



Lewandowsky, S., Ballard, T., Oberauer, K., & Benestad, R. E. (2016). A Blind Expert Test of Contrarian Claims about Climate Data. *Global Environmental Change*, 39, 91-97.
<https://doi.org/10.1016/j.gloenvcha.2016.04.013>

Peer reviewed version

Link to published version (if available):
[10.1016/j.gloenvcha.2016.04.013](https://doi.org/10.1016/j.gloenvcha.2016.04.013)

[Link to publication record in Explore Bristol Research](#)
PDF-document

This is the author accepted manuscript (AAM). The final published version (version of record) is available online via Elsevier at <http://www.sciencedirect.com/science/article/pii/S0959378016300577>

University of Bristol - Explore Bristol Research

General rights

This document is made available in accordance with publisher policies. Please cite only the published version using the reference above. Full terms of use are available:
<http://www.bristol.ac.uk/pure/about/ebr-terms>

A Blind Expert Test of Contrarian Claims about Climate Data

Stephan Lewandowsky

University of Bristol and University of Western Australia

Timothy Ballard

University of Bristol and University of Queensland

Klaus Oberauer

University of Zurich

Rasmus Benestad

The Norwegian Meteorological Institute

Abstract

Although virtually all domain experts agree that CO₂ emissions are causing anthropogenic global warming, public discourse is replete with contrarian claims that either deny that global warming is happening or dispute a human influence. Although the rejection of climate science is driven by ideological, psychological, and political variables rather than scientific disagreement, contrarian views have considerable prominence in the media. A better understanding of contrarian discourse is therefore called for. We report two studies in which experts evaluated representative public contrarian statements about climate variables in light of the data. In Study 1, climate experts found the statements to be misleading, and affirmed that the interpretative techniques (e.g., “cherry-picking”) are common among contrarians. In Study 2, expert economists and statisticians were presented with the same statements translated into an economic or demographic context. In that blind expert test, contrarian statements were again found to be misleading. By contrast, mainstream scientific interpretations of the data were judged to be accurate and policy relevant. The results imply that media reliance on contrarian statements increases bias rather than balance.

Address correspondence to the first author at:

School of Experimental Psychology and Cabot Institute,

University of Bristol,

12a Priory Road,

Bristol BS8 1TU,

United Kingdom

Email: stephan.lewandowsky@bristol.ac.uk

Web: <http://www.cogsciwa.com>

Highlights

- We identified representative claims about data made by climate contrarians.
- Experts evaluated these claims translated into an economic context for accuracy and credibility.
- The contrarian claims were found to be misleading in this blind test.
- Mainstream scientific interpretations of the same data were found to be accurate in the blind test.

A Blind Expert Test of Contrarian Claims about Climate Data

Abstract

Although virtually all experts agree that CO₂ emissions are causing anthropogenic global warming, public discourse is replete with contrarian claims that either deny that global warming is happening or dispute a human influence. Although the rejection of climate science is known to be driven by ideological, psychological, and political factors rather than scientific disagreement, contrarian views have considerable prominence in the media. A better understanding of contrarian discourse is therefore called for. We report a blind expert test of contrarian claims about climatological variables. Expert economists and statisticians were presented with representative contrarian statements (e.g., “Arctic ice is recovering”) translated into an economic or demographic context. In that blind test, contrarian claims were found to be misleading. By contrast, mainstream scientific interpretations of the data were judged to be accurate and policy relevant. The results imply that media inclusion of contrarian statements may increase bias rather than balance.

Keywords: Climate change; Climate change denial; Public discourse about climate change

In light of the pervasive scientific agreement that humanity is facing a risk from climate change (Anderegg, Prall, Harold, & Schneider, 2010; Cook et al., 2013; Doran & Zimmerman, 2009; Oreskes, 2004), the prominence of contrarian discourse in the media (Boykoff & Boykoff, 2004; Painter & Gavin, 2015) and the possible declining public acceptance of the underlying science (Brulle, Carmichael, & Jenkins, 2012; McCright & Dunlap, 2011b; Scruggs & Benegal, 2012) must give rise to concern. A better understanding of why and how people reject the scientific consensus on climate change is therefore called for.

Considerable progress has been made in identifying the political, psychological, and ideological variables underlying the rejection of science (Dunlap & Jacques, 2013; Kahan, 2010; Lewandowsky, Oberauer, & Gignac, 2013; Lewandowsky, Gignac, & Oberauer, 2013; McCright & Dunlap, 2011a). For example, it is known that the rejection of climate science is more prevalent on the political right than the political left (Dunlap & Jacques, 2013; Lewandowsky, Gignac, & Oberauer, 2013; McCright & Dunlap, 2010, 2011a; McCright, Dunlap, & Xiao, 2013), presumably because of the regulatory implications associated with mitigation which challenge people who endorse laissez-faire free-market economics (Heath & Gifford, 2006; Oreskes & Conway, 2010). However, comparably less is known about

the rhetorical and argumentative techniques employed by contrarians in their opposition to mainstream science. There is evidence that the opposition to climate science and climate mitigation policies is organized rather than haphazard (Brulle, 2013; Dunlap & McCright, 2010, 2011), and it is known that one of the major talking points in contrarian opinion pieces is the questioning of the scientific consensus (Elsasser & Dunlap, 2013). It is also known that contrarian documents employ language that is more certain than mainstream publications (Medimorec & Pennycook, 2015). However, the specific techniques underlying contrarian claims and arguments have largely escaped scrutiny to date. A better understanding of those techniques is necessary because it may open avenues for communication and, where necessary, rebuttal of misinformation (e.g., Lewandowsky, Ecker, Seifert, Schwarz, & Cook, 2012).

