Motivated Bias in Detecting Climate Change Misinformation

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Abstract

Misinformation undermines a shared understanding of the complexity of climate change and impedes public support for mitigation policies to build resilience. This paper reports an empirical study (N=398) of U.S. adults' accuracy and bias in identifying true and false headlines related to climate change. The headlines were evenly balanced such that half were true and half false (fake news); likewise, half emphasized, and half questioned the urgency of climate change. Respondents indicated whether they believed each of the 24 headlines was true or false and provided confidence ratings. Pooled ROC analyses suggested moderate accuracy (AUC = 0.68) and a bias (c=0.09) favoring accuracy for false headlines (specificity=0.67) and attenuating the accuracy rate for true headlines (sensitivity = 0.60). Regression analysis on individual Signal Detection Theory (SDT) performance measures revealed that political liberalism and actively open-minded thinking (AOT) positively predicted accuracy (AUC), while climate change anxiety (CCAS) positively predicted bias.

Keywords: Signal Detection Theory, truth detection, fake news, ROC analysis, Item Response Theory

1. Introduction

Although ninety-seven percent of scientists agree that humans drive climate change, people continue to question climate science (van der Linden et al., 2015; Lewandowsky, 2021; Compton et al., 2021). Compared to other countries in the Western world, climate change is particularly scrutinized in the United States, and climate denialism and misinformation surrounding climate change run rampant (Lewandowsky, 2021; Dixon et al., 2017). Climate change misinformation tends to take the form of climate skepticism and denialism - which refutes the existence of climate change and the effect of humans on the environment. The dissemination of denialist misinformation is attributed to the fossil fuel industry, conservative think tanks, and even conservative leaders themselves (Treen et al., 2020; Lewandowsky, 2021). When all these forces combine, they create a "climate change denial machine" (Treen et al., 2020).

While less widely discussed, climate alarmist information is also considered misinformation as it spreads concerning, catastrophic, and drastic claims that scare and mislead individuals. O'Neill and Nicholson-Cole (2009) found that fear-inducing climate change claims can draw attention to the issue but are ineffective in encouraging action. Less is known about the dissemination of climate alarmist-related media items. However, it is widely debated on social media, and of the two, climate denialism claims seem to be more systematic, at least in the U.S. (Treen et al., 2020). Nonetheless, exposure to both kinds of misinformation is harmful because it can affect judgments and beliefs, even if false claims are successfully refuted (Cook et al., 2017).

Public acceptance of correct, factual climate information is critical for effective climate policy. If citizens are unable to discern between true and false information, there will likely be attenuated compliance and support surrounding climate-related policies (Cook et al., 2017).

1.1 Climate change misinformation

Most past research surrounding climate change misinformation focuses on the effectiveness of interventions to combat false claims, individuals' propensity to share climate change-related information, or a combination of the two (Lutze et al., 2019; van der Linden et al., 2017; Maertens and van der Linden, 2020). A large area of research focuses on attitudinal inoculation, which involves showing subjects climate change misinformation and then countering the idea (Lewandowsky, 2021; Maertens et al., 2020; Cook, 2019). Overall, results from intervention studies are mixed.

For this study, the types of misinformation utilized in these studies were of interest. Most studies examined information only related to climate denialism or true information supporting climate

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change (Lutze et al., 2019; van der Linden et al., 2017; Drummond et al., 2020). Studies related to climate alarmism are "negligible," and research about true items that acknowledge high levels of uncertainty surrounding climate change is basically non-existent (Treen et al., 2020). Studies on climate alarmism tend to focus on the effectiveness of fear as a technique to encourage action to fight against climate change, but not the ability to discern between true and false claims (O'Neill & Nicholson-Cole, 2009). As a result of these gaps in the research, we decided to include items that have not been studied widely.

2. The current study

We utilize a Signal Detection Theory (SDT) framework to determine United States adults' ability to discern between true and false climate change-related headlines. This study differs from previous research as four different groups of headlines are considered (see Table 1). In addition to "typical" items, we include atypical headlines (i.e., true items that questioned climate change and false items that support climate change) not typically used in research. We also include two individual difference measures hypothesized to predict accuracy and bias in truth detection performance.

Table 1. Types of headlines utilized in this study.

Types of Headlines:

Supporting: Both t/f statements supporting climate change

Questioning: Both t/f statements questioning climate change

Typical: True items supporting climate change, false items questioning climate change

Atypical: True items questioning climate change, false items supporting climate change

2.1 Signal detection theory (SDT)

SDT was used to measure respondents' truth detection performance rather than relying on the percentage of correct answers to differentiate between accuracy and bias (Byrd & John, 2022; Batailler et al., 2022). Relying simply on the percentage of correct answers ignores participant bias and can lead to incorrect conclusions about determinants of accuracy.

