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Effect of outdoor temperature, heat primes and anchoring on belief in global warming

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ABSTRACT

It is generally acknowledged that global warming is occurring, yet estimates of future climate change vary widely. Given this uncertainty, when asked about climate change, it is likely that people's judgments may be affected by heuristics and accessible schemas. Three studies evaluated this proposition. Study 1 revealed a significant positive correlation between the outdoor temperature and beliefs in global warming. Study 2 showed that people were more likely to believe in global warming when they had first been primed with heat-related cognitions. Study 3 demonstrated that people were more likely to believe in global warming and more willing to pay to reduce global warming when they had first been exposed to a high vs. a low anchor for future increases in temperature. Together, results reveal that beliefs about global warming (and willingness to take actions to reduce global warming) are influenced by heuristics and accessible schemas. Several practical implications are discussed.

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1. Introduction

Over the past several years, belief that global warming is occurring has been endorsed by relatively high numbers of the American public (Leiserowitz, Maibach, & Roser-Renouf, 2009; Nisbet & Myers, 2007). However, recent polls have found that the number of Americans who believe in global warming has declined drastically in the past year. For example, the PewResearch Center (2009) found that the percentage of Americans who agree that there is solid evidence the earth is warming dropped from 71% in 2008 to 57% in 2009. A FOX news poll found similar reductions (from 82% in 2007 to 69% in 2009; Blanton, 2009). This trend toward increasing skepticism is unfortunate, because many negative consequences of global warming are already evident, including melting glaciers, sea level rise, changes in migration patterns of species, and coral bleaching (IPCC, 2007), and future climate change scenarios predict exacerbation of many of these problems. Fortunately, by changing certain everyday behaviors, individuals can play a major role in mitigating global warming (Dietz, Gardner, Gilligan, Stern, & Vandenberg, 2009; Vandenberg, Barkenbus, & Gilligan, 2008). Because people are more likely to take actions to mitigate global warming when they believe global warming is

occurring (e.g., Heath & Gifford, 2006; Lubell, Zahran, & Vedlitz, 2007), it is important to identify factors that may affect (or correlate with) belief in global warming.

Several studies have shown that belief in global warming is lower among males, Republicans, and Caucasians (e.g., Dunlap & McCright, 2008; O'Connor, Bord, & Fisher, 1999), and those working in private (vs. public) sectors (Nilsson, von Borgstede, & Biel, 2004). Belief in global warming is also associated with environmental values (Kellstedt, Zahran, & Vedlitz, 2008; Lubell et al., 2007; Nilsson et al., 2004), attitudes (Bord, O'Connor, & Fisher, 2000; O'Connor et al., 1999), apathy and a free market ideology (Heath & Gifford, 2006), self-efficacy (Heath & Gifford, 2006; Kellstedt et al., 2008; Lubell et al., 2007), and risk perceptions (Lubell et al., 2007; O'Connor et al., 1999). A final important correlate of belief in global warming is knowledge about global warming (e.g., Bord et al., 2000; Heath & Gifford, 2006; Malka, Krosnick, & Langer, 2009; O'Connor et al., 1999; Sundblad, Biel, & Gärling, 2007; cf. Kellstedt et al., 2008).

If knowledge is linked with belief in global warming, it behooves researchers to understand how people gather, receive, and process information regarding global warming. Research indicates that the public gets much of its information about global warming from mass media reports and discussions among friends and family which leads to knowledge about the causes, consequences and solutions to global warming (Krosnick, Holbrook, & Visser, 2000; Stamm, Clark, & Eblacas, 2000). Unfortunately, despite the wealth

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of available information, research indicates that laypersons are not as knowledgeable as experts about global warming (Sundblad, Biel, & Gärling, 2009), people do not fully understand which behaviors affect global warming (Whitmarsh, 2009), and people have a hard time understanding the risks of global warming conveyed in scientific publications such as those prepared by the Intergovernmental Panel on Climate Change (Budescu, Broomell, & Por, 2009). Given the latter, Budescu and colleagues have argued that "...social scientists specializing in risk assessment and communication can, and should, play a major role in the debate on this important public-policy issue, by ensuring that all sides understand the state of the scientific findings and their underlying uncertainty" (p. 299) (cf. Trumbo & Shanahan, 2000).

In the present studies, we explore how several factors relevant to the communication process can affect belief in global warming (i.e., heuristics and cognitive primes). Heuristics are cognitive short cuts or quick decision rules that people use to guide their decisions when evaluating overwhelming risks or difficult problems, whereas cognitive primes are stimuli that activate associated networks of related concepts to influence perception and behavior. In theory, heuristics and cognitive primes could have a significant effect on how the public responds to communications about global warming. For example, arbitrarily low or high "anchors" (e.g., estimates of likely changes in temperature) or recently primed schemas (e.g., related to heat) could affect whether the public believes that global warming is occurring, and these beliefs may in turn affect whether the public is willing to take action to mitigate global warming.

Several characteristics of global warming make it likely that people will use heuristics or be susceptible to cognitive primes when making judgments of global warming. First, the science behind global warming is extremely complicated and few laypeople fully understand the scientific processes underlying the greenhouse effect (Bostrom, Morgan, Fischhoff, & Read, 1994; Dunlap, 1998; Nisbet & Myers, 2007). Second, because greenhouse gases are not visible and the consequences of global warming are dispersed geographically and temporally, direct cause and effect relationships are difficult to observe (DuNann Winter & Koger, 2004). Third, global warming is a large scale problem, with greenhouse gas concentrations in the atmosphere described in terms of parts per billion and consequences of global warming described as having ramifications for millions of people, and cognitive psychology has shown that humans have difficulty processing risks of this complexity and magnitude (DuNann Winter & Koger, 2004). Due to these characteristics, citizens and policy makers alike may base their decisions about the existence of global warming on heuristics or cognitive primes.