Scientific publications containing contrarian arguments are few in number (Cook et al., 2013), and have been routinely challenged in the literature. Recent work has shown that contrarian articles are frequently flawed (Abraham et al., 2014) and may be best considered as examples of how one can learn from mistakes in climate research (Benestad et al., 2015). Along similar lines, in this article we examine the validity of public claims made by contrarians about climatological variables. Those claims frequently underpin the media presence of contrarian opinions. To illustrate, a Factiva search of Australia's only national daily broadsheet returned 17 articles (and 3 letters to the editor) in 2014 that contained the phrase "sea level rise." Of those, one article noted that properties worth a total of A\$226 billion were at risk from sea level rise, and the remainder ($N = 16$) questioned the extent of the risk, referring variously to "sea level alarmism" or claiming that the rate of sea level rise is "going in the opposite direction to predictions." (The Online Supplementary Material contains all articles.) Although such claims about sea level rise are at odds with mainstream scientific views (e.g., Cazenave et al., 2014; Church et al., 2013), highlighting such a deviation from the scientific mainstream may be insufficient to convince the public or journalists that contrarian claims are flawed: Given that climate change is considered a "hoax" by some politically prominent voices (Inhofe, 2012)—a claim echoed in numerous books by contrarians (Bell, 2011; Montford, 2010; Solomon, 2008; Sussman, 2010)—climate scientists' rejection of contrarian claims may not be considered strong evidence by a notable segment of the public (Lewandowsky, Oberauer, & Gignac, 2013; Lewandowsky, Gignac, & Oberauer, 2013; Smith & Leiserowitz, 2012).

The present article therefore reports a blind expert test of contrarian claims about climate data. Blind experiments, in which participants are unaware of the nature of the stimuli or experimental manipulation, are common practice to eliminate contributions of participant bias. In a previous blind study involving climate data, naïve participants were shown graphs with the global temperature time series: It was found that irrespective of whether the data were identified as temperatures or as fictitious share prices, participants uniformly expected the upward trend in the time series to continue (Lewandowsky, 2011), in line with expert expectation and contrary to the "skeptical" claim that global warming "stopped in 1998" (e.g., Carter, 2006). Building on this precedent, in the present investigation experts responded to several scenarios, each comprised of a graph showing climatological data and an accompanying claim gathered from public sources (e.g., internet or media) that was representative of contrarian discourse.

Study 1 conducted an internet search to establish the prevalence of various contrarian arguments in public discourse. The representativeness of the contrarian claims we selected on that basis was then confirmed by a number of climate experts. Study 2 presented expert economists and expert statisticians with the contrarian claims identified in Study 1 accompanied by climatological data, but translated into economic or demographic scenarios for a blind test in which experts commented on the validity of those claims in light of the data.

Study 1: Internet validation of representativeness of contrarian statements

Contrarian climate statements were sampled from public sources (i.e., TV, radio, internet, media) by the authors with a view towards covering a broad range of climate indicator variables (Table 1). Two of the statements were drawn from material provided by an American think tank with a history of opposition to mainstream climate science and a U.K.-based similar organization, respectively. Another statement was drawn from a widely read tabloid newspaper in the U.K. A further statement was made on air by a well-known TV personality in the U.S., and the remaining two statements were drawn from climate-contrarian internet blogs.

Statements were selected on the basis of three criteria: We judged them to be representative of contrarian discourse pertaining to the climate variable, they had to appear incompatible with the scientific consensus, and they had to permit comparison with the actual data to assess their validity. For example, the statement “Our glaciers are growing, not melting”, accompanied by the further claim that “almost all of the ice-covered regions of the Earth are now gaining mass” appeared representative of contrarian discourse in the authors’ opinion. It also appears incompatible with peer-reviewed literature (Zemp, Hoelzle, & Haeberli, 2009), and its validity can be assessed in comparison to the data.

Method

To confirm that the chosen statements were representative of contrarian discourse, we conducted a content analysis of the 3 most prominent “skeptical” blogs. The blogs were chosen from a list used in previous research (Sharman, 2014) by first restricting the list to blogs with an Alexa rank below 250,000,000, and then picking the 3 blogs with the highest centrality using Freeman’s metric. Alexa is a company, owned by *Amazon*, that collects and publishes data on browsing behavior and web traffic. Centrality is a concept from social network analysis that refers to how close an individual (or blog) is to the action in a network (Sharman, 2014). Freeman’s metric is one measure of centrality that has previously been used to rank high-traffic sites (see Table 3 in Sharman, 2014).

For each of those blogs, site-specific Google searches were conducted using the keywords in Table 2 and selectively searching entries for 2013, 2014, and 2015 to date (30 September 2015). The unconstrained search terms were designed to pick up all content for each of the 4 distinct indicator variables used in Study 1. The contrarian search terms additionally contained a keyword designed to pick up content related to the specific claims used in Study 1. For example, the claims about arctic ice postulate a “recovery” of sea ice extent, and the claim about temperatures relates to purported “cooling.” Those additional

Table 1: Stimulus scenarios used in both studies

| Label | Source of data for scenario | Translation ^a |
|-------|--|--------------------------------------|
| AI1 | Arctic sea ice extent (ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/daily/data/NH_seaice_extent_final.csv) | Profits (supreme widget corporation) |
| AI2 | Arctic sea ice extent (ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/north/daily/data/NH_seaice_extent_final.csv) | Trade surplus |
| GL | Glaciers (http://www.wgms.ch/mbb/sum11.html) | Rural population growth |
| SLR1 | Sea level rise (http://sealevel.colorado.edu/files/2014_re14/sl_ns_global.txt) | Daily global currency trade volume |
| SLR2 | Sea level rise (http://sealevel.colorado.edu/files/2014_re14/sl_ns_global.txt) | World lithium production |
| GMST | Global mean surface temperature (http://cdiac.ornl.gov/ftp/trends/temp/hansen/gl_land_ocean.txt) | World agricultural output |

^a Translations were used in Study 2.