Using SDT disentangles two aspects of ability: one's ability to determine between true and false media information and response biases that occur regardless of the accuracy of the information in the headlines (Batailler et al., 2022).

Batailler et al.'s (2022) re-analyses of data from fake news identification studies demonstrate how SDT allows researchers to understand truth detection ability better. The separation of one's truth-telling ability and response biases is especially important to understanding the role that different biases - such as partisan bias, cognitive bias, etc. - may play. For this study, SDT is used to gain an understanding of truth detection ability independent of biases in the realm of climate change. Given that the study seeks to assess the ability of U.S. adults, predispositions and prior beliefs are likely at play, and ability must be assessed separately (Lewandowsky 2021).

SDT has been used in other truth detection studies, such as Byrd and John's (2021, 2022) studies of misinformation following natural disasters and soft-target terrorist attacks in the United States and Barajas and John's (2023) study of COVID-19 pandemic fake news. In these studies, SDT is used to model participants' decision thresholds for the truth signal of each news item (Byrd & John, 2022). Ideally, respondents' thresholds would minimize the expected number of errors, assuming that true and false items are equally likely, the number of false positives (saying that false information is true) and false negatives (saying true information is false). SDT can also be used to derive Receiver Operating Curves (ROC) and Area Under Curve (AUC) estimates, which is a bias-free indicator of accuracy (Byrd & John, 2022; Barajas & John, 2023).

2.2 Individual difference variables

Actively Open-Minded Thinking (AOT) describes how people consider new information despite existing beliefs and is of particular interest in this study (Haran et al., 2013). AOT is useful as it refers to the extent to which an individual considers evidence before making a decision - in this case, deciding whether a headline is mostly true or false (Haran et al., 2013). AOT is a useful predictor because it is not context-specific and can be applied in virtually all misinformation studies (Baron, 2018b).

AOT has been found to be negatively correlated with susceptibility to misinformation (Baron, 2018a; Pennycook et al., 2020). Barajas & John (2023) found that AOT was positively correlated with truth detection for headlines related to COVID-19 vaccines.

It follows that someone with a high level of AOT would be open to accepting information that conflicts

with their underlying beliefs as well as updating their beliefs as needed (Baron, 2017). In contrast, someone with low levels of AOT would not accept evidence that goes against their own beliefs and would be susceptible to confirmation bias (Nickerson, 1998). We expect that AOT will be positively related to accuracy in distinguishing true and false information about climate change.

2.3 Climate change anxiety

We also included Clayton and Karazsia's (2020) climate change anxiety scale (CCAS), which measures concerns about climate change and its effect on personal health. As climate change poses extensive threats to human safety and security, it is reasonable that people would experience varying degrees of anxiety about resource scarcity, population growth, and other things related to the climatic future (Clayton and Karazsia, 2020). We expect those with higher levels of climate change anxiety to be more knowledgeable about climate change and thus perform better. However, this positive effect could be negated as those with high levels of anxiety could be biased to respond true to all items supporting the severity of climate change and false to all items questioning climate change.

Though this is a relatively new scale, it has been found to be a "valid measure of climate change anxiety in general U.S. populations" (Cruz and High, 2022). Clayton and Karazsia (2020) argue for the separation of cognitive-emotional and functional impairment within the CCAS, but Cruz and High (2022) found that these measures are highly correlated and should be treated as a unidimensional scale. For this reason, we used an overall climate change anxiety score rather than CCAS subscales to assess different components of climate change anxiety.

2.4 Other individual differences

The effect of political party orientation is also of interest, as climate change is politically polarized in the United States, and prior research demonstrates a strong relationship between conservatism and climate skepticism (Lewandowsky, 2021; Dixon et al., 2017; Cook, 2019). People who self-identify as conservative are more likely to interact and engage with fake news posts and less likely to trust factual climate news (Lutze et al., 2019). Conversely, liberals do not seem to be as influenced by climate misinformation (Cook, 2019). Given the novel nature of the headlines included, political orientation is of great interest as we seek to examine whether political affiliation is predictive of accuracy and bias. We also account for performance differences by age, gender, race, and education level.

