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Two kinds of polar knowledge

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ABSTRACT

Outreach and communication with the public have substantial value in polar research, in which studies often find changes of global importance that are happening far out of sight from the majority of people living at lower latitudes. Seeking evidence on the effectiveness of outreach programs, the U.S. National Science Foundation sponsored large-scale survey assessments before and after the International Polar Year in 2007/2008. Polar-knowledge questions have subsequently been tested and refined through other nationwide and regional surveys. More than a decade of such work has established that basic but fairly specific knowledge questions, with all answer choices sounding plausible but one being uniquely correct, can yield highly replicable results. Those results, however, paint a mixed picture of knowledge. Some factual questions seem to be interpreted by many respondents as if they had been asked for their personal beliefs about climate change, so their responses reflect sociopolitical identity rather than physical-world knowledge. Other factual questions, by design, do not link in obvious ways to climate-change beliefs—so responses have simpler interpretations in terms of knowledge gaps, and education needs.

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Background

Global climate change is, by many indicators, happening "first and worst" in polar regions such as the Antarctic Peninsula and the Arctic (AMAP, 2019; IPCC, 2014; Schoolmeester et al., 2019). Such regions seem remote from the perspective of lower-latitude population centers, but polar change has global implications for sea level, ocean circulation, and weather. Many polar scientists, seeing the speed of change and its global connections, have engaged in outreach efforts to communicate their research to the public (e.g., SEARCH, 2019; SIPN, 2019). Accompanying science communication efforts has been a growing interest in finding out, through the use of surveys, what the nonscientist public understands or believes about polar regions.

A number of surveys have sought the views of people living within far northern regions on climate change and other topics. One of the first and most ambitious, although not focused on climate change, was the international Survey of Living Conditions in the Arctic (SLiCA; for an overview, see Eliassen et al., 2012). Other northern surveys include Leiserowitz and Craciun (2006) on Alaska; Craciun Research (2010) on Alaska's Northwest Arctic Borough; the Munk-Gordon Arctic Security Program (2015) surveys in northern and southern Canada, Alaska and the continental United States, Russia, and five Nordic countries; Hamilton et al. (2017) on Alaska and other U.S. states; Anisimov and Orttung (2019) on northern Russia; and Minor et al. (2019) on Greenland. A common theme emerging from diverse studies is that northern residents recognize the reality of climate change, often from its local manifestations, and are concerned about adverse effects. At the same time, northerners appear no more likely than their southern compatriots, and perhaps even less so, to attribute climate change to human causes that should be addressed through fossil-fuel use reductions.

A few of these surveys permit comparisons between the Arctic knowledge of northern and nonnorthern citizens within particular countries. Knowledge about northern Canada proves limited among southern Canadians (Munk-Gordon, 2015), as does knowledge about Arctic Alaska among residents of other U.S. states (Institute of the North, 2013), although even among Alaskans, most of whom live in more southerly parts of the state, barely half know that the United States has territory and population north of the Arctic Circle (Hamilton et al., 2017).

Since 2006, a somewhat distinct line of cumulative research has focused on assessing polar science knowledge among midlatitude populations such as the lower U.S. states. Through iterations on broad nationwide surveys, these studies refined the art of asking good questions, and incidentally discovered that there are two kinds of knowledge: factual items that are, or are not, commonly answered on the basis of individuals' sociopolitical identity instead of physical-world knowledge.

The first general U.S. polar surveys

In 2006, anticipating research and education activities planned for the International Polar Year (IPY, 2007–2008), the Office of Polar Programs together with the Social,