Table 2: Google search terms for confirmatory blog content analysis in Study 1

| Indicator Variable ^b | Search Term ^a | |
|---------------------------------|----------------------------------|---|
| | Unconstrained | Contrarian |
| Arctic Ice | “arctic ice” OR “arctic sea ice” | “arctic ice” OR “arctic sea ice” AND recovery |
| Glaciers | glaciers | glaciers AND growing |
| SLR | “sea level rise” | “sea level rise” AND slowing |
| GMST | temperature | temperature AND cooling |

^a Each search term was used exactly as shown in a site-specific Google search for each blog, for three time periods (2013, 2014, and 2015 to date).

^b Indicator variables are explained in Table 1.

keywords for the contrarian searches were chosen because they were found to be most prominent during a preliminary examination of possible terms to express the contrarian claim—for example, arctic ice might “rebound” or “recover” or “return” to previous levels. Among these terms, “recover” appeared to be the most frequent in our initial examination.

Results

Table 3 shows the results of the content analysis for each indicator variable and each blog. The first two columns of data present the raw number of hits, summed across the three years, for the two types of search terms in Table 2. The next three columns present the proportions of hits for the contrarian search terms that were verified by inspection of the top 20 hits returned for each blog and each year.

Verification is necessary because a hit in response to “recovery” in the context of “arctic ice” might involve the expected contrarian polarity (e.g., “arctic ice continue to recover”) or its opposite (e.g., “no evidence that arctic ice is recovering”). The verification is broken down by whether the contrarian polarity was identified in an article (blog post) or in the comment stream. The verified total proportion (summing across articles and comments) estimates the prevalence of actual contrarian polarity within the contrarian hits, which is converted into an estimate of the prevalence of contrarian content among *all* hits for that climatological variable in the final column.

To illustrate, suppose there are 1,000 hits for “arctic ice” across the three years, 500 of which are also returned with “recovery” added to the search string. The top 20 of the latter hits for each year (i.e., 60 out of 500 across the three years being considered) were then explicitly checked for their polarity by following the links and reading articles and comments until contrarian polarity could be detected (if the article and all comments could be read without evidence of contrarian polarity, then this hit was not considered to be

contrarian). Supposing that 40 of those 60 were thus confirmed to be contrarian, then the verified prevalence of contrarian discourse in the overall population of sea ice content would be .33; $40/60 \times 500/1000 = .33$.

The results confirm that the claims selected by the authors were representative of contrarian discourse: Nearly two-thirds of all mentions of temperature on the three top contrarian blogs included a claim of “cooling”; and likewise more than a quarter of all mentions of arctic ice alluded to its “recovery”, and so on. Those numbers represent a lower bound on the prevalence of the claims in contrarian discourse because the claims can be expressed in a number of additional ways that we did not consider in our content analysis. For example, arctic ice might “rebound” or “return” to earlier levels, and so on.

One limitation of the Google analysis is that while it confirmed the representativeness of the chosen claims, it considered claims only at a broad semantic level, based on overlap between keywords. To confirm that the representativeness extended to the particular wording and phrase structure in our candidate stimuli, we asked several climate experts to judge each candidate claim on various attributes, including representativeness. We additionally asked the climate experts to identify the rhetorical techniques used in the various claims. The expert ratings confirmed that the rhetorical techniques used in our stimuli were representative and could be classified reliably with respect to an inventory of such techniques. (Details of the rating study are provided in the Online Supplementary Material).

Study 2: Blind expert test of contrarian claims

The second study subjected the contrarian statements identified by Study 1 to a blind test by converting them into an equivalent scenario in a different domain (economics or demographics), and presenting them to experts for evaluation. For example, the GL scenario pairs the claim that “our country’s rural population is growing, not shrinking” with a figure that showed the change in population for numerous individual villages, akin to a figure depicting the mass balance of individual glaciers.

In addition, an alternative statement was constructed for each scenario that summarized the mainstream scientific interpretation of the climate data, again translated into economic or demographic terms (e.g., “almost all of the rural regions of the country are losing population”). For each scenario and each participant, one of the two versions of the statement was randomly paired with the graph of the data.

Method

Participants. There were two groups of participants, comprising expert economists and expert statisticians. The first group was recruited through an online survey firm (Qualtrics.com). To be included in the sample, participants had to hold a Master’s degree or PhD in economics or an allied discipline. This group comprised 22 experts (7 female, mean age 41.3, $s = 11.3$). Four of the participants had less than one year (or no) professional experience, the remainder had professional experience of 1–2 years ($N = 4$), 3–5 years ($N = 4$), 6–10 years ($N = 3$), or more than 10 years ($N = 5$; 2 participants did not respond to this question). Two participants had published articles in the peer-reviewed literature on economics or an allied discipline. Participants were compensated by Qualtrics with cash-equivalent points.