3. Hypotheses

This current study examines the following hypotheses:
1. One's ability to identify true and false information related to climate change can be accurately measured through the selected, balanced group of headlines.
2. As climate change is widely discussed in the media, U.S. adults are familiar with it and can somewhat accurately (AUC > .6) determine whether headlines are true or false.
3. Given the highly polarized nature of climate change and the systematic dissemination of climate denialism information in the United States, we expect that bias will be slightly positive (inclination to mark an item as false).
4. Consistent with previous research, we expect individuals with high levels of Actively Open-Minded Thinking (AOT) will perform better than those with low levels of AOT on all groups of headlines.
5. Consistent with previous research, we expect that those who identify as more conservative will be less accurate when classifying all groups of headlines.
6. Climate change anxiety will be positively correlated with performance. It follows that people who are more concerned about climate change are more knowledgeable and, therefore, will be more accurate.

4. Methodology

We collected 24 climate change-related headlines: 12 that support climate science and 12 that question it. Within each subset, six headlines are true, and six are false. We then collected true/false judgments and confidence ratings for all 24 headlines, individual difference measures, and demographic information. Item Response Theory (IRT) analysis was conducted on the true/false headline judgments for each headline subgroup to generate Item Characteristic Curves (ICCs). Following IRT analysis, we used SDT to construct pooled Receiver Operating Characteristic (ROC) curves and AUC estimates. We then obtained individual SDT performance measures (AUC, sensitivity, specificity, bias) and conducted multiple linear regressions to identify individual

predictors of bias and accuracy separately for typical and atypical headlines and all headlines combined.

4.1 Participants

A sample of English-speaking U.S. adults (N=398) was recruited to take the survey via Prolific, and each was compensated $2. Prolific is an online platform that helps researchers gather high-quality data. The median survey completion time was 8 minutes and 45 seconds, and the shortest completion time was 5 minutes and 40 seconds. No participants were removed based on completion time, and attention checks were not utilized. Participants could not submit responses until viewing each headline for at least 10 seconds.

Overall, 45% of participants identified as female, 51.3% identified as male, and 3.7% identified as non-binary. Political ideology ranged from 1 (extremely liberal) to 7 (extremely conservative). Most participants (62.6%) identified as liberal (extremely liberal to liberal), 17.6% identified as neutral, and the remaining 19.8% identified as conservative (leaning conservative to extremely conservative). Most participants had some college education (33.2%) or a 4-year college degree (38.4%). The remaining participants had a high school degree or below (14.1%) or a postgraduate degree (14.3%). The average age of participants was 38; the oldest and youngest participants were 78 and 18, respectively. Finally, 75.4% of participants self-identified as white, 10.1% as Asian, 6.8% as African American, 6.4% as mixed race, and 1.3% as Native American or Indigenous.

4.2 Study procedure

All data was collected using the Qualtrics platform. The order of the headlines was randomized for each participant. After identifying each headline as "mostly true" or "mostly false," respondents rated their confidence in their answer on a scale of 1 (not at all confident) to 5 (extremely confident), following previous studies, e.g., Byrd and John (2021, 2022) and Barajas and John (2023).

After classifying the headlines, participants completed Haran's (2013) 7-item AOT scale and Clayton and Karazsia's (2020) 13-item climate change anxiety scale (CCAS). In both measures, participants denote their level of agreement with each statement on a Likert scale. For the CCAS, we computed an overall climate anxiety score ranging from 1-5 by computing the average of the 13 Likert ratings (Reyes et al. 2021). Higher scores indicated higher levels of climate

anxiety (Reyes et al., 2021). AOT was scored similarly, and we computed an overall score between 1-7 as a 7-point Likert scale was used. Participants were asked demographic questions (race, gender, education level, political ideology) as well as where they got most of their news. Lastly, they were asked whether anything on the survey was confusing and to leave any additional feedback.