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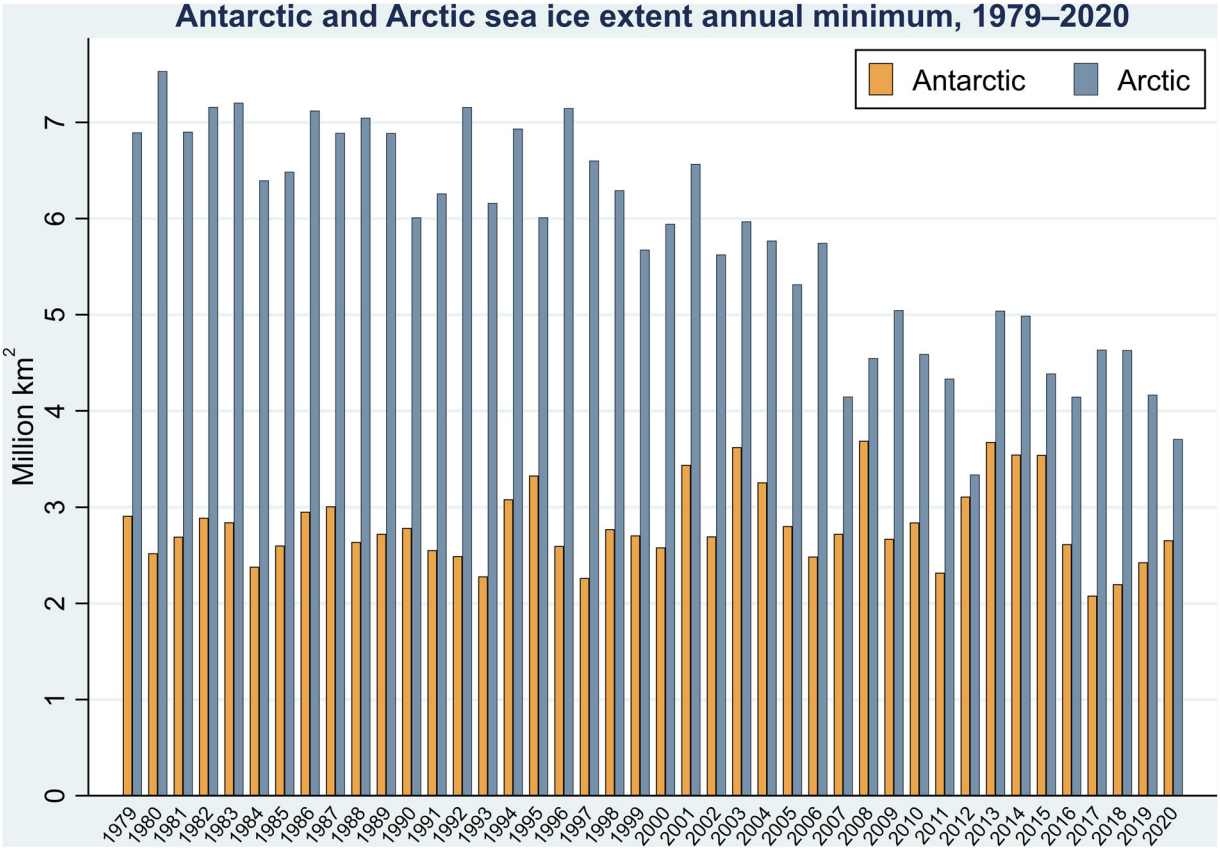

Figure 1. Minimum daily extent of Antarctic and Arctic sea ice (1979–2020), based on data from National Snow and Ice Data Center (NSIDC, 2020).

Behavioral, and Economic Science Directorate of the U.S. National Science Foundation (NSF) designed a set of survey questions to assess general-public knowledge about polar regions. These questions, roughly modeled on longstanding NSF studies of science literacy (National Science Board, 2010), were developed through an iterative process of discussion, review, and pretesting. Their content reflected contemporary scientific concerns about polar-region change, such as the impacts of warming on land and sea ice, ecosystems, and people. The polar questions were incorporated into the 2006 and 2010 General Social Survey (GSS; Smith et al., 2019), to give nationally representative benchmarks before and after the IPY.

Test questions were meant to be straightforward, necessary for public comprehension on this first-of-its-kind polar-knowledge survey. For example, asking about ice trends: "Would you say the polar ice caps have gotten larger or smaller over the last 25 years?"

