency of weather-related events and negative experience of the consequences of weather indicate that perceived change in the frequency of weather-related events accounts for greater variance in climate belief ($\Delta R^2 = 0.08$; $F(3, 1,840) = 76.39$; $p < 0.001$) than negative experiences of the consequences of weather ($\Delta R^2 = .01$; $F(5, 1,835) = 7.58$; $p < 0.001$). Further details are available from the authors on request.

Some of these perceptions, such as the increase in flooding and periods of heavy rainfall, are relatively consistent with observed weather data^(48–50) although the latter show complexities at the seasonal and regional scale that were not explored in our survey. Based on a linear trend from 1961 to 2006, U.K. summers have been shown to become hotter.⁽⁵¹⁾ However, from 2007 to 2012, five out of six summers were below the long-term average of 1981–2000, thus potentially explaining people's perception of a decrease in hot weather. Indeed, as previously mentioned, the survey was conducted shortly after a cold snap, during which eight consecutive days of negative temperatures were recorded in central England.⁽²³⁾

Our findings are inline with research in judgment and decision making, which suggests that heuristics play a role in the formation of people's judgments of risk. Specifically, the *availability heuristic* predicts that people judge the seriousness of climate change by the ease with which perceived changes in salient weather come to mind. The *affect heuristic* predicts that concerns about climate change will be stronger if the concept triggers negative affective experiences with, for example, extreme weather-related events that are perceived to have resulted from climate change. Our findings suggest that both (presumably "available") weather perceptions and (presumably negative "affective") experiences with extreme weather independently contribute to climate change beliefs. Even if perceptions and experiences make independent contributions to climate change beliefs, the two heuristics may not be so easily disentangled. Perceptions and experiences of extreme weather may both be more "available" from memory if they are associated with stronger negative affect. A similar argument has been made about the relationship between flood experience and flood risk perception (which holds after controlling for actual flood risk), which may be due to a combination of salient memories and strong negative affect.⁽⁵²⁾

We took a country-specific approach to examining perceptions of weather-related events and climate change beliefs because perceptions of changes in specific weather-related events may vary by country. Previous research that was mostly conducted in the United States found that people's experiences with and perceptions of high temperature increased their climate change beliefs,^(7–11) which raised questions about the climate change beliefs of people in moderate climates. We found that U.K. residents focus more on wet-weather-related events when form-

ing their climate change beliefs, with flooding and precipitation being perceived as having especially increased.

Like any research project, ours had limitations. First, it is important to keep in mind that at the time at which the survey was conducted England and Wales were experiencing winter temperatures below the 1981–2010 average⁽²³⁾ and that the country had recently witnessed widely publicized flooding events.⁽²²⁾ As a result, these types of weather-related events may have been especially likely to come to our U.K. participants' minds when reporting climate change beliefs. Although this limitation does not undermine the conclusion that specific salient weather-related events may play a role in the formation of climate change beliefs, it does suggest that climate change beliefs may not be stable, but rather be driven by weather-related events that happen to become salient as weather changes over time. In addition, other factors such as mainstream media coverage,⁽¹⁸⁾ cues from political elites,⁽¹³⁾ changes in the economy,^(18,53) and other competing concerns⁽¹³⁾ may also be driving people's concerns over time. A second limitation pertains to our sample. Although our data were collected with a national U.K. sample, participants who were retained in the analysis were, on average, older than those who were excluded due to missing responses. Inline with previous work,⁽³⁹⁾ analyses of our control variables suggest that age was negatively related to climate change beliefs.

Another limitation is that our data were correlational in nature. As a result, caution is warranted when drawing causal conclusions. Our findings are inline with previous work that has suggested that perceptions of past weather changes are correlated with current climate change beliefs.^(8–11) Prior research also suggests that perceived fluctuations in temperature⁽⁵⁴⁾ and local climate⁽²⁶⁾ tend to correspond with observed events. However, it is possible that our correlational findings can be explained by people with stronger climate change beliefs remembering larger changes in specific weather patterns. It is also possible that the type of people who pay more attention to weather and climate tend to be able to remember larger changes in weather patterns and also to have stronger climate change beliefs. To examine whether perceptions of weather-related events cause changes in climate change beliefs, it would be necessary to conduct an experiment in which participants are randomly assigned to communications that increase perceptions of weather-related changes or

a control group, and then to examine the effect on changes in their climate change beliefs.