4.3 Headline collection

Table 2. Classification of the 24 headlines presented to participants

	True	False
Supporting	1. "Floods Show National Security Threat Posed by Climate Change" 2. "Biggest Extinction in Earth's History Caused by Global Warming Leaving Ocean Animals Gasping for Breath" 3. "A 1922 Associated Press Article Warned of Ocean Warming and Glacier Melt" 4. "More than 99.9% of studies agree: Humans caused climate change" 5. "'Nowhere to Run': UN Report Says Global Warming Nears Limits" 6. "The Big Sneeze: Climate Change to Make Pollen Season Nastier"	1. "'Next year or the year after, the Arctic will be free of ice'" 2. "The Arctic Doomsday Seed Vault Flooded. Thanks Global Warming" 3. "Our Empty Oceans: Scots Team's Research Finds Atlantic Plankton All but Wiped Out in Catastrophic Loss of Life Due to Ocean Warming" 4. "Scientists Warn of 'global climate emergency' Over Shifting Jet Stream" 5. "Ticking 'Methane Bomb' Could Cost Economy $60 Trillion" 6. "New Report Warns 'High Likelihood of Human Civilization Coming to An End' Within 30 Years Due to Climate Change"
Questioning	1. "High Level of Scientific Uncertainty Surrounding Climate Change and Tornado Frequency" 2. "U.N. Panel's Himalayan Glacier-Disaster Claims Melting Away" 3. "Scientists Acknowledge Key Errors in Study of How Fast the Oceans are Warming" 4. "Feds: Don't Blame 2011-14 California Drought on Global Warming" 5. "Poop and Pee, not Climate Change, Fueled the Huge Algae Bloom in San Francisco Bay. Fixing the Problem Could Cost $14 Billion" 6. "It's Not Just Climate: We are Ignoring Other Causes of Extreme Weather Disasters"	1. "31,000 Scientists say 'no convincing evidence' in Support of Climate Change" 2. "NASA: 'Climate Change' and Global Warming Caused by Changes in Earth's Solar Orbit and Axial Tilt - Not Man-Made Causes" 3. "Don't Look Now, But Arctic Sea Ice Mass Has Grown Almost 40% Since 2012" 4. "NASA Confirms: Sea level FALLING Across the Planet for Two Years… Media SILENT" 5. "Global Warming Data FAKED by Government to Fit Climate Change" 6. "Stunning New Data Indicates El Niño Drove Record Highs in Global Temperatures Suggesting Rise May Not Be Down to Man-made Emissions"

Our selected headlines were sourced from various websites, including Snopes.com (11), FactCheck.org (1), educational institutions (Cornell, Yale) (2), news organizations (Scientific American, NPR, Fox News, NBC, Slashdot, S.F. Chronicle, Daily Mail) (7), and ClimateFeedback.org (3). Headlines from FactCheck and Snopes were obtained through sections of the website that are specifically concerned with fact-checking headlines. Headlines that were not sourced on Snopes were either obtained from reputable news sources (Associated Press, NPR, etc.) or were thoroughly fact-checked and corroborated by additional sources (CNN, Yale University, Scripps Institution of Oceanography, etc.). Finally, some

headlines were retrieved from ClimateFeedback.org - a website scientists run that fact-checks various climate change articles. A few headlines were edited slightly to improve clarity.

After fact-checking and classifying headlines, we selected six in each category that seemed plausible and not obviously true or false. For example, a headline claiming cannibalism would help prevent climate change-related food shortages was excluded. While this is a climate-related headline, it is not probable nor one that would promote deep thinking about the validity of the headline. Headlines with similar themes or content were considered but eliminated to avoid redundancy.

5. IRT Analysis

We estimated two-parameter IRT models for the four subsets of six headlines using the "ltm" package in R. Discriminability refers to how well a given headline can classify individuals based on ability, and difficulty refers to how hard it is to classify a headline correctly (An and Yung, 2014).
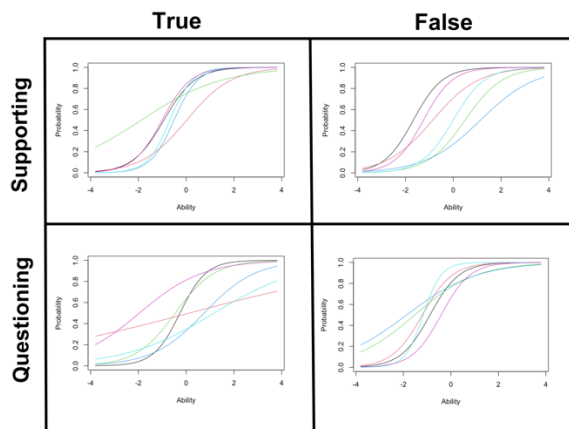

Figure 1. Item Characteristic Curves (ICCs) for all 24 headlines

Item Characteristic Curves (ICCs) are presented in Figure 1 for the headlines based on the estimated 2-parameter models for each of the four subsets. ICCs represent the probability of a correct answer as a function of difficulty and subject ability (An and Yung, 2014). Each ICC curve corresponds to one headline. The slope of the curve at approximately probability=.5 demonstrates discriminability - the steeper the slope, the more discriminable an item is (Barajas and John, 2023). Typically, an item is considered "good" and is kept for data analysis if it generates an "S-shaped" ICC. In our analysis, we found typical headlines tended to have higher levels of discriminability.