Seventy-seven percent of the 2006 GSS respondents ($n = 1{,}853$) and 81% of the 2010 respondents ($n = 697$) chose "smaller" (Hamilton et al., 2012a), which was intended to be the accurate response. High nominal accuracy and a small although statistically significant improvement from 2006 to 2010 offered a generally positive portrait of polar literacy. Interpretation before critical audiences was undercut, however, by the question's ambiguity. Do "polar ice caps" refer to land ice, sea ice, or some combination of the two? What metric defines size for each feature? Should seasonality be specified, as summer trends may differ from winter? A uniquely true answer to the survey question might be elusive, depending on how such ambiguities are resolved.

Figure 1, graphing data from the National Snow and Ice Data Center (NSIDC, 2020), illustrates the complications even if we focus only on sea ice, and on the minimum extent reached each year. From the start of modern satellite measurements (in 1979) through the GSS years of 2006 or 2010, minimum sea ice extent was clearly trending down in the Arctic, but not so in the Antarctic, where the highest minima of the satellite era occurred in 2003 and 2008. (Since 2010, however, Arctic, Antarctic, and global sea ice extent have all set new record lows.) Trends for East Antarctica, by far the largest mass of land ice, were even less clear cut at the time of these GSS surveys, with large uncertainties and conflicting estimates regarding mass balance.

Sharper questions

I was not involved with the GSS study's design or execution, becoming aware of this fascinating project only after publication of the 2006 survey data by the National Opinion Research Center (NORC, 2019). No one else seemed to be working with these data, so I wrote up the first detailed analysis in an article for *Arctic, Antarctic, and Alpine Research* (Hamilton, 2008). Subsequent publication of 2010 GSS data allowed tests for post-IPY changes, which proved to be detectable although not large (Hamilton et al., 2012a,