Table 3: Results of confirmatory blog content analysis in Study 1

| Indicator Variable ^a | Hits | | | Proportion Verified Contrarian | | Verified Prevalence |
|---------------------------------|----------------------------|-------------------------|---------|--------------------------------|-------|---------------------|
| | Unconstrained ^b | Contrarian ^b | Article | Comments | Total | |
| Arctic ice | | | | | | |
| Blog 1 | 1277 | 496 | 0.25 | 0.50 | 0.75 | 0.29 |
| Blog 2 | 103 | 29 | 0.07 | 0.31 | 0.38 | 0.11 |
| Blog 3 | 276 | 106 | 0.10 | 0.50 | 0.60 | 0.23 |
| Weighted average ^c | | | | | | 0.26 |
| Glaciers | | | | | | |
| Blog 1 | 2932 | 1151 | 0.08 | 0.40 | 0.48 | 0.19 |
| Blog 2 | 123 | 53 | 0.04 | 0.10 | 0.14 | 0.06 |
| Blog 3 | 199 | 126 | 0.03 | 0.13 | 0.17 | 0.11 |
| Weighted average | | | | | | 0.17 |
| SLR | | | | | | |
| Blog 1 | 2746 | 669 | 0.23 | 0.43 | 0.67 | 0.16 |
| Blog 2 | 147 | 46 | 0.21 | 0.19 | 0.40 | 0.13 |
| Blog 3 | 265 | 124 | 0.05 | 0.30 | 0.35 | 0.16 |
| Weighted average | | | | | | 0.16 |
| GMST | | | | | | |
| Blog 1 | 5020 | 4330 | 0.28 | 0.52 | 0.80 | 0.69 |
| Blog 2 | 783 | 459 | 0.20 | 0.57 | 0.77 | 0.45 |
| Blog 3 | 714 | 536 | 0.17 | 0.62 | 0.78 | 0.59 |
| Weighted average | | | | | | 0.65 |

^a Indicator variables are explained in Table 1.

^b Search terms are shown in Table 2.

^c Average verified prevalence across the three blogs, weighted by total number of hits.

The second group responded to an invitation to participate voluntarily and without remuneration that was circulated on two expert mailing lists; one within a university department of mathematics in England, and one on an online bulletin board for the UK Education and Research communities dedicated to statistical issues. This group comprised 30 respondents (11 female, 1 unwilling to indicate gender; mean age 39.3, $s = 13.1$). Two participants had less than one year (or no) professional experience, the remainder had professional experience of 1–2 years ($N = 4$), 3–5 years ($N = 3$), 6–10 years ($N = 3$), or more than 10 years ($N = 18$). Nineteen participants had published at least one peer-reviewed article, and 7 participants had published more than 10.

Materials. The stimuli were derived from the materials used in Study 1. All statements and graphs for each scenario were translated into equivalent economic or demographic terms with the assistance of two economists (see Table 1). For example, the statement “. . . so far from there being a greater increase in *sea level*, the official figures show that, if anything, there was a slightly smaller increase in *sea level* in the second half of the 20th century than in the first half” would be translated as “. . . so far from there being a greater overall increase in *daily global currency trade volume*, the official figures show that, if anything, there was a slightly smaller increase in *daily global currency trade volume* in the second half of the 20th century than in the first half.” The economic labels were selected to be plausible in light of the actual data; for example, the historical trend of currency trade volume broadly resembles the data for sea level rise. Statements were arbitrarily ascribed to bloggers, news analysts, and so on. The Online Supplementary Material provides full details of the stimuli.

A second statement was prepared for each scenario that was also couched in economic terms but captured the scientifically-acknowledged meaning of the data, as confirmed by 4 climate experts. For example: “Daily global currency trade volume has risen throughout the previous century. If anything, there was a larger increase in daily global currency trade volume in the second half of the 20th century than in the first half.”

Procedure. Upon entering the survey online (at Qualtrics.com), participants provided informed consent and then responded to the 6 scenarios. The order of scenarios as well as the assignment of statement (contrarian vs. mainstream science) to each scenario was randomized for each participant.

Each scenario was followed by 4 questions, each using a 6-point scale that ranged from “strongly disagree” to “strongly agree.” There was no “neutral” or “don’t know” category. The questions appeared in the same order for each scenario as follows (where “X” refers to the fictitious name given to the person making a claim in the particular scenario, such as “Blogger Mr. Z” or “a news analyst”): (1) The data confirm the claim made by X; (2) The data contradict the claim made by X; (3) The claim made about the data by X is misleading; (4) The statement summarizes the data in a way that is appropriate for advising and supporting decisions by policy makers, industry, or other decision-making bodies. (For analysis, items 1 and 4 were reverse-scored to equalize polarity of items.) A fifth question was presented for 5 of the scenarios that involved time-series plots (i.e., all except the glacier item, GL; see Table 1), which asked participants to extrapolate the time series in the scenario by picking the most likely value for the year past the end of the series. Participants chose from among 7 candidate values that spanned a range of magnitudes

above and below the final plotted data point. (The Online Supplementary Material reports the extrapolation results.)

After completing all 6 scenarios, participants provided some demographic information and were then asked to re-express their consent after being informed that the presumed “economic” scenarios were actually displaying climate data. Only participants who reiterated consent upon debriefing, and who correctly answered 2 attention filter questions presented at a random point in between scenarios, were included in the final sample. Finally, participants were queried whether during completion of the survey they felt that the stimulus scenarios involved real (as opposed to artificial) data. (The reported results are not materially affected if consideration is restricted to participants who least suspected that the stimulus data were synthetic.)¹

Results

Responses to each scenario were averaged across items (reverse-scored where necessary) and zero-centered (by subtracting the mean from 3.5) to create a “correctness score.” Figure 1 shows the means across scenarios and for both groups of participants.

Because versions of statements (mainstream vs. contrarian) were randomly assigned to scenarios for each subject, the scenario-specific means in the figure are based on unequal sub-samples of participants. That is, by chance more participants might experience a given scenario with a contrarian claim than with a mainstream interpretation, or vice versa. For analysis, we therefore calculated each participant’s mean response to all scenarios they received with a mainstream statement, and to all scenarios they received with a contrarian statement. That way all participants contributed to the analysis equally.

A 2 (participant group) \times 2 (version of statement) between-within participant analysis of variance (ANOVA) confirmed the obvious pattern in Figure 1: The ANOVA returned no effect of group, $F(1, 50) = 2.14, p > .10$, and group did not interact with statement version, $F(1, 50) = 2.10, p > .10$, but there was a highly significant main effect of the version of the statement, $F(1, 50) = 96.24, p < .0001$. That is, irrespective of their discipline, both groups of experts agreed that the contrarian claims were more misleading than the mainstream scientific claims about the same data. To highlight the magnitude of the effect, Figure 2 shows the distribution of responses for the two types of statements for both groups of experts: It is clear that the preponderance of responses identified contrarian claims as misleading whereas mainstream interpretations were classified as being accurate.