The ICCs demonstrate a range of difficulty, defined as the ability level on the horizontal axis corresponding to p=0.50 on the vertical axis. Atypical headlines (false supporting and true questioning) span a greater range of difficulty. The relatively flat ICC for some questioning true headlines indicates low discriminability, meaning that the latent overall classification ability for that type of headline was not strongly related to the probability of correctly classifying that particular headline.

6. SDT analysis

6.1 Pooled SDT analysis (ROC)

A pooled ROC analysis was conducted considering data from all respondents (N=398) using the SPSS 28 ROC procedure. Judgment confidence in this study was self-reported by participants on a scale of 1 (not at all confident) to 5 (extremely confident). Following Barajas and John (2023) and Byrd and John (2022), we unfolded confidence ratings to create a truth signal index from 1 (confident headline is false) to 10 (confident headline is true):

- If the headline was judged as true: truth signal = confidence rating + 5
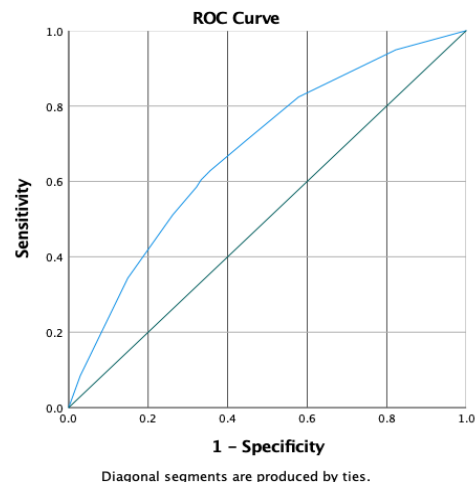- If the headline was judged as false: truth signal = 6 - confidence rating

Figure 2. ROC Curve for all 24 items; AUC = 0.68

Figure 2 displays the ROC plot of sensitivity vs. false alarm rate (1-sensitivity) for different thresholds for saying true or false. This curve combines data across participants but requires no assumptions about the underlying distributions of true and false headlines truth signals.

Using all 24 items, the AUC was 0.68 (standard error = .005), corresponding to a moderate accuracy

level and a d' value of .76, assuming normal, equal variance truth signal distributions. Intuitively, an AUC of 0.68 indicates that for a randomly drawn pair of true and false headlines, the true headline will have a higher truth signal than the false in 68% of the draws.

6.2 Individual SDT predictive analyses

Individual estimates for sensitivity, specificity, and bias were generated using Stanislaw and Todorov's 2-alternative, forced-choice method (1999), assuming true and false headline truth signal distributions were normally distributed with equal variance. The mean of individual AUC values for all 24 headlines was 0.69 (standard deviation = 0.13), close to the AUC generated from pooled ROC analysis with no distributional assumptions.

Bias was computed "as the difference between the optimal threshold and each individual's observed empirical threshold" under the same assumptions as above (Barajas and John, 2023). A positive number indicates a propensity to mark an item as false, and a negative value indicates an inclination toward classifying an item as true. Bias for all 24 headlines was 0.09 (standard deviation = 0.37), indicating a propensity to classify items as false.

Sensitivity is the proportion of true items correctly identified as true, and specificity is the proportion of false items correctly identified as false. The mean sensitivity was 0.60 (standard deviation = .17), and the mean specificity was 0.67 (standard deviation = .15). Hence, bias shifted respondents' threshold on the ROC curve from the unbiased optimal threshold of 0.63 for both sensitivity and specificity.

6.3 Multiple linear regression analysis

We conducted multiple regression analyses to determine the relationship, if any, between our individual difference predictor variables (CCAS, AOT, political orientation, age, race, gender, and education level) and performance-related outcomes (AUC, bias, sensitivity, and specificity). Race and education level were collapsed to create dichotomous variables. Race was coded as white or non-white due to the high percentage of White participants (75.4%). Education level was broken down into below and above a college degree. Gender was collapsed into a trichotomous variable (male, female, non-binary). Table 3 presents raw regression parameters using all 24 headlines. None of the demographic variables (age, race, education level, and gender) were significant predictors of AUC, sensitivity, specificity, or bias.

We found that AOT was a significant, positive predictor of AUC, consistent with prior research.

Political conservatism was a negative predictor of AUC, indicating that AUC decreases as political orientation leans more conservative. CCAS was a significant predictor of bias, sensitivity, and specificity.

Table 3. Raw regression parameters for all 24 headlines.