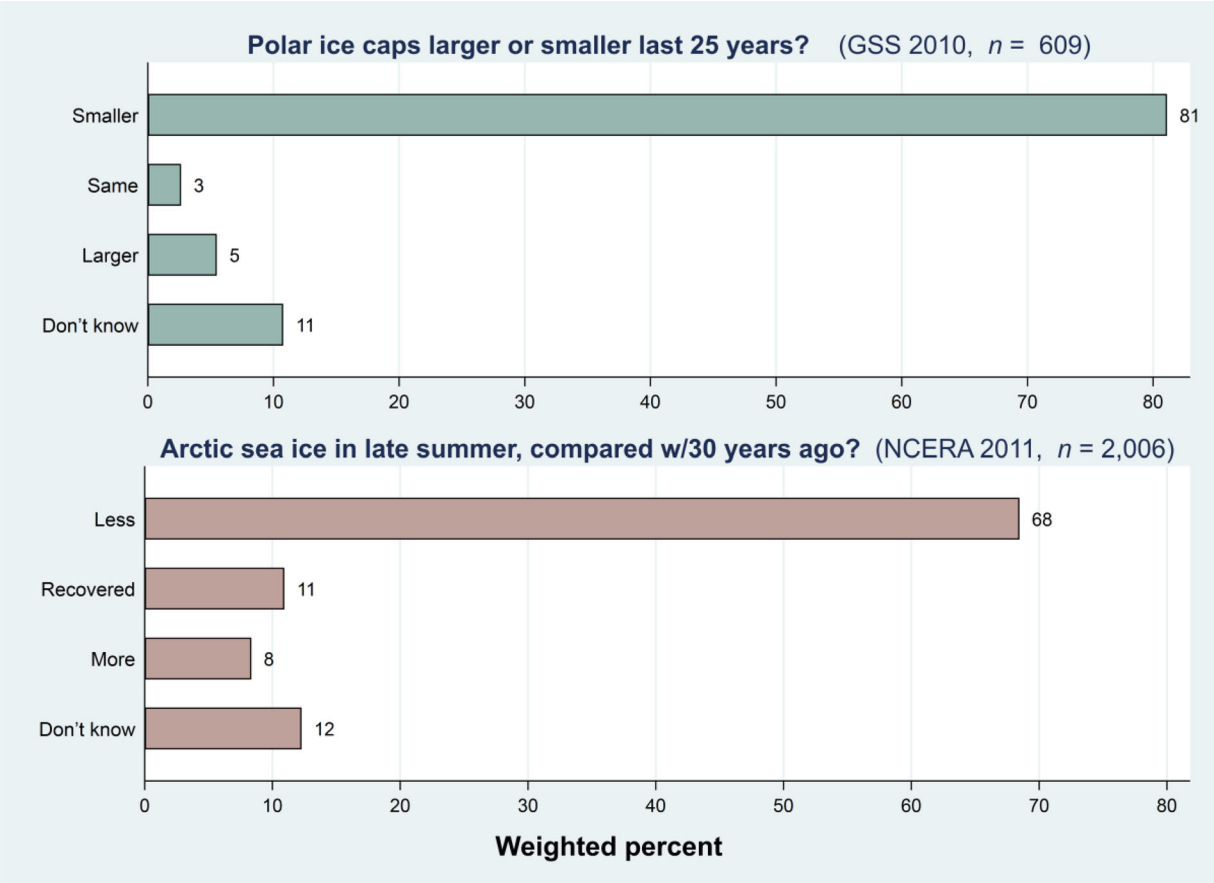

Figure 2. Responses to differently worded questions about polar ice trends, asked on the 2010 General Social Survey and the 2011 NCERA survey. See Hamilton et al. (2012a) and Hamilton (2012) regarding the GSS and NCERA surveys, respectively.

2012b). Presenting these results before skeptical audiences, however, brought home the problem with interpreting very general questions as indicators of knowledge. Seeking a more definitive alternative, I drafted a question about ice trends that, without being much more complex, specified not only the time frame (past few years vs. 30 years ago) but also the location (the Arctic Ocean), season (late summer), and metric (area)—making one answer unambiguously correct. The order of response choices was rotated in telephone interviews.

> Which of the following three statements do you think is more accurate? Over the past few years, the ice on the Arctic Ocean in late summer …
> a. covers less area than it did 30 years ago (*correct*).
> b. declined but then recovered to about the same area it had 30 years ago.
> c. covers more area than it did 30 years ago.

The National Community and Environment in Rural America (NCERA) survey—despite its name, a nationally representative sample—included this question in 2011 (Hamilton, 2012). Unlike the GSS, which employs primarily face-to-face interviews, NCERA interviews were conducted over the telephone by trained interviewers at the University of New Hampshire Survey Center, calling randomly selected numbers nationwide. As with the GSS, weights proportional to the inverse probability of selection were calculated to adjust for known design bias, and for sampling bias inferred from comparisons with Census data. Such weights are applied to all graphs and analyses in this article. Figure 2 compares responses to the old and new ice-trend questions, from 2010 GSS and 2011 NCERA surveys.

In this newer ice question, the "declined but then recovered" option intentionally echoed arguments promoted by climate-change deniers who were focusing on short-term variation to counter scientific observations of decadal decline (e.g., Idso & Singer, 2009; discussed in Hamilton, 2012). This NCERA response choice proved more popular than the GSS question's "same" response, and particularly so among people who, according to another question on the same survey, did not believe anthropogenic climate change is happening. To a lesser degree, that subgroup also favored "more area." Overall, however, the two distributions in Figure 2 are not strikingly different, and the nominally correct responses have similar demographic predictors in both cases (comparing GSS analysis in Hamilton et al., 2012b, with NCERA analysis in Hamilton, 2012). Two-thirds of NCERA respondents chose the scientifically accurate "less area." The advantages of more precise wording mainly involved cleaner interpretation and detection of patterns in *systematically wrong* answers (Hamilton, 2012), rather than different main conclusions.