Discussion

We showed that representative contrarian claims about climatological variables do not withstand scrutiny in a blind expert test. Across two groups of experts and across 6 different scenarios, contrarian claims were judged to be misleading, inaccurate, and unsuitable for policy advice. Conversely, mainstream scientific interpretations were found to be accurate and suitable for policy advice overall.

¹Both studies ended with an open-ended question seeking general comments from respondents that was included to inform further research and is not analyzed here.

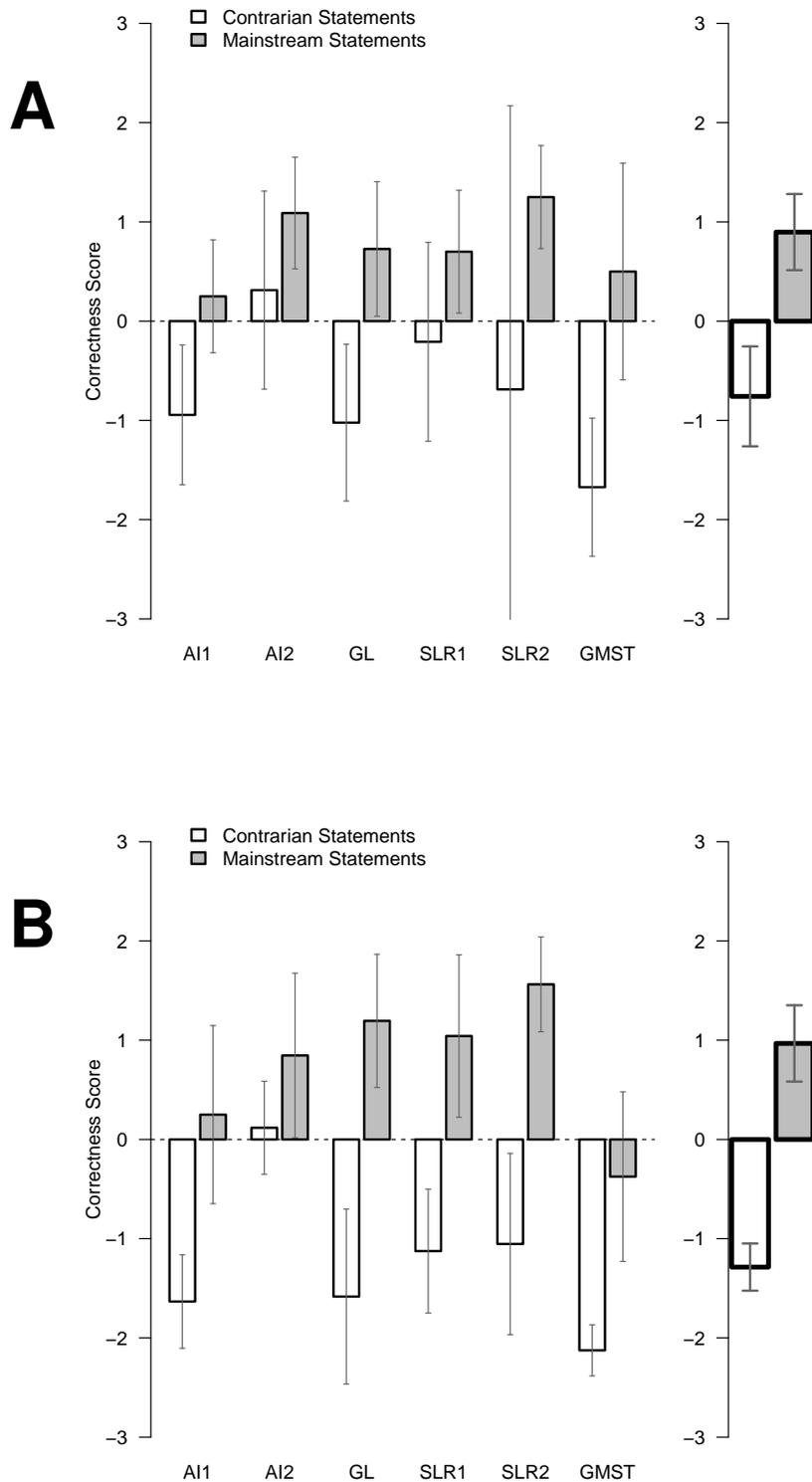


Figure 1. Mean correctness scores and 95% confidence intervals for expert economists (Panel A) and statisticians (B) in Study 2. Any negative value indicates that a claim was judged to be incorrect or misleading, whereas any positive value indicates that a claim was found to be accurate or in accord with the data. Labels for scenarios are explained in Table 1. The side panels labeled “all” show means across all scenarios and subjects. It is those observations that contributed to the analysis.