1.1. Overview of studies

To investigate the effects of heuristics and cognitive primes on belief in global warming, we conducted three studies which aimed to determine whether outdoor temperature served as an availability heuristic that would be associated with belief in global warming (Study 1); whether priming people with words related to heat would increase their belief that global warming is occurring (Study 2); and whether participants who were experimentally induced (through an anchoring and adjustment technique) to estimate that temperature would rise a large (vs. small) amount would be more likely to believe that global warming is occurring and would report stronger intentions to take action to reduce global warming (Study 3). Prior to each study, we discuss relevant prior research, existing gaps in the literature, and our hypotheses.

2. Study 1

The goal of Study 1 was to determine whether outdoor temperature would serve as an availability heuristic which would be associated with belief in global warming. When faced with an evaluation of a risk, people often rely on the availability heuristic; they make judgments of the likelihood of events based on how easily they can remember or imagine instances of the event (Slovic, Fischhoff, & Lichtenstein, 1990; Tversky & Kahneman, 1974). When people can easily bring to mind examples of an event, they judge that event to be more likely than when they cannot easily bring examples of the event to mind.

With regard to climate change, while exposed to a fair amount of media attention, laypeople are not expected to have extensive previous experiences with or direct observations of climate change. Instead, laypeople often associate global warming with images of heat and rising temperatures (Leiserowitz, 2005; Lorenzoni, Leiserowitz, Doria, Poortinga, & Pidgeon, 2006) and often conflate climate change with weather (Bostrom & Lashof, 2007; Bostrom et al., 1994; Read, Bostrom, Morgan, Fischhoff, & Smuts, 1994). As a result, changes in local weather may bias perceptions of changes in climate. Several studies are consistent with this reasoning. For example, the unusually hot summers of the 1980s have been argued to be responsible for the rise of concern for global warming during this time (Read et al., 1994; Ungar, 1992; cf. Bostrom & Lashof, 2007), and media coverage of climate change tends to increase during warmer temperatures (Shanahan & Good, 2000). More relevant, studies have also shown that belief in global warming is positively related to the perception that local temperature had changed in recent years (Krosnick, Holbrook, Lowe, & Visser, 2006) and perception of outdoor temperature among residents of Portland (Semenza et al., 2008).

Although previous research has found that *perceptions* of changes in weather are associated with belief in global warming (Krosnick et al., 2006; Semenza et al., 2008), little research has directly investigated whether actual outdoor temperature serves as a heuristic that is associated with belief in global warming. In one exception, Schuldt and Schwarz (2008) found a positive correlation between belief in global warming and actual outdoor temperature change between the survey day and the previous day. However, in that study, participants were first asked to judge whether world temperature had changed in the past few years. Arguably, this could have increased participants' awareness of the outdoor temperature. In the current study, we explored whether outdoor temperature would be positively associated with belief in global warming, even when participants had not been recently prompted to think about the outdoor temperature. In line with previous research, we hypothesized that outdoor temperature would positively correlate with belief in global warming (*Hypothesis 1*).

2.1. Method

2.1.1. Participants and procedure

Introductory psychology students at a state university in the northwestern United States ($N = 93$) participated in exchange for course credit. The sample included 60 females, 33 males, and was mostly Caucasian (63%). Median age was 19.

Participants were run individually in a small lab at different times throughout the year which resulted in a range of outdoor temperatures. The lab had one small window which remained covered during the study, so that participants could not directly observe the weather. At the beginning of each experimental session, unbeknownst to the participant, the experimenter noted the outdoor temperature at the time of the session (www.weather.com). We attempted to get a range of different temperatures by running the study during different months, but no systematic

attempt was made to assign participants to different seasons or outdoor temperature conditions. This convenience sampling approach resulted in outdoor temperatures which ranged from 30 to 82 degrees Fahrenheit ($M = 59.01$, $SD = 15.00$).

During each session, participants completed a brief questionnaire assessing their belief in global warming and provided demographics as part of a larger survey titled "Attitudes Toward Current Events."¹ Embedded within the survey were four items assessing belief in global warming (see Table 1; Heath & Gifford, 2006). Participants responded to each statement on a scale from 1 (strongly disagree) to 7 (strongly agree). A reliability analysis indicated that the four items could be combined into an overall global warming index, which proved to be a reliable scale ($\alpha = 0.82$). Also included in the survey were three items assessing environmental values drawn from Stern, Dietz, and Guagnano's (1998) Brief Inventory of Values. The values were: (1) protecting the environment, preserving nature; (2) unity with nature, fitting into nature; (3) respecting the earth, harmony with other species ($\alpha = 0.79$). Participants rated the importance of each value on a 6-point scale (0 = opposed to my values, 1 = not at all important, 5 = extremely important).

2.2. Results

Table 1 presents correlations between the outdoor temperature and belief in global warming.² As can be seen, outdoor temperature showed a significant positive correlation with the overall global warming index, and each of the four items (though the correlation with item 1 did not reach traditional levels of significance). To further explore this relationship, we examined the scatterplot between outdoor temperature and the global warming index. As shown in Fig. 1, the relationship appeared stronger when the outdoor temperature was relatively low (below 60 degrees) than when the temperature was relatively high (above 60 degrees).