From a climate policy perspective our findings suggest that those seeking to communicate the risks posed by climate change to the public should not limit their focus to the hot-weather-related events that may be implied by the phrase “global warming.” Highlighting other locally salient weather-related events, such as flooding, that are likely to increase in frequency as a consequence of climate change may serve to increase public engagement with the issues surrounding climate change mitigation and adaptation.

ACKNOWLEDGMENTS

This work was supported by the PREPARE programme (funded by the U.K. Department for Environment, Food and Rural Affairs and led by Ricardo-AEA Ltd), Carnegie Mellon’s National Science Foundation Center for Climate and Energy Decision Making (SES-0949710), the European Research Council (ERC) under the European Union’s Seventh Framework Programme for Research (FP7/2007–2013) ERC Grant agreement 284369, and the Economic and Social Research Council (ES/L00805X/1). We thank Matthew Evans, Kelly Klima, and Edward Langley for their comments and insights.

REFERENCES

1. Stocker T, Dahe Q, Plattner GK. Working Group I Contribution to the IPCC Fifth Assessment Report (Ar5), Climate Change 2013: The Physical Science Basis. Geneva, Switzerland: Intergovernmental Panel on Climate Change, 2013.
2. Lorenzoni I, Leiserowitz A, De Franca Doria M, Poortinga W, Pidgeon NF. Cross-national comparisons of image associations with “global warming” and “climate change” among laypeople in the United States of America and Great Britain. *Journal of Risk Research*, 2006; 9(3):265–281.
3. Whitmarsh L. What’s in a name? Commonalities and differences in public understanding of “climate change” and “global warming.” *Public Understanding of Science*, 2009; 18(4):401–420.
4. Ratter BMW, Philipp KHI, von Storch H. Between hype and decline: Recent trends in public perception of climate change. *Environmental Science & Policy*, 2012; 18:3–8.
5. Weber EU, Stern PC. Public understanding of climate change in the United States. *American Psychologist*, 2011; 66(4):315–328.
6. Krosnick JA, Holbrook AL, Lowe L, Visser PS. The origins and consequences of democratic citizens’ policy agendas: A study of popular concern about global warming. *Climatic Change*, 2006; 77(1–2):7–43.
7. Li Y, Johnson EJ, Zaval L. Local warming: Daily temperature change influences belief in global warming. *Psychological Science*, 2011; 22(4):454–459.
8. Donner SD, McDaniels J. The influence of national temperature fluctuations on opinions about climate change in the US since 1990. *Climatic Change*, 2013; 118(3–4):537–550.
9. Deryugina T. How do people update? The effects of local weather fluctuations on beliefs about global warming. *Climatic Change*, 2013; 118(2):397–416.
10. Egan PJ, Mullin M. Turning personal experience into political attitudes: The effect of local weather on Americans’ perceptions about global warming. *Journal of Politics*, 2012; 74(3):796–809.
11. Hamilton LC, Stampone MD. Blowin’ in the wind: Short-term weather and belief in anthropogenic climate change. *Weather Climate and Society*, 2013; 5(2):112–119.