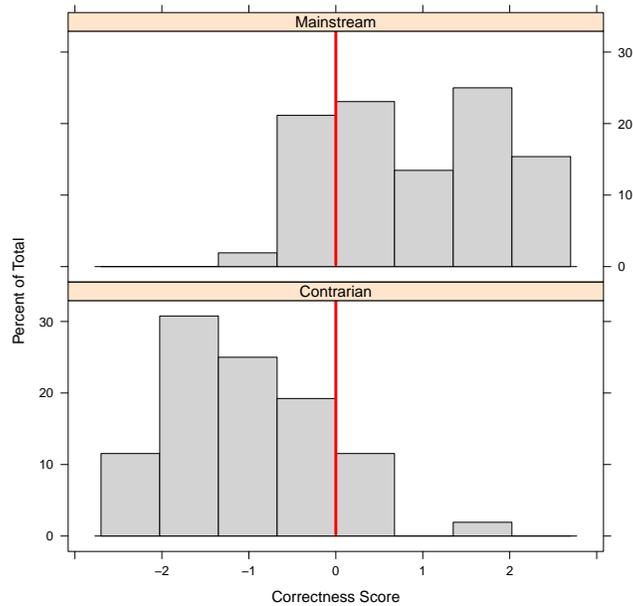


Figure 2. Distribution of correctness scores in Study 2 for both groups of experts combined for mainstream interpretations of the data (top panel) and contrarian claims (bottom panel). The red vertical lines at zero indicate the midpoint of the scale: Any value above that line indicates that statements were judged to be accurate, whereas any value below indicates that statements were judged to be incorrect or misleading.

Potential limitations

At least three criticisms might be leveled at the current study. The first involves the fact that we only used 6 scenarios, and that a different selection of contrarian claims may have been judged as accurate. We cannot rule out the possibility that some contrarian claims are accurate. We are, however, confident that the scenarios used here were representative of contrarian claims: Study 1 showed that the claims used in our study constituted a notable share of contrarian internet discourse. This conclusion was further buttressed by the rating study reported in the Online Supplementary Material, which affirmed that climate experts were consistently able to identify the techniques used by contrarians in our scenarios, and additionally judged those techniques to be common and representative.

The second criticism might invoke the possibility that the experts' judgments were colored by their tacit expectations about trends in the data—for example, economists may have some expectation about how lithium production is likely to have unfolded. We ensured that those expectations would not uniformly favor the contrarian or mainstream interpretation of the data in several ways: for example, we used the profits of a fictitious company (the “Supreme Widget Corporation”) for one of our scenarios, and to the extent that one can form expectations about a fictitious company, they are likely to point to an increase in profits rather than a decline. Because the data actually plotted the decline in Arctic ice, any

expectations about increasing profits would thus favor the contrarian interpretation which denied the decline. Similarly, the trends in rural village population are going to be different depending on country or region, so even if our experts had some prior beliefs about rural populations, different participants would have had different countries or regions in mind. In consequence, it is difficult to see how expectations could have consistently favored one interpretation over another for this scenario.

A third criticism might hold that Study 2 did not examine opposing claims by actors who accept the findings from climate science but might distort their interpretations for “alarmist” or “activist” political purposes. The existence of misleading or exaggerated claims by people who otherwise endorse the IPCC consensus position cannot be ruled out. However, it is clear that exaggerated “alarmist” claims play little role in public discourse (at least in the U.S. and U.K.; Painter & Ashe, 2012). The fault line of political debate lies between mainstream climate science, as embodied by the IPCC, on the one hand, and contrarian claims that downplay the existence or extent of climate change on the other (e.g., Boykoff & Boykoff, 2004; Boykoff, 2013; Freudenburg & Muselli, 2013). Our study therefore addressed the question of greatest public interest; namely, whether contrarian argumentation withstands scrutiny in a blind test. We found that it fails to do so.

Implications

The results extend earlier findings that uncovered flaws in the few contrarian academic publications (Abraham et al., 2014; Benestad et al., 2015). Intriguingly, the climate experts in the Rating study identified some contrarian techniques as being highly prevalent that Benestad et al. (2015) also identified as attributes of flawed contrarian publications. Whereas previous authors relied on judgment and statistical re-analyses to identify flaws, the present results arose in a blind test of experts from two different disciplines. This rules out the possibility that participants may have been driven by any extraneous considerations in their adjudication.

Our blind test constitutes a particularly conservative test of the claims. By translating the data into economic terms, a broader range of interpretations becomes permissible than in the initial climate context which is constrained by the underlying physics. The role of physics and relevant expert knowledge became most apparent in the AI2 scenario, which pertained to the decline of arctic sea ice extent. The contrarian claim highlighted a short-term rebound from a record minimum (in 2012), whereas the mainstream statement emphasized the underlying downward trend over the past decades (e.g., Kinnard et al., 2011). The experts in Study 2 were more tolerant of the contrarian claim when presented within a trade surplus scenario. This likely reflected the fact that a trade surplus, unlike the decline in arctic ice, is not driven by inexorable physical processes that unfold over longer time scales. A focus on annual variations is thus judged to be less misleading for economic indicators.

We conclude that public statements by contrarians fail to meet expert approval. Their uncritical inclusion in media discourse therefore does the public a disservice and confirms that media “balance” can be a form of bias (Boykoff & Boykoff, 2004) or even self-censorship if contrarian views override scientific opinions (Antilla, 2010).

The insertion of misleading contrarian statements into public discourse has demonstrable adverse consequences. For example, when people watch climate “skeptical” movies,

the experience notably decreases environmental concern compared to a neutral movie (Greitemeyer, 2013). Similar adverse effects on attitudes have been observed after the presentation of “cherry-picked” misleading numbers akin to some of the claims examined here (Ranney & Clark, 2016), and after presentation of contrarian frames (McCright, Charters, Dentzman, & Dietz, 2016). The insertion of dissenting opinions can reduce the perception of expert consensus, and support for corrective policies, even when participants are given numeric information about a strong expert consensus (Koehler, 2016).

More worryingly still, contrarian claims may have altered the course of science itself (Brysse, Oreskes, O’Reilly, & Oppenheimer, 2013; Lewandowsky, Oreskes, Risbey, Newell, & Smithson, 2015; Lewandowsky, Risbey, & Oreskes, 2015). In at least one instance, an interpretation of global temperature data that originated in contrarian circles but then found entry into mainstream climate science—viz. the alleged recent “pause” or “hiatus” in global warming (Boykoff, 2014)—has been found to be wanting in a blind test similar to the one reported here (Lewandowsky, Risbey, & Oreskes, 2015).