Other polar-knowledge questions have subsequently been developed with the same philosophy: addressing important

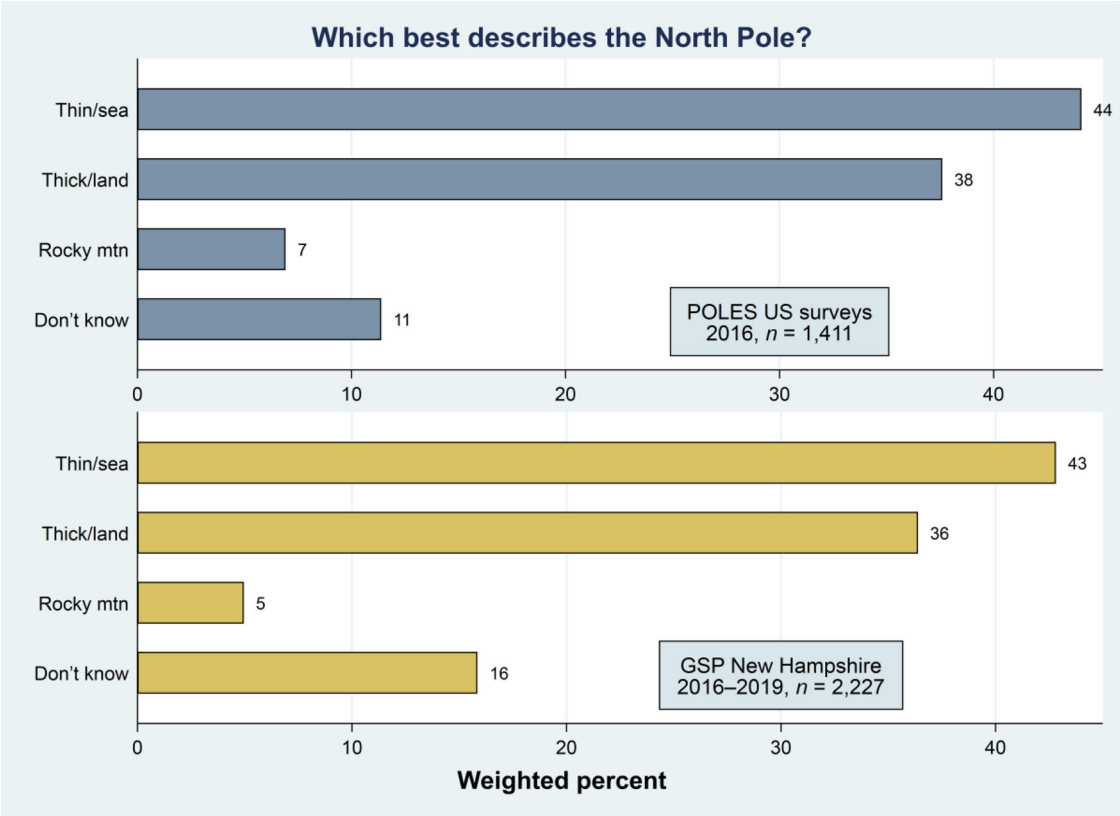

Figure 3. North Pole question responses from the nationwide POLES surveys (2016) and a series of statewide New Hampshire surveys (2016–2019), updated from Hamilton (2016).

but basic facts (not trivia or numerical specifics) the informed public might reasonably know; using neutral but fairly precise wording; and offering answers that all sound plausible, although only one is clearly correct. For example, the following question was asked on the Polar, Environment, and Science (POLES) survey in 2016, again with rotated response choices.

> Which best describes the North Pole?
> a. Ice a few feet or yards thick, over a deep ocean (correct).
> b. Ice more than a mile thick, over land.
> c. A rocky, mountainous landscape.

Figure 3, updated from Hamilton (2016), charts the nationwide POLES survey results alongside results from a series of statewide New Hampshire surveys, the Granite State Poll (GSP), which tell the same story. New Hampshire often proves to be a reasonable and cost-effective proxy for nationwide surveys on climate, polar, and other science-related topics (e.g., Hamilton 2016; Hamilton et al., 2019).