12. Risen JL, Critcher CR. Visceral fit: While in a visceral state, associated states of the world seem more likely. *Journal of Personality and Social Psychology*, 2011; 100(5):777–793.
13. Brulle RJ, Carmichael J, Jenkins JC. Shifting public opinion on climate change: An empirical assessment of factors influencing concern over climate change in the US, 2002–2010. *Climatic Change*, 2012; 114(2):169–188.
14. Hertwig R, Barron G, Weber EU, Erev I. Decisions from experience and the effect of rare events in risky choice. *Psychological Science*, 2004; 15(8):534–539.
15. Kahneman D, Slovic P, Tversky A. *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge: Cambridge University Press, 1982.
16. Morewedge CK, Gilbert DT, Wilson TD. The least likely of times—How remembering the past biases forecasts of the future. *Psychological Science*, 2005; 16(8):626–630.
17. Bruine de Bruin W, van der Klaauw W, Topa G. Expectations of inflation: The biasing effect of thoughts about specific prices. *Journal of Economic Psychology*, 2011; 32(5):834–845.
18. Scruggs L, Benegal S. Declining public concern about climate change: Can we blame the great recession? *Global Environmental Change*, 2012; 22(2):505–515.
19. Palutikof JP, Agnew MD, Hoar MR. Public perceptions of unusually warm weather in the UK: Impacts, responses and adaptations. *Climate Research*, 2004; 26(1):43–59.
20. Annex I. Managing the risks of extreme events and disasters to advance climate change adaptation. *Sciences*, 2012; 10:97–104.
21. Great Britain. Department for Environment F, Affairs R. UK Climate Change Risk Assessment: Government Report. Stationery Office, 2012.
22. UK Met Office. Education Case Study: November 2012 Flooding, 2013. Available at: http://www.metoffice.gov.uk/media/pdf/f/9/13.0066_Edu_CS_Nov_Flood.pdf, Accessed May 12, 2014.
23. UK Met Office Hadley Centre. Central England Temperature Data: Daily HadCET 1772–Present, 2014. Available at: <http://www.metoffice.gov.uk/hadobs/hadcet/cetd1772on.dat>, Accessed May 12, 2014.
24. Bostrom A, Morgan MG, Fischhoff B, Read D. What do people know about global climate-change.1. Mental models. *Risk Analysis*, 1994; 14(6):959–970.
25. Reynolds TW, Bostrom A, Read D, Morgan MG. Now what do people know about global climate change? Survey studies of educated laypeople. *Risk Analysis*, 2010; 30(10):1520–1538.
26. Akerlof K, Maibach EW, Fitzgerald D, Cedeno AY, Neuman A. Do people “personally experience” global warming, and if so how, and does it matter? *Global Environmental Change-Human and Policy Dimensions*, 2013; 23(1):81–91.
27. Grothmann T, Reusswig F. People at risk of flooding: Why some residents take precautionary action while others do not. *Natural Hazards*, 2006; 38 (1–2):101–120.
28. Slovic P, Peters E, Finucane ML, MacGregor DG. Affect, risk, and decision making. *Health Psychology*, 2005; 24(4):S35–S40.
29. Finucane ML, Alhakami A, Slovic P, Johnson SM. The affect heuristic in judgments of risks and benefits. *Journal of Behavioral Decision Making*, 2000; 13(1):1–17.
30. Harries T. The anticipated emotional consequences of adaptive behaviour-impacts on the take-up of household flood-protection measures. *Environment and Planning A*, 2012; 44(3):649–668.