To evaluate this possible difference, we split the sample into two groups based on a median split of the outdoor temperature variable. The outdoor temperature in the low temperature group ranged from 30 to 61 degrees, while the outdoor temperature in the high temperature group ranged from 62 to 82 degrees. We subsequently computed correlations between the outdoor temperature and the global warming index and items within each group. As can be seen in the right half of Table 1, the correlation between outdoor temperature and belief in global warming was only significant when the outdoor temperature was relatively low.

2.3. Discussion

The present study supported the hypothesis that belief in global warming would be positively correlated with outdoor temperature, though, as we discuss in more detail in the general discussion, the relationship between outdoor temperature and belief in global warming was only significant when the outdoor temperature was low. While intriguing, the present results are merely correlational. As such, there could be any number of reasons why outdoor temperature would correlate with belief in global warming. In Studies 2 and 3, we complemented these findings with experiments exploring how cognitive primes related to heat, and the anchoring and adjustment heuristic affect belief in global warming.

¹ To disguise the true purpose of the study, attitudes toward other topics (e.g., torture) were also assessed in the survey.

² Correlations are not adjusted based on environmental values, as environmental values did not correlate with any of the global warming items (all p -values > 0.12), and controlling for environmental values did not alter the results.

Table 1

Correlations between Outdoor Temperature and Belief in Global Warming (Study 1).

Global warming item	Mean	SD	Outdoor temperature		
			Overall (30–82)	Low (30–61)	High (62–82)
Global warming index (average of items below)	5.03	1.17	0.27**	0.54***	-0.02
1. I have already noticed some signs of global warming	5.13	1.41	0.19 ⁺	0.45**	-0.12
2. It seems to me that the temperatures warmer now than in years before	4.73	1.38	0.24*	0.41**	-0.09
3. It seems to me that weather patterns have changed compared to when I was a child	5.18	1.36	0.19*	0.53***	-0.05
4. I am quite sure global warming is occurring now	5.10	1.65	0.24*	0.27 ⁺	0.15

Note. Overall, $N = 93$ (low group, $N = 47$; high group, $N = 46$). Outdoor temperature ($M = 59.01$, $SD = 15.00$).

⁺ $p < 0.07$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

3. Study 2

In Study 2 we sought to extend the findings from Study 1 by exploring whether experimentally-induced cognitive primes affect belief in global warming. According to spreading activation theory, cognitive priming occurs when a category is activated in memory and becomes accessible, and the activation from that category spreads through the neural network to constructs closely related to that category (Collins & Loftus, 1975). Categories and constructs that are activated (primed) are more easily accessible and more quickly retrieved for future tasks and evaluations. As an example, Bargh, Chen, and Burrows (1996) found that participants primed with concepts related to the stereotype of the elderly walked slower than participants primed with neutral words. In a subsequent study, participants who were primed with the trait of intelligence correctly answered more trivia questions than participants primed with the trait of stupidity (Dijksterhuis & van Knippenberg, 1998). More directly relevant to the present study, Viscusi and Zeckhauser (2006) showed that participants who read a paragraph intended to increase climate change accessibility – which contained general background information about greenhouse gasses, global warming and U.S. opposition to the Kyoto Protocol – had higher estimates of future temperature increases than participants not given the paragraph (cf. Cialdini, Reno, & Kallgren, 1990; Durfee, 2006 for examples of priming effects in other environmental domains). Viscusi and Zeckhauser's (2006) results indicate that it is possible to subtly prime belief in global warming. However, the close connection between the prime (paragraph related to global warming) and the outcome (estimates of future

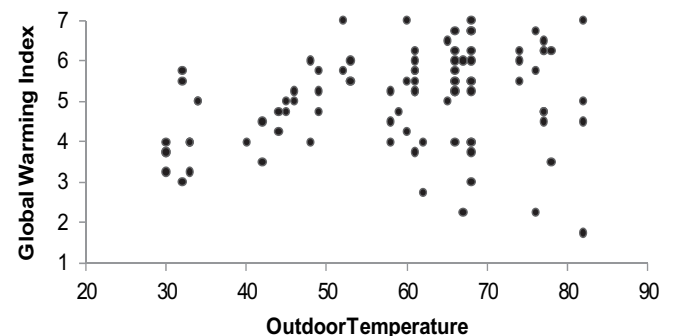


Fig. 1. Plot of global warming index by outdoor temperature (Study 1).

temperature increases) raises the question of whether even more subtle priming techniques can achieve the same result. In Study 2, we addressed this question by having respondents complete a simple word search puzzle prior to completing the global warming scale. For half of the participants, the word search puzzle contained a variety of words related to heat (heat, boil, fry etc.). As we noted earlier, global warming is clearly linked to the concept of heat. As such, we expected that participants would be more likely to believe in global warming if they had first been primed with heat-related words than if they had not been primed with heat-related words (*Hypothesis 2*).

3.1. Method

3.1.1. Participants and procedure

Introductory psychology students at a state university in the northwestern United States ($N = 42$) participated in exchange for course credit. The sample included 23 females, 19 males and was mostly Caucasian (88%). Median age was 21.

Participants, run in a classroom in groups of 12–25, were randomly assigned to one of two word search puzzles designed to manipulate heat-related cognitions. The words participants were required to search for are shown in the Appendix, separated by condition. Participants were told that the word search was designed to “clear their minds” before other measures were taken. After completing the word search puzzle participants completed the 4-item global warming index used in Study 1 ($\alpha = 0.88$) as part of a larger survey titled “Attitudes Toward Current Events.” To rule out any possible effects based on mood, participants then completed the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988). Following the PANAS, participants rated the importance of the three environmental values noted in Study 1 ($\alpha = 0.90$) and provided demographic information.