Fewer than half of the POLES or GSP respondents in Figure 3 recognized that the North Pole is on sea ice, over an ocean. Similar proportions thought it was either on thick ice over land, or a rocky, mountainous landscape, suggesting they do not accurately visualize a globe or know basic geography. Compared with the ice-trend results in Figure 2, the North Pole results in Figure 3 suggest much lower public knowledge about polar regions. Moreover, the two results seem paradoxical: How could so many of the same survey respondents accurately report that the Arctic Ocean ice area has declined and yet not know where that ocean and ice are?

Two kinds of knowledge

The paradox is resolved through closer analysis of these questions and others, revealing "two kinds" of polar-related facts: those that can be guessed from more general beliefs about climate change (Hamilton, 2015a), which in contemporary America covaries closely with sociopolitical identity (Shwom et al., 2015), and those that cannot. Thus, people whose identity inclines them to reject the scientific consensus on climate change will also more often say that Arctic sea ice has recovered or that global CO_2 levels are not changing. Such counterfactual propositions conform better to beliefs that anthropogenic climate change is not happening, and are actively promoted by media and political figures to support climate-change denial (Dunlap & McCright, 2015). Conversely, people who accept the scientific consensus on climate change more often respond accurately about sea ice or CO_2, whether informed by physical-world knowledge or by their more general climate beliefs. Interestingly, people who say they are unsure about climate change often exhibit greater accuracy on the climate-linked questions than people who reject anthropogenic climate change (Hamilton, 2012).

Responses to climate belief-linked factual questions consequently present an intractable mixture of objective knowledge with sociopolitical identity. But whatever one's position on climate change, it whispers no clues about the North Pole's location. This illustrates a second kind of question that has direct relevance for understanding climate change, but for which one's beliefs about the reality of

Table 1. Six questions of two different kinds, asked on surveys to assess polar knowledge (answers rotated in interviews, to avoid bias). See Hamilton (2018) for responses to belief-neutral questions on nationwide surveys.

Climate belief-linked questions
Which of the following three statements do you think is more accurate? Over the past few years, the ice on the Arctic Ocean in late summer …
Covers less area than it did 30 years ago (*correct*)
Declined but then recovered to about the same area it had 30 years ago
Covers more area than it did 30 years ago
Which of the following three statements do you think is more accurate? Scientific measurements have confirmed that in recent decades, the concentration of CO_2 or carbon dioxide in the Earth's atmosphere is …
Increasing (*correct*)
Staying about the same
Decreasing
Climate-relevant but belief-neutral questions
Which of these best describes the North Pole?
Ice a few feet or yards thick, over a deep ocean (*correct*)
Ice more than a mile thick, over land
A rocky, mountainous landscape
Which of these best describes the South Pole?
Ice a few feet or yards thick, over a deep ocean
Ice more than a mile thick, over land (*correct*)
A rocky, mountainous landscape
Which of the following possible changes would, if it happened, do the most to raise sea levels?
Melting of sea ice on the Arctic Ocean
Melting of land ice in Greenland and the Antarctic (*correct*)
Melting of glaciers in the Himalaya and Alaska
Which country has territory and thousands of people living north of the Arctic Circle?
United States (*correct*)
China
Estonia
Britain
None of these

climate change do not suggest a particular answer. Responses to such questions are consequently more interpretable as indicators of knowledge. Table 1 lists six examples of knowledge questions, representing both types, which have been asked on recent surveys.

Responses to belief-linked climate or polar questions diagnostically exhibit political gradients like those in the top two panels of Figure 4. A 35-point gap separates Democrats from Tea Party supporters on the reality of sea ice decline. Regarding CO_2 trends, this gap widens to 40 points. Some people are giving scientifically accurate answers, whereas others answer questions about scientifically established facts as if they had been asked, instead, for their personal opinions about climate change—or, more basically, about who they are. Presumably some of the *accurate* answers also stem from sociopolitical beliefs rather than physical-world knowledge, but in those cases the sociopolitical beliefs are informed by science (Hamilton, 2018; Hamilton & Fogg, 2019). Similar gradients in accuracy on belief-linked questions occur if we break down responses by self-assessed ideology, or even by approval of President Donald Trump (Hamilton, 2016; Hamilton & Fogg, 2019). In the United States today, climate beliefs correlate with virtually any measure of sociopolitical identity so consistently that they could serve as markers for such identity, nearly as valid as typical questions about ideology or political party (Hamilton et al., 2020; Kahan, 2015). Certain nonclimate topics—such as fossil fuel vs. renewable energy development and the need for species or ecosystem protection—exhibit milder degrees of this attribute (e.g., Hamilton et al., 2019).