The present results may therefore be valuable for communicators who seek to guard against the influence of misleading information by “inoculation”; that is, by explaining *why* particular messages are misleading (Banas & Rains, 2010).

References

- Abraham, J. P., Cook, J., Fasullo, J. T., Jacobs, P. H., Mandia, S. A., & Nuccitelli, D. A. (2014). Review of the consensus and asymmetric quality of research on human-induced climate change. *Cosmopolis*.
- Anderegg, W. R. L., Prall, J. W., Harold, J., & Schneider, S. H. (2010). Expert credibility in climate change. *Proceedings of the National Academy of Sciences*, *107*, 12107–12109. doi: 10.1073/pnas.1003187107
- Antilla, L. (2010). Self-censorship and science: a geographical review of media coverage of climate tipping points. *Public Understanding of Science*, *19*(2), 240–256. doi: 10.1177/0963662508094099
- Banas, J. A., & Rains, S. A. (2010). A meta-analysis of research on inoculation theory. *Communication Monographs*, *77*, 281–311.
- Bell, L. (2011). *Climate of corruption - politics and power behind the global warming hoax*. Austin, Texas: Greenleaf Book Group Press.
- Benestad, R., Nuccitelli, D., Lewandowsky, S., Hayhoe, K., Hygen, H., van Dorland, R., & Cook, J. (2015). Learning from mistakes in climate research. *Theoretical and Applied Climatology*, 1–5. doi: 10.1007/s00704-015-1597-5
- Boykoff, M. T. (2013). Public enemy no. 1? Understanding media representations of outlier views on climate change. *American Behavioral Scientist*. doi: 10.1177/0002764213476846
- Boykoff, M. T. (2014). Media discourse on the climate slowdown. *Nature Climate Change*, *4*, 156–158. doi: 10.1038/nclimate2156
- Boykoff, M. T., & Boykoff, J. M. (2004). Balance as bias: global warming and the US prestige press. *Global Environmental Change*, *14*, 125–136. doi: 10.1016/j.gloenvcha.2003.10.001
- Brulle, R. J. (2013). Institutionalizing delay: foundation funding and the creation of US climate change counter-movement organizations. *Climatic Change*, *122*, 681–694. doi: 10.1007/s10584-013-1018-7
- Brulle, R. J., Carmichael, J., & Jenkins, J. C. (2012). Shifting public opinion on climate change: an empirical assessment of factors influencing concern over climate change in the U.S., 2002–2010. *Climatic Change*, *114*, 169–188. doi: 10.1007/s10584-012-0403-y

- Brysse, K., Oreskes, N., O'Reilly, J., & Oppenheimer, M. (2013). Climate change prediction: Erring on the side of least drama? *Global Environmental Change*, *23*, 327–337. doi: 10.1016/j.gloenvcha.2012.10.008
- Carter, B. (2006, April). *There IS a problem with global warming... it stopped in 1998*. Retrieved from <http://www.telegraph.co.uk/comment/personal-view/3624242/\\There-IS-a-problem-with-global-warming...-it-stopped-in-1998.html> (Accessed 18 August 2010)
- Cazenave, A., Dieng, H.-B., Meyssignac, B., von Schuckmann, K., Decharme, B., & Berthier, E. (2014). The rate of sea-level rise. *Nature Climate Change*, *4*, 358–361. doi: 10.1038/nclimate2159
- Church, J., Clark, P., Cazenave, A., Gregory, J., Jevrejeva, S., Levermann, A., ... Unnikrishnan, A. (2013). Sea level change [Book Section]. In T. Stocker et al. (Eds.), *Climate change 2013: The physical science basis. contribution of working group i to the fifth assessment report of the intergovernmental panel on climate change* (p. 11371216). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. Retrieved from www.climatechange2013.org doi: 10.1017/CBO9781107415324.026
- Cook, J., Nuccitelli, D., Green, S. A., Richardson, M., Winkler, B., Painting, R., ... Skuce, A. (2013). Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters*, *8*, 024024. doi: 10.1088/1748-9326/8/2/024024
- Doran, P. T., & Zimmerman, M. K. (2009). Examining the scientific consensus on climate change. *Eos*, *90*(3), 21–22. doi: 10.1029/2009EO030002
- Dunlap, R. E., & Jacques, P. J. (2013). Climate change denial books and conservative think tanks: Exploring the connection. *American Behavioral Scientist*, *57*, 1–33. doi: 10.1177/0002764213477096
- Dunlap, R. E., & McCright, A. M. (2010). Climate change denial: sources, actors, and strategies. In C. Lever-Tracy (Ed.), *Handbook of climate change and society* (pp. 240–259). Abingdon, UK: Routledge.
- Dunlap, R. E., & McCright, A. M. (2011). Organized climate change denial. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *The Oxford handbook of climate change and society* (pp. 144–160). Oxford, UK: Oxford University Press.
- Elsasser, S. W., & Dunlap, R. E. (2013). Leading voices in the denier choir: Conservative columnists dismissal of global warming and denigration of climate science. *American Behavioral Scientist*, *57*, 754–776. doi: 10.1177/0002764212469800
- Freudenburg, W. R., & Muselli, V. (2013). Reexamining climate change debates: Scientific disagreement or scientific certainty argumentation methods (SCAMs)? *American Behavioral Scientist*, *57*, 777–795. doi: 10.1177/0002764212458274
- Greitemeyer, T. (2013). Beware of climate change skeptic films. *Journal of Environmental Psychology*, *35*, 105 - 109. doi: <http://dx.doi.org/10.1016/j.jenvp.2013.06.002>
- Heath, Y., & Gifford, R. (2006). Free-market ideology and environmental degradation: The case of belief in global climate change. *Environment and Behavior*, *38*, 48–71. doi: 10.1177/0013916505277998
- Inhofe, J. (2012). *The greatest hoax: How the global warming conspiracy threatens your future*. Washington, DC: WND Books.
- Kahan, D. M. (2010). Fixing the communications failure. *Nature*, *463*, 296–297. doi: 10.1038/463296a
- Kinnard, C., Zdanowicz, C. M., Fisher, D. A., Isaksson, E., de Vernal, A., & Thompson, L. G. (2011). Reconstructed changes in Arctic sea ice over the past 1,450 years. *Nature*, *479*, 509–513.
- Koehler, D. J. (2016). Can journalistic “false balance” distort public perception of consensus in expert opinion? *Journal of Experimental Psychology: Applied*. doi: 10.1037/xap0000073