3.2. Results

Environmental values were positively correlated with the overall global warming index and two of the four individual scale items (items 1 and 4) (all p -values < 0.001). Moreover, environmental values tended to be higher in the heat prime condition (though the difference was not significant, $p = 0.20$). In light of these findings, to test hypothesis 2 while adjusting for these differences, we conducted a multiple regression analysis in which we regressed the global warming index on both heat prime condition (coded 1 = control, 2 = heat prime) and environmental values simultaneously. Fig. 2 displays the covariate adjusted means

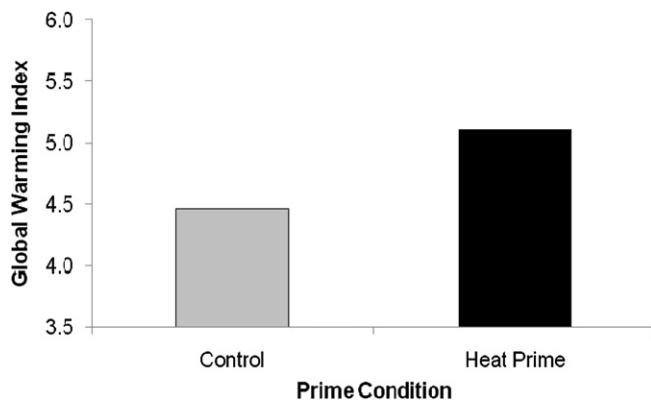


Fig. 2. Effect of heat prime on global warming index (Study 2).

on the global warming index in the control and heat prime conditions. Consistent with hypothesis 2, those in the heat prime condition scored higher on the global warming index than those in the control condition, $\beta = 0.26$, $t(38) = 1.79$, $p = 0.041$ (one-tailed). The regression analysis also revealed a significant positive relationship between environmental values and the global warming index, $\beta = 0.40$, $t(38) = 2.78$, $p < 0.001$ (one-tailed). Similar multiple regression analyses on the four individual global warming items (using one-tailed tests) revealed that those in the heat prime condition scored significantly higher than those in the control condition on item 1 ($p = 0.043$) and item 2 ($p = 0.048$), marginally higher on item 3 ($p = 0.075$), but not on item 4 ($p = 0.14$). Further analyses revealed that those in the heat prime condition did not differ from those in the control condition on positive or negative mood (both p -values > 0.08), and mood did not correlate with the global warming index or any of the four individual global warming items (all p -values > 0.16), indicating that differences in mood cannot explain the results.

3.3. Discussion

The present study supported the hypothesis that heat-related primes would increase belief in global warming. Participants primed with heat-related words (vs. neutral words) were significantly more likely to have noticed signs of global warming and to believe that the temperature is warmer now, and were marginally more likely to believe that weather patterns have changed. Our finding that experimentally-induced primes can increase belief in global warming provides an important complement to the correlational results from Study 1.

4. Study 3

The purpose of Study 3 was three-fold. First, we aimed to investigate how the anchoring and adjustment heuristic would affect belief in global warming. In their initial demonstration of this heuristic, Tversky and Kahneman (1974) showed that participants' estimates of a quantity (percentage of African nations that were part of the United Nations) were biased by questions presented to them before the estimation task. Participants who had first been asked whether the percentage was greater than or less than 45% gave lower estimates than those who had first been asked whether the percentage was greater than or less than 65%. The anchoring and adjustment heuristic has been applied to a variety of judgments, including the risk of nuclear war (Plous, 1989) and the expected longevity of a common resource (Joireman, Posey, Truelove, & Parks, 2009) (for reviews, see Chapman & Johnson, 2002; Gilovich & Griffin, 2002).

Because beliefs about global warming represent a judgment of risk under uncertainty, the anchoring and adjustment heuristic is directly relevant to the problem of global warming. This is especially true given how information about global warming is conveyed to the public. The public is frequently presented with information from the media about the expected rise in global temperature over the coming years, and these estimates can vary widely. For example, according to the Intergovernmental Panel on Climate Change (IPCC, 2007), it is estimated that the earth's temperature will rise between 2 degrees and 11.5 degrees (Fahrenheit) over the next 90 years. In theory, the low and high ends of this range could serve as important anchors that affect belief in global warming. In accordance with the anchoring and adjustment heuristic, we hypothesized that participants given a high (vs. low) anchor regarding the amount of temperature increase expected in the future would report stronger global warming beliefs (*Hypothesis 3*).

Our second goal in Study 3 was to extend Studies 1 and 2, which showed that heuristics and priming increase *belief* in global warming, by evaluating the effect of the anchoring and adjustment heuristic on *intentions* to reduce global warming (i.e., willingness to pay to reduce global warming). Previous research has generally found that belief that climate change is occurring or is likely to occur predicts intention to act to reduce global warming (Heath & Gifford, 2006; O'Connor et al., 1999; c.f., O'Connor, Bord, Yarnal, & Wiefek, 2002). Based on our previous reasoning that heuristics may explain variance in global warming beliefs, we expected that beliefs in global warming would mediate the relationship between anchoring and adjustment condition and intention, such that those who anchored on a high (vs. low) number would have a stronger belief in global warming which, in turn, would predict increased intentions to reduce global warming (*Hypothesis 4*).