The four lower panels in Figure 4 illustrate the contrasting profiles of belief-neutral questions. Political differences are smaller (11 points or less), do not form clear gradients, and here are not statistically significant. That is not to assert that no political differences should exist on belief-neutral questions of fact, or that responses must be uncorrelated with climate views; other evidence suggests they are not (Hamilton, 2018; Hamilton & Fogg, 2019). But the neutral questions provide more interpretable indicators of knowledge for such research, being less confounded with sociopolitical identity and climate beliefs at the start. They make better sense also for regional comparisons, such as testing to what extent Alaska residents know more than other Americans about the Arctic (Hamilton et al., 2017).

Implications

My comments have focused on polar knowledge of the U.S. general public, but the recommendations for nontrivial yet clear knowledge questions, and for caution when interpreting responses that could be inferred (right or wrongly) from individuals' climate-change beliefs, should apply for nonpolar topics and beyond the United States. Correlations between climate-change beliefs and sociopolitical identity have been observed in many countries (McCrightet al., 2016), although such correlations are particularly strong in the United States and, perhaps to a growing degree, other Anglophone countries. For comparison with U.S. patterns, the Australian Social Survey in 2017 carried the North Pole and several other knowledge questions listed in Table 1 (Evans, 2018). Tranter (2019) reports Australian results broadly similar to those from U.S. studies.

Good polar knowledge questions, for use among nonscientists, should not be arguably ambiguous, such as, "Have