N=398	AUC	Bias	Sensitivity	Specificity
Predictor:	B (SE)	B (SE)	B (SE)	B (SE)
CCAS	0 (.011)	**-.138 (.031)**	**.046 (.014)**	**-.047 (.013)**
AOT	**.029 (.009)**	-.007 (.025)	.024 (.011)	.02 (.01)
Political Orientation	**-.016 (.004)**	.004 (.013)	-.014 (.006)	-.01 (.005)
Age	0 (0)	.004 (.001)	-.002 (.001)	.001 (.001)
Race	-.012 (.015)	-.078 (.044)	.018 (.019)	-.034 (.018)
Education level	.005 (.013)	-.045 (.037)	.018 (.016)	-.009 (.015)
Gender	-.007 (.007)	-.025 (.019)	.003 (.008)	-.012 (.008)
R^2	.105	.091	.111	.085
Constant	.596 (.063)	.256 (.181)	.484 (.080)	.65 (.074)

Notes: Beta (S.E.), bolded = p <.001

7. Atypical and Typical Headlines

We present pooled and individual SDT analyses for the subset of 12 typical headlines (six true supporting climate science and six false challenging climate science) for comparison with previous research. We also present separate SDT analyses (individual SDT parameters and multiple linear regressions) of the 12 atypical headlines.
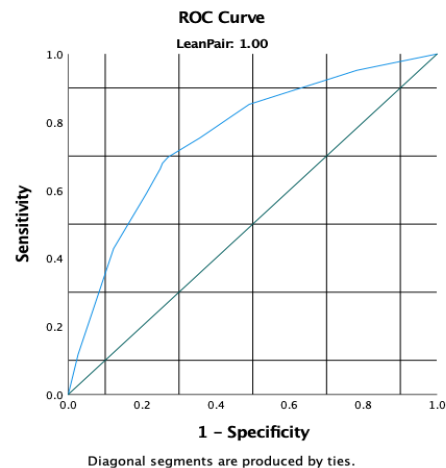
7.1 Pooled ROC Analysis

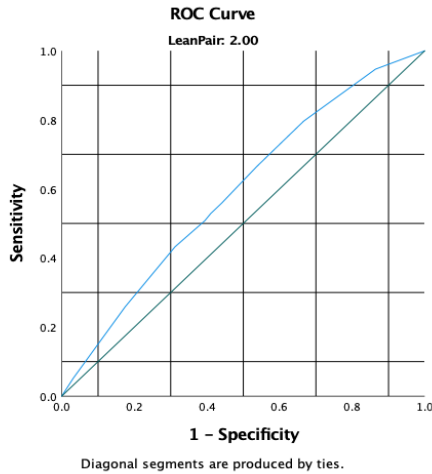**Figure 3. ROC Curves for 12 typical headlines (AUC = .76).**

Figure 4. ROC Curve for 12 atypical headlines (AUC = .59).

Analogous pooled ROC analyses were conducted separately for the typical (six true headlines that support climate change and six false headlines that question climate change) and atypical (six false alarmist and six true headlines that climate science) groups of headlines. ROC curves are plotted for the 12 typical headlines in Figure 3 and the 12 atypical headlines in Figure 4.

As predicted, the AUC value for the typical 12 headlines (AUC = 0.76, standard error = .007) was greater than the AUC for the atypical 12 headlines (AUC=0.59. standard error = .008).

7.2 Individual SDT analysis of typical and atypical headlines

Mean values for AUC, bias, sensitivity, and specificity for the typical and atypical headlines are presented in Table 4, again assuming normal truth signal distributions and equal variances. The mean AUC is higher for the typical headlines (AUC = .75) than the atypical (AUC = .58); both means are close to the pooled estimates computed with no distributional assumptions.

Table 4. Individual SDT parameters for the atypical and typical groups.

N=398	AUC	Bias	Sensitivity	Specificity
12 headlines, typical	.75 (.27)	.11 (.46)	.68 (.28)	.74 (.26)
12 headlines, atypical	.58 (.25)	.10 (.51)	.53 (.24)	.59 (.25)

Notes: Mean (Standard Deviation)

Mean bias is positive for both typical and atypical headlines, indicating the same shift in the threshold, resulting in more false responses than true responses. As expected from the AUCs, sensitivity and specificity are greater by 0.15 for typical compared to atypical headlines. Also, as anticipated, the observed bias results in greater specificity than sensitivity for both typical and atypical headlines.