Our third goal in Study 3 was to create a more comprehensive model of intentions to reduce global warming that included values and political party in addition to our primary variable of interest (anchoring and adjustment heuristic). In line with Stern's (2000) Value-Belief-Norm Theory, environmental values have repeatedly been shown to correlate with environmental beliefs (de Groot & Steg, 2008; Steg, Dreijerink, & Abrahamse, 2005; Stern, Dietz, Kalof, & Guagnano, 1995) and environmental behavioral intentions (Dietz, Fitzgerald, & Shwom, 2005; de Groot & Steg, 2008; Nilsson et al., 2004; Stern et al., 1995), with environmental beliefs (or personal norms) often mediating the values-behavior relationship. Moreover, as noted earlier, belief in global warming is linked with environmental values (Kellstedt et al., 2008; Lubell et al., 2007; Nilsson et al., 2004) and political party affiliation (e.g., Dunlap & McCright, 2008; O'Connor et al., 1999). Based on these findings, we hypothesized that (a) environmental values would be positively associated with willingness to pay to reduce global warming and that this relationship would be mediated by belief in global warming (*Hypothesis 5*), and (b) that Republicans would be less willing to pay to reduce global warming (than those from other political parties) and that this difference would be mediated by belief in global warming (*Hypothesis 6*).

4.1. Method

4.1.1. Participants and procedure

Marketing undergraduate students ($N = 159$) from a state university in the northwestern U.S. participated in groups of up to 12 for course credit. The sample included 73 females, 84 males and 2 who did not identify their sex, and most were Caucasian (83.6%). Median age was 21.

Participants were randomly assigned to one of two anchoring conditions. In the *low anchor condition*, participants were first asked, "Do you believe the earth's temperature will rise by exactly 1 degree Fahrenheit over the next 30 years?" (close to the low end of the IPCC estimate for climate change). In the *high anchor condition*, participants were asked, "Do you believe the earth's temperature will rise by exactly 10 degrees Fahrenheit over the next 30 years?" (close to the high end of the IPCC estimate for climate change). If participants answered no to this initial question, they were asked "By how many degrees do you think the earth's temperature will rise (in Fahrenheit) over the next 30 years?" and were allowed to write their answer in an open-ended format. Next, participants completed the 4-item global warming scale used in Studies 1–2 ($\alpha = 0.85$), followed by a 2-item willingness to pay scale in which participants indicated whether they would agree to pay higher taxes and higher prices for products and services to reduce global warming (1 = strongly disagree to 7 = strongly agree) ($\alpha = 0.90$). Participants then rated the importance of four environmental values drawn from Stern et al.'s (1998) Brief Inventory of Values on

a 9-point scale (–1 = opposed to my values, 0 = not important, 6 = very important, 7 = of extreme importance). The four values were: (1) protecting the environment, preserving nature; (2) unity with nature, fitting into nature; (3) respecting the earth, harmony with other species; (4) preventing pollution, protecting natural resources ($\alpha = 0.90$). Finally, participants provided demographics and indicated their political affiliation by selecting one of four categories that best reflected their political orientation (Republican, $n = 32$, Democrat, $n = 57$, Independent, $n = 15$, Other, $n = 51$).

4.2. Results

4.2.1. Manipulation check

We expected that most participants in both anchoring conditions would say no to the initial question they were asked, as temperatures are unlikely to rise by exactly 1 or 10 degrees over the next 30 years. However, many participants agreed to the initial question, and this tendency was more likely in the low anchor condition (54.9%) than in the high anchor condition (30.7%), $\chi^2(1) = 9.35, p < 0.01$.³ Nevertheless, enough participants said no to the initial question that we were able to evaluate our manipulation check with this subsample. In line with our expectations, participants in the high anchor condition believed the earth's temperature would increase (in degrees Fahrenheit) by a significantly larger amount ($M = 4.55, SD = 2.96$) than those in the low anchor condition ($M = 2.62, SD = 3.14$), $t(79) = 2.81, \eta^2 = 0.09, p < 0.01$.

4.2.2. Primary results

To simplify our analysis of the political party variable, we chose to compare Republicans (coded 1) to the remaining three groups (Democrats, Independents, and Other) combined (coded 2). We did this because the mean for Republicans was equal to or below the scale midpoint of 4 (on global warming and willingness to pay respectively), while means for the remaining three groups were above the scale midpoint of 4. This suggests that, on average, Republicans tended to disagree that global warming is occurring and were unwilling to pay to reduce global warming, whereas the remaining three groups agreed that global warming is occurring and were willing to pay to reduce global warming.

To test our mediation hypotheses, we conducted a series of regression analyses. Analyses were based on all participants, regardless of how they answered the initial anchoring and adjustment question (yes, no). In our first analysis, we regressed the global warming index on anchoring condition (1 = low, 2 = high), environmental values (continuous), and political party (1 = Republican, 2 = Remaining Parties Combined). While environmental values and political party were both significantly associated with the global warming index (both p -values < 0.001), anchoring condition was not ($p = 0.30$). Closer inspection revealed that the anchoring condition only affected item 4 (I am quite sure that global warming is occurring now). Thus, we conducted a series of regression analyses using item 4 and willingness to pay as criterion variables, and testing the mediation hypothesis. Supporting our predictions, Table 2 shows that participants in the high anchor condition were more likely to agree that "global warming is occurring now," and scored higher on willingness to pay, once environmental values and political party had been controlled.⁴ Fig. 3 displays the covariate adjusted means on belief in global

³ Given that participants made predictions in Fahrenheit, we excluded from all analyses 21 participants who indicated that they "typically think in terms of Celsius."

⁴ Prior to controlling for environmental values and political party, the anchoring condition effect was not significant ($p = 0.20$).

Table 2
Multiple Regression Analyses Predicting Belief in Global Warming and Willingness to Pay to Reduce Global Warming (Study 3).