31. Bradford RA, O'Sullivan JJ, van der Craats IM, Krywkow J, Rotko P, Aaltonen J, Bonaiuto M, De Dominicis S, Waylen K, Schelfaut K. Risk perception—Issues for flood management in Europe. *Natural Hazards and Earth System Sciences*, 2012; 12(7):2299–2309.
32. Whitmarsh L. Are flood victims more concerned about climate change than other people? The role of direct experience in risk perception and behavioural response. *Journal of Risk Research*, 2008; 11(3):351–374.
33. Spence A, Poortinga W, Butler C, Pidgeon NF. Perceptions of climate change and willingness to save energy related to flood experience. *Nature Climate Change*, 2011; 1(1):46–49.
34. Leiserowitz A. Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climatic Change*, 2006; 77(1–2):45–72.
35. Spence A, Poortinga W, Pidgeon N. The psychological distance of climate change. *Risk Analysis*, 2012; 32(6):957–972.
36. Smith N, Leiserowitz A. The rise of global warming skepticism: Exploring affective image associations in the United States over time. *Risk Analysis*, 2012; 32(6):1021–1032.
37. Leiserowitz AA. American risk perceptions: Is climate change dangerous? *Risk Analysis*, 2005; 25(6):1433–1442.
38. Dessai S, Adger WN, Hulme M, Turnpenney J, Köhler J, Warren R. Defining and experiencing dangerous climate change—An editorial essay. *Climatic Change*, 2004; 64(1–2):11–25.
39. Whitmarsh L. Scepticism and uncertainty about climate change: Dimensions, determinants and change over time. *Global Environmental Change-Human and Policy Dimensions*, 2011; 21(2):690–700.
40. Poortinga W, Spence A, Whitmarsh L, Capstick S, Pidgeon NF. Uncertain climate: An investigation into public scepticism about anthropogenic climate change. *Global Environmental Change-Human and Policy Dimensions*, 2011; 21(3):1015–1024.
41. Clements B. Exploring public opinion on the issue of climate change in Britain. *British Politics*, 2012; 7(2):183–202.
42. McCright AM, Dunlap RE. Cool dudes: The denial of climate change among conservative white males in the United States. *Global Environmental Change-Human and Policy Dimensions*, 2011; 21(4):1163–1172.
43. UK Office for National Statistics. Population Estimates for UK, England and Wales, Scotland and Northern Ireland—Mid 2012, 2013. Available at: <http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/mid-2011-and-mid-2012/rft--mid-2012-uk-population-estimates.zip>, Accessed May 12, 2014.
44. 2011 Census: KS501UK Qualifications and students, local authorities in the United Kingdom [Internet]. UK: Office for National Statistics, 2013. Available at: <http://www.ons.gov.uk/ons/rel/census/2011-census/key-statistics-and-quick-statistics-for-local-authorities-in-the-united-kingdom--part-2/rft-ks501uk.xls>, Accessed May 12, 2014.
45. Met Office Hadley Centre Observation Data: HadUKP Data [Internet]. UK: Met Office Hadley Centre. 1931–present, 2014. Available at: <http://www.metoffice.gov.uk/hadobs/hadukp/data/download.html>, Accessed May 12, 2014.
46. Dunlap RE, Van Liere KD, Mertig AG, Jones RE. Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues*, 2000; 56(3):425–442.
47. Spence A, Venables D, Pidgeon N, Poortinga W, Demski C. Public Perceptions of Climate Change and Energy Futures in Britain: Summary Findings of a Survey Conducted in January–March 2010. Technical Report (Understanding Risk Working Paper 10–01). Cardiff: School of Psychology, 2010. Available at: [psych.cf.ac.uk/understandingrisk/docs/final report.pdf](http://psych.cf.ac.uk/understandingrisk/docs/final%20report.pdf), Accessed May 12, 2014.
48. Osborn TJ, Hulme M. Evidence for trends in heavy rainfall events over the UK. *Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences*, 2002; 360(1796):1313–1325.
49. Robson AJ. Evidence for trends in UK flooding. *Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences*, 2002; 360(1796):1327–1343.
50. Hannaford J, Buys G. Trends in seasonal river flow regimes in the UK. *Journal of Hydrology*, 2012; 475:158–74.
51. Jenkins GJ, Perry M, Prior J, *et al.* The climate of the United Kingdom and recent trends: Met Office Hadley Centre, 2007.
52. Keller C, Siegrist M, Gutscher H. The role of the affect and availability heuristics in risk communication. *Risk Analysis*, 2006; 26(3):631–639.
53. Poortinga W, Aoyagi M, Pidgeon NF. Public perceptions of climate change and energy futures before and after the Fukushima accident: A comparison between Britain and Japan. *Energy Policy*, 2013; 62:1204–1211.
54. Howe PD, Markowitz EM, Lee TM, Ko CY, Leiserowitz A. Global perceptions of local temperature change. *Nature Climate Change*, 2013; 3(4):352–356.