CORRESPONDENCE:

Eliminating the local warming effect

To the Editor — Perceived deviations in daily local temperatures can alter individuals' views on global warming[1–6]. Here, however, I use an experiment to show that prompting individuals to remember how the weather felt over the past year severs the relationship between perceptions of the daily temperature with estimates of last year's temperature deviations and eliminates the 'local warming effect'. The results demonstrate the limits of this effect and suggest ways to rhetorically counteract it.

Zaval *et al.*[6] show that when individuals perceive the day's local temperature to be warmer than usual, they then overestimate the number of warm days through the year, which, in turn, leads them to increase their stated belief in and concern about global warming. Moreover, information about the distinction between weather and climate, or changes in terminology (for example, global warming versus climate change) do not counteract the impact of local temperatures on beliefs. The size of the local warming effect rivals the impact of age, race, and education on global warming attitudes[1].

Evidence for the local warming effect, as it is often called[5–6], is in line with literature showing that people base survey responses on whatever information most quickly comes to mind[7]. The easy availability of today's temperature in memory triggers people to then remember other warm days in the past, overestimate the frequency of warm days through the year, and increase their belief in and concern about global warming. What is at work is attribute substitution, where individuals base beliefs on what is salient in the mind regardless of its 'objective' relevance[8]. But the effect may not be particularly robust: it depends on how the survey question is asked. Attribute substitution can be counteracted via individual motivation and/or the information environment[9,10]. In the case of the local warming effect, one approach is to ensure the availability of other memories, such as temperature trends over the past year[10].

To test this, I implemented an experiment with two randomly assigned conditions. The 'non-prompt' condition replicates study 4 of Zaval and colleagues[6]. Participants answered the same four questions. Is the local temperature today colder or warmer than usual for this time of year? (1, much colder; 2, somewhat colder; 3, about the same; 4, somewhat warmer, 5, much warmer). Over the past year, what percentage of days seemed to be warmer than usual for that time of year, compared with the historical average? How convinced are you that global warming is happening? (1, not at all convinced; 2, a little convinced; 3, somewhat convinced; 4, completely convinced). How personally worried are you about global warming? (1, not at all worried; 2, a little worried; 3, somewhat worried; 4, a great deal worried).

The second condition was identical, except the question asking respondents to estimate the percentage of warm days last year included the instruction: "When thinking about temperatures over the last year, remember that temperature patterns vary; indeed consider last winter compared to today. Thus think not only of the feeling today but also how you felt throughout the year". This prompt is meant to make the sensations of temperatures over time available in memory, eliminating the reliance on the sensory availability of today's temperature[11–14]. This prompt should sever the relationship between today's temperature and last year's estimate.

I conducted the study on a convenience sample (as did Zaval *et al.*[6]) in Evanston, Illinois on 29 September 2014. Participants were recruited in person by approaching each potential respondent and asking whether he/she would complete a brief paper survey with no identifying

Table 1 | Experimental results showing the prompt eliminates the local warming effect

	No prompt (n = 59)	Prompt (n = 61)
Today's temperature (TT; average)	3.93	3.81
Standard deviation	0.93	0.83
Percentage days warmer (PDW; average)	38.24**	31.84**
Standard deviation	(20.64)	(19.45)
PDW and TT correlation	0.38***	0.09
Global warming belief (GWB) and PDW correlation	0.35***	0.37***
Global warming salience (GWS) and PDW correlation	0.34***	0.35***
GWB (average)	3.09***	2.56***
Standard deviation	(0.97)	(0.83)
GWS (average)	2.70**	2.38**
Standard deviation	(1.06)	(0.92)
GWB and TT correlation	0.31**	-0.05
GWS and TT correlation	0.30**	-0.06
GWB regressed on TT and PDW		
(entries are regression coefficients)	0 .22	-0.08
TT	0.01*	0.02***
PDW	1.73**	2.34**
Constant term	0.16	0.15
R^2		
GWS Regressed on TT and PDW		
(entries are regression coefficients)		
TT	0.22	-0.10
PDW	0.01*	0.02***
Constant term	1.30**	2.23***
R^2	0.15	0.10

*** p ≤0.01; ** p ≤0.05; * p ≤0.10 (one-tailed tests). The distribution of responses for TT is: (1) 0%; (2) 5%; (3) 31%; (4) 37%; and (5) 27%. The distribution for GWB is: (1) 7.5%; (2) 32%; (3) 32.5%; and (4) 28%. The distribution of responses for GWS is: (1) 17.5%; (2) 31%; (3) 32.5%; and (4) 19%. The respective means (standard deviations) are: 3.87 (.88), 2.82 (.94), and 2.53 (1.0). The mean (standard deviation) for PDW is 34.98 (20.22); the median is 30 and the mode is 20. These scores are higher than one might have anticipated and there was also chunking (crowding) around the scores of 10, 20, 30, and 40. This may reflect the complexity of survey questions asking for past frequency estimates[7]. Replication data are available on the Harvard Dataverse network (http://thedata.harvard.edu/dvn) under the title 'Eliminating the Local Warming Effect'.

information. As mentioned, participants were randomly assigned to the non-prompt or prompt condition. A prerequisite for participation was that the individual had lived in the area during the previous winter. The temperature on the day of the study registered a relatively high 80 °F, compared with a normal high of 70 °F. The previous winter was the coldest in the last 30 years and led to a number of school closings, atypical for the area. The use of a single sample/location on a particular day has the advantage of ensuring control over actual temperatures, thereby offering a test for the conditions of the local warming effect. Future work, however, should explore the impact of different prompts with distinct samples and locations where the daily temperature is not clearly high.