Predictor variable	Global warming is occurring now			Willingness to pay to reduce global warming			Willingness to pay to reduce global warming ^a		
	B	β	<i>p</i>	B	β	<i>p</i>	B	β	<i>p</i>
Anchor condition	0.41	0.14	0.040	0.44	0.14	0.040	0.22	0.07	0.240
Environmental values	0.49	0.43	0.001	0.50	0.42	0.001	0.25	0.21	0.003
Political party	0.93	0.25	0.001	1.01	0.26	0.001	0.53	0.14	0.040
GW is occurring now	—	—	—	—	—	—	0.52	0.49	0.001

Note. *N* = 155. GW = global warming. B = unstandardized regression coefficient. β = standardized regression coefficient. Anchor Condition (1 = Low, 2 = High). Political Party (1 = Republican, 2 = Other).

^a Mediation model including mediator (global warming is occurring now).

warming and willingness to pay by condition. An inspection of Table 2 also reveals that those scoring high on environmental values and those identifying as other than Republican scored higher on belief in global warming and willingness to pay. Consistent with our mediation hypothesis, the third analysis (in the rightmost part of the table) shows that when belief in global warming is entered as a control variable, the effect of anchoring became non-significant, and the relationship of environmental values and political party with willingness to pay became notably weaker (though still significant), suggesting full mediation of the anchoring effect and partial mediation of the values and political party effects.

To further test our overall model (beyond the more focused mediation hypotheses), we conducted a path analysis to test the hypothesis that the relationship of anchoring, environmental values and political party with willingness to pay would be mediated via belief in global warming. As just noted, anchoring only affected item 4 (I am quite sure global warming is occurring now). As such, the model test focuses on this one item, rather than the overall global warming index. The initial model (with no direct paths from anchoring, values or political party to willingness to pay) fit the data reasonably well: $\chi^2(5) = 15.71$, $p = 0.007$, Goodness of Fit (GFI) index = 0.96, Comparative Fit (CFI) index = 0.93, Root Mean Squared Error of Approximation (RMSEA) = 0.12, though the RMSEA value was higher than the standard criterion of 0.05 (Browne & Cudeck, 1993). To improve the model fit, we examined a revised model including direct paths from environmental values and political party to willingness to pay. That model, which appears in Fig. 4, fit the data well: $\chi^2(3) = 2.06$, $p = 0.56$, GFI = 0.99, CFI = 1.00, RMSEA = 0.00. The model explained one-third of the variance in belief that global warming is occurring now and almost half of the variance in willingness to pay.

4.3. Discussion

Consistent with our hypotheses, when people were given an initially high anchor for possible increases in the earth's temperature, they were more likely to believe global warming is occurring now and were more willing to pay to reduce global warming, with belief that global warming is occurring mediating the relationship between anchoring and willingness to pay. Overall, these results add further credence to the hypothesis that heuristics affect belief in global warming and willingness to take steps to reduce global warming. Additional results revealed that environmental values and political party were significantly correlated with belief in global warming and willingness to pay, and the relationship of values and political party with willingness to pay was (partly) mediated through belief that global warming is occurring now.

Although the variables included in this study (environmental values, political party, and anchoring) were able to explain a significant amount of variance in global warming beliefs, several limitations should be noted. To begin, more than half of the variance in beliefs was unaccounted for by the model. Thus, as we note in the general discussion, future research should expand the model to include other predictors that have been shown to influence belief in global warming. When interpreting the current results, it is also important to recall that the anchoring manipulation was not perfect – over half of the participants did not complete the manipulation check (estimated change in temperature) because they agreed with the initial anchoring question. This was surprising, especially in the high anchor condition, given that the initial question in this condition implied that the earth's temperature would rise by (exactly) 10 degrees Fahrenheit over the next 30 years. While a 10 degree increase is within the range of possibilities for the next century (IPCC, 2007), it is clearly on the high end, and is very unlikely within the next 30 years. Participants' agreement with this rather extreme estimate suggests that they have little understanding of climate change, and/or that they were processing the information at a relatively superficial level. Yet, some participants disagreed with the initial anchor. Thus, one interesting direction for future research would be to further explore what influences whether people agree or disagree with an initial anchor they receive. Despite this, the anchoring manipulation did affect belief that global warming is occurring now and willingness to pay to reduce global warming. Third, it is important to note that the anchoring manipulation only affected item 4 on the global warming scale (I am quite sure global warming is occurring now). One explanation for this result is that item 4 is the most direct assessment of belief in global warming. As shown in Table 1, the other three items each involve reflecting on the past, and reflecting on the past may be less susceptible to the anchoring and adjustment heuristic, which in this study was operationalized in terms of future changes in temperature. Given our findings, future researchers would do well to carefully inspect each item on their global

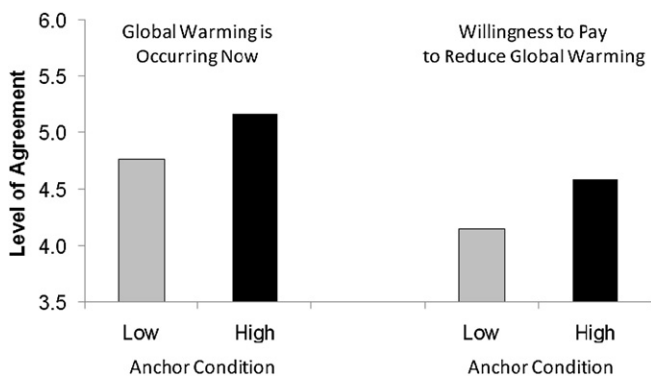


Fig. 3. Effect of numerical anchor on belief in global warming and willingness to pay to reduce global warming (Study 3).