- Lewandowsky, S. (2011). Popular consensus: Climate change set to continue. *Psychological Science*, *22*, 460–463.
- Lewandowsky, S., Ecker, U. K. H., Seifert, C., Schwarz, N., & Cook, J. (2012). Misinformation and its correction: Continued influence and successful debiasing. *Psychological Science in the Public Interest*, *13*, 106–131. doi: 10.1177/1529100612451018
- Lewandowsky, S., Gignac, G. E., & Oberauer, K. (2013). The role of conspiracist ideation and worldviews in predicting rejection of science. *PLoS ONE*, *8*, e75637. doi: 10.1371/journal.pone.0075637
- Lewandowsky, S., Oberauer, K., & Gignac, G. E. (2013). NASA faked the moon landing—therefore (climate) science is a hoax: An anatomy of the motivated rejection of science. *Psychological Science*, *24*, 622–633. doi: 10.1177/0956797612457686
- Lewandowsky, S., Oreskes, N., Risbey, J. S., Newell, B. R., & Smithson, M. (2015). Seepage: Climate change denial and its effect on the scientific community. *Global Environmental Change*, *33*, 1–13. doi: 10.1016/j.gloenvcha.2015.02.013
- Lewandowsky, S., Risbey, J. S., & Oreskes, N. (2015). The “pause” in global warming: Turning a routine fluctuation into a problem for science. *Bulletin of the American Meteorological Society*. doi: 10.1175/BAMS-D-14-00106.1,
- McCright, A. M., Charters, M., Dentzman, K., & Dietz, T. (2016). Examining the effectiveness of climate change frames in the face of a climate change denial counter-frame. *Topics in Cognitive Science*. doi: 10.1111/tops.12171
- McCright, A. M., & Dunlap, R. E. (2010). Anti-reflexivity: The American conservative movement’s success in undermining climate science and policy. *Theory Culture & Society*, *27*, 100–133. doi: 10.1177/0263276409356001
- McCright, A. M., & Dunlap, R. E. (2011a). Cool dudes: The denial of climate change among conservative white males in the United States. *Global Environmental Change*, *21*, 1163–1172. doi: 10.1016/j.gloenvcha.2011.06.003
- McCright, A. M., & Dunlap, R. E. (2011b). The politicization of climate change and polarization in the American public’s views of global warming, 2001–2010. *The Sociological Quarterly*, *52*, 155–194. doi: 10.1111/j.1533-8525.2011.01198.x
- McCright, A. M., Dunlap, R. E., & Xiao, C. (2013). Perceived scientific agreement and support for government action on climate change in the USA. *Climatic Change*. doi: 10.1007/s10584-013-0704-9
- Medimorec, S., & Pennycook, G. (2015). The language of denial: text analysis reveals differences in language use between climate change proponents and skeptics. *Climatic Change*. doi: 10.1007/s10584-015-1475-2
- Montford, A. W. (2010). *The hockey stick illusion: Climategate and the corruption of science*. London: Stacey Publishing.
- Oreskes, N. (2004). The scientific consensus on climate change. *Science*, *306*, 1686. doi: 10.1126/science.1103618
- Oreskes, N., & Conway, E. M. (2010). *Merchants of doubt*. London: Bloomsbury Publishing.
- Painter, J., & Ashe, T. (2012). Cross-national comparison of the presence of climate scepticism in the print media in six countries, 200710. *Environmental Research Letters*, *7*, 044005. doi: 10.1088/1748-9326/7/4/044005
- Painter, J., & Gavin, N. T. (2015). Climate skepticism in British newspapers, 20072011. *Environmental Communication: A Journal of Nature and Culture*. doi: 10.1080/17524032.2014.995193
- Ranney, M. A., & Clark, D. (2016). Climate change conceptual change: Scientific information can transform attitudes. *Topics in Cognitive Science*, *8*. doi: 10.1111/tops.12187
- Scruggs, L., & Benegal, S. (2012). Declining public concern about climate change: Can we blame the great recession? *Global Environmental Change*, *22*, 505–515. doi: 10.1016/j.gloenvcha.2012.01.002
- Sharman, A. (2014). Mapping the climate sceptical blogosphere. *Global Environmental Change*.

- Smith, N., & Leiserowitz, A. (2012). The rise of global warming skepticism: Exploring affective image associations in the United States over time. *Risk Analysis*, *32*, 1021–1032. doi: 10.1111/j.1539-6924.2012.01801.x
- Solomon, L. (2008). *The deniers: The world renowned scientists who stood up against global warming hysteria, political persecution, and fraud and those who are too fearful to do so*. Minneapolis, MN: Richard Vigilante Books.
- Sussman, B. (2010). *Climategate: A veteran meteorologist exposes the global warming scam*. Washington, DC: WND Books.
- Zemp, M., Hoelzle, M., & Haeberli, W. (2009). Six decades of glacier mass-balance observations: a review of the worldwide monitoring network. *Annals of Glaciology*, *50*, 101–111.