I present the results in Table 1, with a column for each condition. The first row reveals that, not surprisingly given the warmth of the day, the average for both groups on the 'today's temperature' (TT) question was near 4 on the scale. No participants rated it as 1 and only six rated it as 2. The next two rows reveal differences in the percentage of warm days (PDW) last year, and more importantly, the correlation between PDW and TT. Today's temperature substantially correlates with past year's estimates for the non-prompt group (0.38) at a level similar to that reported by Zaval *et al.*[6]. This relationship does not exist in the prompt group. The next two rows reveal strong relationships between global warming belief and concern with PDW, with similar correlations for both groups.

As explained, PDW is higher in the non-prompt group — because it is driven by the high TT on that day — and the consequence is higher belief and concern scores. In other words, PDW drives beliefs and concerns, regardless of the prompt, but the prompt severs the connection that lead TT to drive up PDW. The downstream effect of the prompt is to vitiate global warming beliefs and concern. The final four rows show that TT correlates with beliefs and concern in the non-prompt condition but not in the prompt condition; and then, in multiple regressions, PDW affects beliefs and concerns rather than TT (even for the non-prompt condition). The findings show that (1) without a prompt, temperature on the day of survey shapes the perceived number of warm days last year, which in turn affects global warming beliefs and concerns; and (2) with a prompt, this temperature has no effect on the perceived number of warm days last year. Perceived number of warm days shapes global warming beliefs and concerns, but beliefs and concerns are not influenced by today's temperature.

That PDW continues to have an influence across conditions is intriguing, and may suggest relatively salubrious processes involved in opinion formation given that perceptions of local weather trends tend to be accurate[15]. The results indicate that science communicators who are troubled by the fleeting nature of the local warming effect[2] can counteract it with rhetoric that emphasizes temperature deviations over time. Similarly, when writing survey questions, researchers might consider alternative phrasing that minimizes the inadvertent usage of attribution substitution processes[13]. In both cases, it is unknown whether variables — such as partisan identity and cultural worldview — become increasingly impactful as the local warming effect dissipates[16]. ❐

References

1. Egan, P. J. & Mullin, M. *J. Politics* **74,** 796–809 (2012).
2. Egan, P. J. & Mullin, M. *Nature Clim. Change* **4,** 89–90 (2014).
3. Krosnick, J. A., Holbrook, A. L., Lowe, L. & Visser. P. S. *Climatic Change* **77,** 7–43 (2006).
4. Semenza, J. C. *et al. Am. J. Prev. Med.* **35,** 479–487 (2008).
5. Li, Y., Johnson, E. J. & Zaval. L. *Psychol. Sci.* **22,** 454–450 (2011).
6. Zaval, L., Keenan, E. A., Johnson, E. J. & Weber, E. U. *Nature Clim. Change* **4,** 143–147 (2014).
7. Tourangeau, R., Rips, L. P. & Rasinski, K. *The Psychology of Survey Response* (Cambridge Univ. Press, 2000).
8. Kahneman, D. & Frederick, S. in *Heuristics and Biases: The Psychology of Intuitive Judgment Representativeness Revisited: Attribute Substitution in Intuitive Judgment* (eds Gilovich, T., Griffin, D. & Kahneman, D.) Ch. 2, 49–81 (Cambridge Univ. Press, 2002).
9. Druckman, J. N. *Am. Polit. Sci. Rev.* **98,** 671–686 (2004).
10. Bless, H., Fiedler, K. & Stack, F. *Social Cognition: How Individuals Construct Reality* (Taylor & Francis, 2004).
11. Graber, M. L. *et al. BMJ Qual. Safety* **21,** 535–557 (2012).
12. Healy, A., Malhotra, N. & Mo, C. H. *Proc. Natl Acad. Sci. USA* **107,** 12804–12809 (2010).
13. Healy, A. & Lenz, G. S. *Am J. Polit. Sci.* **58,** 31–47 (2014).
14. Schwarz, N. & Clore, G. L. *J. Pers. Soc. Psychol.* **45,** 513–523 (1983).
15. Howe, P. D., Markowtiz, E. M., Lee, T. M., Ko, C-Y. & Leiserowitz, A. *Nature Clim. Change* **3,** 352–356 (2012).
16. Goebbert, K., Jenkins-Smith, H. C., Klockow, K. & Silva, C. L. *Weather Clim. Society* **4,** 132–144 (2012).

Acknowledgments

I thank Adam Howat, and Lisa Zaval for insightful advice.

James N. Druckman
Department of Political Science and Institute for Policy Research, Northwestern University, Scott Hall, 601 University Place, Evanston, Illinois 60208, USA.
e-mail: druckman@northwestern.edu

COMMENTARY:

US climate policy needs behavioural science

Amanda R. Carrico, Michael P. Vandenbergh, Paul C. Stern and Thomas Dietz

State implementation of new Environmental Protection Agency climate regulation may shift behavioural strategies from sidelines to forefront of US climate policy.

In a rare move, the US Environmental Protection Agency (EPA), in a new draft rule known as 'The Clean Power Plan', has signalled that it will allow states and utilities to meet emissions standards by reducing electricity demand. The details of this regulation will have a substantial impact on its effectiveness[1], creating a tremendous opportunity to put integrated, multidisciplinary science to the practical end of mitigating climate change. Huge untapped potential exists for using knowledge about how the public responds to new technology, financial incentives and regulations[2]. Financial incentives for home weatherproofing, for example, have varied tenfold in their impact on rates of adoption, depending on a range of features of programme implementation beyond the financial incentives offered[3]. Incorporating insights generated from such integrated