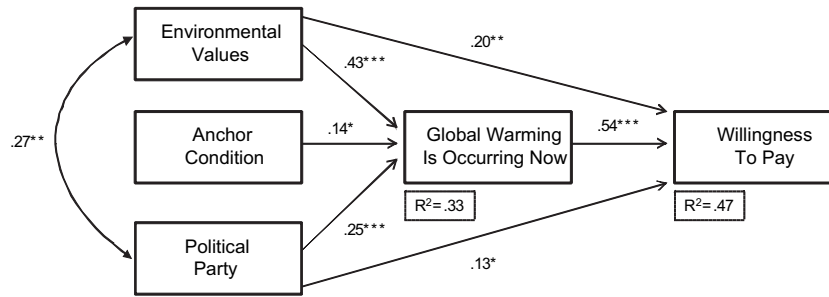


Fig. 4. Path model predicting willingness to pay to reduce global warming (Study 3). Note: Anchor condition (1 = Low, 2 = High). Political party (1 = Republican, 2 = Other). * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

warming scales to determine whether their manipulations (or predictors) are differentially influencing different aspects of global warming beliefs. Finally, the data are correlational. As a result, it is possible that belief in global warming may have a backward causal effect on environmental values and political party.

5. General discussion

Because the problem of global warming is highly complex, and signs of global warming are sometimes difficult to visualize, there is arguably a high degree of uncertainty among the public about the existence of global warming. As such, people are likely to rely on cultural worldviews, heuristics and accessible schemas to make sense of their uncertain world. In line with previous research, we found that two strong correlates of belief in global warming were environmental values and political party (Study 3), reflecting deeply-rooted worldviews. Beyond these well established predictors, we took a close look at how more fluid heuristics and accessible schemas predict belief in global warming. In our first study, we found a positive correlation between outdoor temperature and belief in global warming (though this relationship was non-existent at high temperatures). Arguably, the link between outdoor temperature and belief in global warming reflects an availability heuristic whereby people's judgments are based on concepts that come easily to mind. In our second study, we showed that participants exposed to heat-related words had a stronger belief in global warming. In our third study, we showed that a high anchor for future increases in global temperatures increased belief in global warming and willingness to pay to reduce global warming. Below, we consider several practical implications of our results for researchers studying global warming, and activists interested in encouraging the public to act to reduce global warming. We organize the implications around our three studies.

5.1. Practical implications

Given that outdoor temperature was (within the lower range) associated with increased belief in global warming (Study 1), researchers studying global warming beliefs should be cognizant of the time of year they collect their data. For example, the PewResearch Center (2009) noted that a limitation of their surveys in previous years was that the surveys were conducted at a different time each year (e.g., October vs. April). Our results suggest that such differing beliefs may be partly due to differing outdoor temperatures during these two seasons. From an activist's point of view, the link between outdoor temperature and belief in global warming suggests that the most appropriate time to motivate the public to take actions to mitigate global warming is during the summer months (cf. Ungar, 1992). That said, it is important to recall that outdoor temperature was not significantly associated

with global warming beliefs when the temperature was relatively high. This suggests that while higher temperatures may (in general) be associated with stronger beliefs in global warming, people may (when motivated and/or able) correct their judgments to avoid the influence of irrelevant contextual factors (cf. Kang & Herr, 2006; Martin, Seta, & Crelia, 1990; Wegner & Petty, 1995).

Second, the fact that belief in global warming can be primed (Study 2) serves as a reminder that researchers interested in studying global warming should be careful in the way they design their surveys. Assuming the goal is not to prime belief in global warming, but rather to get an accurate estimate of belief in global warming, researchers should avoid including anything in the survey which might subtly increase the salience of heat-related cognitions (e.g., pictures or text). Activists interested in encouraging the public to reduce global warming, on the other hand, could profitably apply Study 2's findings, for example, by building into media campaigns cognitive primes designed to activate global warming beliefs (cf. Hartmann & Apaolaza-Ibáñez, 2010).

Finally, given that belief in global warming can be affected by the anchoring and adjustment heuristic (Study 3), researchers should carefully consider how the framing of survey questions (especially about actual changes in temperature) may subtly influence belief in global warming. Activists, on the other hand, might utilize the anchoring and adjustment heuristic to increase belief in global warming and motivate the public to address the problem. For example, framing future increases in global temperatures in terms of Fahrenheit, as opposed to Celsius, may be more likely to convince the public that global warming is a problem (e.g., a 1 degree increase in Celsius is roughly equal to a 2 degree increase in Fahrenheit).

5.2. Strengths, limitations and future directions

While the present results help to extend our understanding of beliefs in global warming, several limitations should be kept in mind. First, while we obtained a wide range of temperatures in our first study (32–80 degrees), expanding that range even further is advisable. This is especially important in light of the fact that outdoor temperature was significantly correlated with global warming beliefs only within a more limited range of outdoor temperatures (Table 1). As one reviewer suggested, this finding may reflect the Weber–Fechner law. That is, people may become less sensitive to variations in temperature as the temperature increases, and this may help to explain why temperature showed no relationship with global warming beliefs at higher temperatures. As another reviewer noted, a similar pattern may also be evident below freezing (see Fig. 1), suggesting more generally that people have difficulty differentiating between temperatures at the extremes. If true, temperature is not likely to be significantly correlated with belief in global warming under extreme