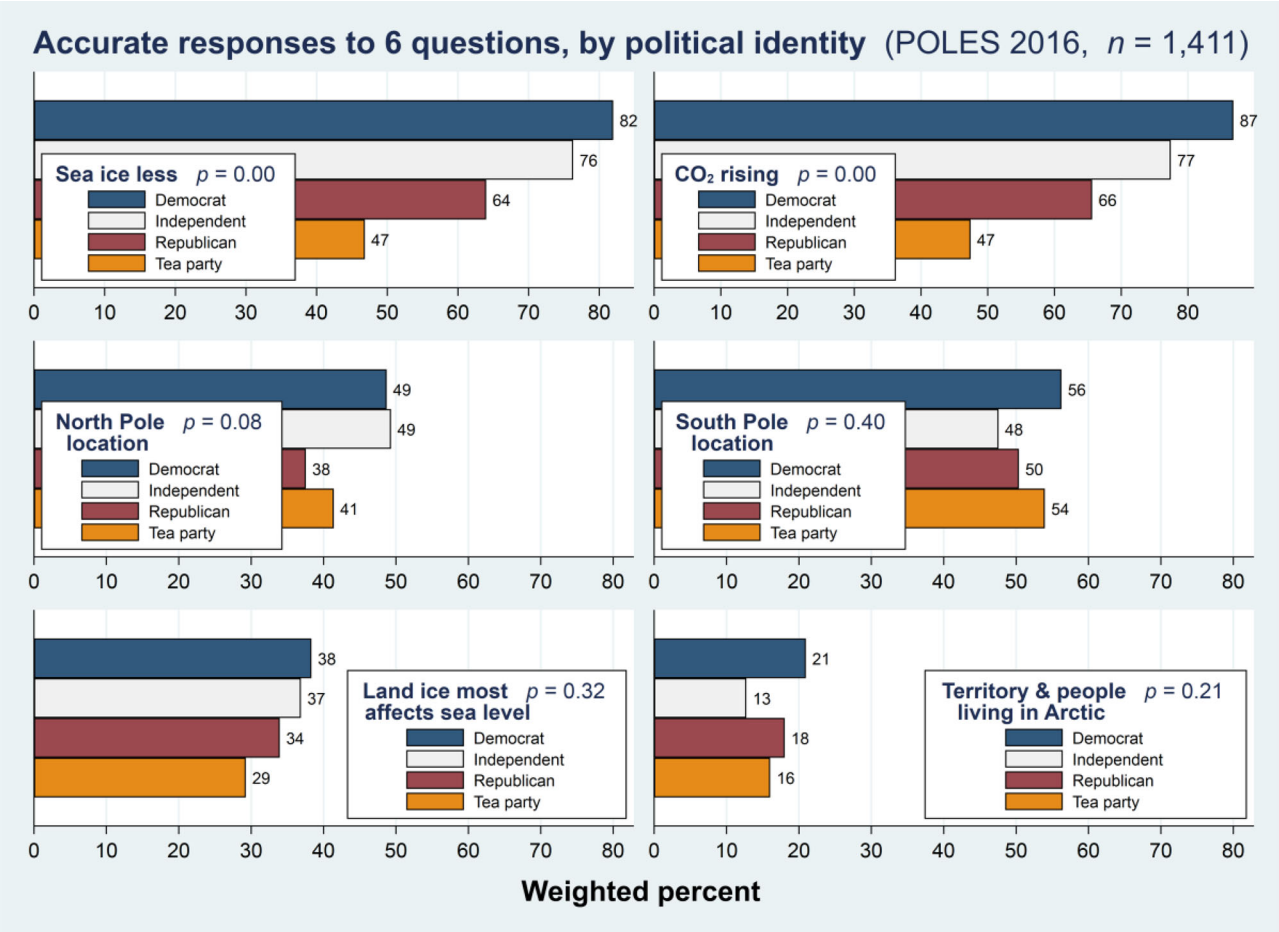

Figure 4. Percentage of accurate responses to six factual questions, by each respondent's political identity (POLES US surveys 2016). Probabilities reflect adjusted Wald tests from weighted logit regressions.

the polar ice caps decreased?" Neither should they be so specific as to mainly invoke guesswork, such as, "By what percentage did September Arctic sea ice area change from 1979 to 2019?" Preferably, the knowledge questions should address major qualitative facts relevant to the topic at hand, salient enough that informed nonscientists might be aware. The answer choices should be neutrally worded and cover plausible alternatives, but with one choice being unambiguously correct. Within the range of such "good" knowledge questions, however, we see two basic kinds: questions for which an individual's sociopolitical identity does suggest obvious answers and those that do not. Both kinds can assess knowledge, but in one case objective knowledge is constrained by identity, making interpretation more complicated. Sociopolitical identity offers no clues about whether the North Pole is over land ice or sea ice. But identity-linked climate beliefs offer obvious clues about whether the Arctic sea ice area has declined compared with 30 years ago, and may even incline people to discredit scientists who say that it has.

To be sure, identity clues could push in either direction. Liberals and moderates, or people who accept the reality of climate change, would be more inclined to answer (correctly) that sea ice has declined, even in the absence of real knowledge. Identity-linked acceptance of climate change is informed in the first place, however, by scientific evidence, which liberals and moderates are more inclined to trust generally (Gauchat, 2012; Nadelson et al., 2014) and with respect to specific topics ranging from climate change and evolution to nuclear power and vaccines (Hamilton et al., 2015a, 2015b). Thus, some liberals or moderates who agree that sea ice has declined might base that agreement on their own knowledge, or they might just be following their partisan elites. But even in the latter case, those partisan elites take their own clues from science. Identity-linked knowledge questions can be studied for insights on politically selective information acquisition, a focus of much current research. Identity-neutral knowledge questions have value for other purposes, such as identification of individuals and areas in which a simple knowledge gaps exist, which could be addressed through education to build a better foundation for understanding polar change.

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Disclosure statement

The author declares no financial interest or benefit that has arisen from direct application of this research.

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