7.3 Multiple Linear Regression

Table 5 displays parameter estimates for regression analyses for the 12 typical headlines. AOT and political orientation were significant predictors of AUC, sensitivity, and specificity. As in the analysis of all 24 items, political conservatism predicted lower AUC, specificity, and sensitivity. CCAS was not a significant predictor of any SDT performance measure, and none of the individual difference measures or demographic variables predicted bias.

Table 5. Raw regression parameters for typical headlines.

N=398	AUC	Bias	Sensitivity	Specificity
Predictor:	B (SE)	B (SE)	B (SE)	B (SE)
CCAS	.022 (.019)	-.099 (.04)	.048 (.02)	-.009 (.019)
AOT	**.062 (.015)**	.014 (.032)	**.054 (.016)**	**.063 (.015)**
Political Orientation	**-.083 (.007)**	.002 (.016)	**-.074 (.008)**	**-.068 (.008)**
Age	-.002 (.001)	.005 (.002)	-.003 (.001)	0 (.001)
Race	.027 (.026)	-.024 (.055)	.037 (.028)	.019 (.026)
Education level	-.007 (.022)	-.013 (.047)	.008 (.024)	.001 (.022)
Gender	-.018 (.011)	-.016 (.024)	-.014 (.012)	-.023 (.011)
R²	.4	.049	.341	.298
Constant	.685 (.107)	.001 (.229)	.612 (.115)	.607 (.109)

Notes: Beta (S.E.), bolded = sig. <.001

Table 6. Raw regression parameters for atypical headlines.

N=398	AUC	Bias	Sensitivity	Specificity
Predictor:	B (SE)	B (SE)	B (SE)	B (SE)
CCAS	-.027 (.02)	**-.205 (.042)**	.045 (.02)	**-.085 (.02)**
AOT	-.022 (.016)	-.024 (.034)	-.006 (.016)	.024 (.016)
Political Orientation	**.061 (.008)**	.006 (.017)	**.046 (.008)**	**.048 (.008)**
Age	.001 (.001)	.004 (.002)	0 (.001)	.002 (.001)
Race	-.062 (.028)	-.132 (.059)	-.001 (.028)	-.086 (.027)
Education level	-.003 (.023)	-.075 (.05)	.03 (.024)	-.019 (.023)
Gender	.008 (.012)	-.033 (.025)	.02 (.012)	-.002 (.012)
R²	.216	.101	.105	.235
Constant	.562 (.115)	.499 (.244)	.355 (.118)	.694 (.113)

Table 6 displays parameter estimates for regression analyses for the 12 atypical headlines. CCAS is a negative predictor of bias and specificity. Greater climate change anxiety predicted less bias (favoring false responses) and lower specificity. Political conservatism was positively related to accuracy (AUC, sensitivity, and specificity), in contrast to the results from the 24-item and typical headline analyses. AOT was not a significant predictor of any SDT-related performance outcomes.

8. Discussion

Results from IRT analysis suggest that the selected headlines provided a reasonable measure of the ability to classify true and false information in each of the four categories (Hypothesis 1). The separation of the ICCs indicated variability in item difficulty, particularly for the atypical headlines. Unfamiliarity with atypical headlines is underscored by the shift of some ICCs to the right. Nearly all ICCs followed the ideal ogive shape, indicating good discriminability.

AUC values generated from pooled ROC analysis suggest moderate accuracy when classifying climate-related headlines. U.S. adults' accuracy was moderate (AUC = 0.68) for all 24 headlines, which corresponds with our prediction in Hypothesis 2. AUC was the highest for typical items (AUC=.76), suggesting that these items were easier for participants to classify than the atypical headlines (AUC=.60). Yet, respondents did perform better than chance for atypical headlines. AUC values generated from individual SDT analyses were like those produced in the pooled ROC analyses.

Average bias was positive for the complete set and the typical and atypical subsets of headlines, corroborating predictions from Hypothesis 3. The positive bias indicates an inclination to classify headlines as false. Positive bias is expected when the base rate of false items is greater than that for true items or when the subjective penalty of a false positive (saying true when the headline is false) is greater than that for a false negative (saying false when the headline is true). This result differs from past research, which found little bias (Barajas and John, 2023).

As expected from the AUC estimates, sensitivity and specificity were higher for the typical headlines than atypical ones. For each group of headlines, specificity was greater than sensitivity, consistent with the positive bias estimates.

The prediction of individual accuracy and bias was contingent on the type of headlines selected. Note that age, gender, race, or education level were not significant predictors of ability across groups.

AOT was a significant positive predictor of performance for all 24 headlines and typical headlines but not for atypical headlines. This conflicts with Hypothesis 4 that AOT would positively predict accuracy for each group of headlines. Moreover, AOT was not a significant predictor of bias for atypical headlines.