temperatures. Another possible explanation for the null relationship at higher temperatures is that people are aware of the influence of outdoor temperature on their belief in global warming and attempt to correct for any possible bias that might affect their global warming judgments (e.g., Kang & Herr, 2006; Martin et al., 1990; Wegner & Petty, 1995). Future research addressing these possibilities could help in the development of effective persuasive appeals aimed at convincing the public that global warming is a problem. Future research might also explore how outdoor temperature interacts with level of source credibility to predict belief in global warming. One possibility is that warmer outdoor temperature can serve as a catalyst that helps add credibility to an otherwise credible source (e.g., Ungar, 1992). Another possibility is that experts can override the tendency toward skepticism about global warming under cooler temperatures. The former prediction suggests that the relationship between temperature and belief in global warming will be stronger in the presence of an expert, while the latter prediction suggests that temperature will be a weaker predictor of belief in global warming in the presence of an expert. Similar predictions could be offered for the interaction between source credibility and heat primes (or high anchors). Finally, along a similar line of reasoning, as one reviewer suggested, it is possible that as people become more knowledgeable about global warming, the role of outdoor temperature, heat primes, and the anchoring and adjustment heuristic might diminish.

A second limitation is that our participants are all college students who reside within a specific region of the U.S. Thus, future research should evaluate the generalizability of our findings across a wider range of participants, regions, and cultures. For example, as one reviewer noted, given that our first study showed that temperature is (generally) associated with beliefs in global warming, it would be informative to replicate our study within different regions of the country (e.g., the Northwest vs. the Southwest). Such studies could identify meaningful regional differences in belief in global warming and test whether such differences are at least partly attributable to regional variations in temperature. Overall, study 1 suggests that people in the Southwest (e.g., Arizona or New Mexico), where the average outdoor temperature is higher, would be more likely than those in the Northwest to believe in global warming. However, given that outdoor temperature was not significantly associated with belief in global warming at higher temperatures (see Table 1), it is possible that outdoor temperature does not predict belief in global warming among residents of the Southwest. Regional differences may also be associated with belief in global warming based on the extent to which global warming is likely to affect residents of a certain region. For example, residents of the Pacific Northwest may be less vulnerable to climate change than residents of the Southeast (e.g., Florida or Louisiana), and this decreased vulnerability is likely to lead to decreased perceptions of the risk of climate change (Brody, Zahran, Vedlitz, & Grover, 2008; cf. Leiserowitz, 2007; Whitmarsh, 2008). Finally, comparing different regions/countries would allow further testing of the spatial optimism bias, the tendency to believe that environmental problems are more serious in parts of the world that are spatially distant from oneself (Gifford et al., 2009).

A third limitation worth mentioning is that we focused on a somewhat narrow set of outcome measures (belief in global warming and willingness to pay to reduce global warming), a relatively narrow range of predictors, and much of our data are correlational. To gain a more complete picture of global warming beliefs and behaviors, future studies should (a) incorporate additional behaviors with the potential to mitigate global warming such as voting intentions, support for political initiatives, and consumer purchases (cf. Lubell et al., 2007; Nilsson et al., 2004; O'Connor et al., 2002), (b) evaluate more comprehensive models that

include socio-demographic variables, environmental values and attitudes, and regional and contextual factors (e.g., Gifford, 2008; Kellstedt et al., 2008), (c) devote more attention to the affective underpinnings of global warming beliefs (cf. Hine, Marks, Nachreiner, Gifford, & Heath, 2007; Lorenzoni et al., 2006; Sundblad et al., 2007), and (d) collect data over time to rule out reverse causal explanations. Future research might also explore how heuristics and cognitive primes influence people's inclination to seek out, rather than simply receive information on global warming (Kahlor, 2007).

The limitations just noted indicate that much remains to be learned about the way outdoor temperature, cognitive primes, and heuristics affect belief in global warming. However, it is also relevant to note that the present studies have several strengths. First, two of the three studies are experiments which allow for causal conclusions. Second, while the first study is technically "correlational" in nature, reverse causality is impossible here, because the variable correlating with belief in global warming (actual outdoor temperature) cannot be influenced by participants' belief in global warming. Finally, we have clearly articulated six practical implications based on our findings, two from each study (one directed to researchers and one directed to activists). While the suggested applications require empirical validation, we believe they provide a fertile ground for future research based on the results of the present studies.

5.3. Conclusion

In conclusion, the present studies provide initial evidence that belief in global warming and willingness to pay to reduce global warming are influenced by heuristics and cognitive schemas. As people attempt to determine the extent to which global warming is occurring, they will likely be influenced by temporary variations in their environment (temperature, anchors, and accessible schemas). Indeed, as we revised our paper in February of 2010, a particularly intriguing piece of anecdotal evidence emerged. As two massive back-to-back snow storms blanketed the Eastern United States, dumping as much as 60 inches of snow, some argued that it was clear evidence that global warming was a "hoax" (Broder, 2010). While merely anecdotal, the "Blizzard of 2010" (or "Snowmaggedon") suggests, once again, that people's belief in global warming is based partly on proximal weather conditions. Clearly, future research on this topic is urgently needed if the world is to mitigate the problems that global warming is likely to bring in its wake.

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Appendix. Words used in control and heat prime word searches (Study 2)

Control		Heat prime	
Bad	Method	Boil	Melt
Chair	Owl	Burn	Method
Civic	Pond	Chair	Shirt
Defense	Rich	Equator	Sunny
Elder	Roar	Fry	Sweat
Heel	Shirt	Heat	Thought
Jack	Thought	Hot	Warm
Learn		Learn	

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