We predicted that political conservatism would have a negative relationship with performance for all groups of headlines (Hypothesis 5). While we found that political conservatism had a negative association with our performance-related outcomes for the full set and for typical headlines, it had a positive relationship for the atypical headlines. For typical headlines, conservatism was found to lead to a lower ability to identify true headlines that support climate change as true and to identify false headlines that question climate change as false. Results in these two categories are consistent with prior research that conservatives are more susceptible to believing misinformation (i.e., more conservative participants will struggle to identify a headline that questions climate change as false) than liberals (Cook, 2019; Lutze et al., 2019).

However, the positive relationship between political conservatism and AUC, sensitivity, and specificity for the atypical headlines is novel. This result suggests that conservatism is positively associated with correctly classifying atypical headlines. This result starkly contrasts the typical narrative surrounding susceptibility to misinformation and conservatism.

CCAS, our measure of climate change anxiety, was a significant predictor of performance-related outcomes for the full set and the atypical headlines. For both, CCAS had a negative relationship with bias and specificity. These results contrast with our Hypothesis 6, which predicted that CCAS would positively predict accuracy.

CCAS scores negatively predicted specificity; the probability of identifying false information as false decreased as participants became more anxious about the climate. This result was expected for atypical headlines (wherein the false headlines were alarmist), as someone with increased levels of climate change anxiety would be more likely to believe scarier headlines about the climate. CCAS was a positive, significant predictor of sensitivity for all 24 headlines. CCAS had no influence on our performance-related outcomes for the typical headlines.

The observed variation in the SDT performance variables' predictability suggests that classification tasks that confound true and false climate change information with support or skepticism for climate science can produce misleading results. While AOT predicted higher accuracy and political conservatism

predicted lower accuracy in both the full and typical set of headlines, results were different for the CCAS. Results using typical headlines suggested that CCAS was unrelated to bias; in contrast, we found that CCAS predicted bias in the full set of headlines. Including atypical headlines creates a more balanced representation of true and false climate change information, not confounded with deep beliefs about climate science.

9. Future Research

The current study strongly suggests that future research on climate change misinformation (and fake news on any polarizing topic) should balance true and false items to represent both ends of the spectrum evenly. Unfortunately, most prior research included only true headlines consistent with beliefs in the urgency to mitigate climate change and false headlines consistent with climate change denial. Future studies should use a representative design of true and false items, not confounded with narratives. Generalization of these findings to other Western countries is an open empirical question due to the extreme polarization and politicization of climate change policy in the U.S.

Future research on interventions to improve accuracy in classifying true and false climate change information would also benefit from using a balanced selection of true and false information items. Should these techniques be used in large-scale climate change misinformation campaigns, such as those run by the government, they must be effective across all types of information to build resilience.

Future climate change misinformation research should also consider including individual difference measures such as the CCAS as indicators of underlying belief systems. It would also be worthwhile to study individual differences further and gain insights into the decision-making process with techniques such as one-on-one interviews with participants; this would enable researchers to understand better how each participant interpreted each headline and concluded whether it was true or false.

While multiple linear regression analysis provides researchers an accessible way to learn about factors that influence ability, future research can be broadened to consider interaction terms and non-linear predictors of accuracy.

10. Limitations

While our sample of U.S. adults was diverse, it was not perfectly representative. While we did not find

that age, race, gender, or education level was a significant predictor of accuracy or bias, our use of a volunteer online sample is a limitation.

The headline collection was completed in 2022. Though each headline was fact-checked in 2022 and at this time, new research and findings could change whether certain headlines are true or false. This limitation is endemic to all misinformation research since science is constantly evolving and producing discoveries, some of which contradict that which was previously known to be true (or false).

11. Conclusion

This study extends current climate change misinformation research by including typical and atypical climate change headlines. While most studies have used only true items supporting climate change and false items that deny it, this study included the inverse of both. This study suggests that it is critical to identify a balanced, representative set of true and false items in studies of climate change misinformation.

Our results suggest that U.S. adults' accuracy in classifying true and false climate change headlines was moderately high but varied depending on headline selection. We found contrasting results for AOT, CCAS, and political orientation based on headline selection. AOT positively predicted accuracy for balanced and typical headlines but had no effect on accuracy for atypical headlines. Political conservatism was a negative predictor of accuracy for the balanced and typical headlines but not for the atypical subset. CCAS was a strong predictor of bias for the full set of headlines but a negative predictor for atypical headlines.

12. Acknowledgement

13. References

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