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In 2016, the Paris Agreement was ratified. Parties to the agreement have pledged to cooperate to keep global temperature increases well below 2°C above pre-industrial levels (United Nations, 2015). The continued cooperation of democratic countries is partly determined by public support. Yet, in America and Australia, public concern for climate change often lags behind other social issues, such as strengthening the economy (Markus, 2021; Pew Research Center, 2022).

Various interventions have been proposed to increase support for climate policy. For example, telling people the proportion of climate scientists who believe in anthropogenic climate change (97%) enhances concern about climate change and policy support (van der Linden et al., 2015; van der Linden, in press). Such interventions treat the public as a homogeneous entity. However, reception to climate change messages can vary due to differences in motivation, ideology, and worldview (Feygina et al., 2010; Kahan, 2012). For example, Hart and Nisbet (2012) exposed Americans to a news story describing climate change risks, before measuring support for mitigation policies. Compared to controls not exposed to an article, liberals who read the news story showed greater support for mitigation policy, whereas conservatives showed reduced support. Thus, when climate change messages clash with a person's pre-existing political beliefs, they can backfire.

To improve interventions, communicators may use *audience segmentation* to divide the public into homogeneous groups (W. R. Smith, 1956). Messages can then be tailored to the characteristics of each group, which may enhance communication effectiveness and mitigate backfire effects (Corner & Randall, 2011). A meta-analysis of health communication suggests segmentation approaches are more effective than a 'one-size-fits-all' approach, particularly when psychological theory is used to understand the segments (Noar et al., 2007).

The most established audience segmentation for climate change communication is the *Six Americas* (Maibach et al., 2011; Yale Program on Climate Change

Communication, 2021). Six segments were developed from a nationally representative survey of Americans. Although multidimensional, the Six Americas may be ordered on continuous dimensions of belief and concern about climate change. The segments range from the 'alarmed', the segment most accepting of climate change science; via the 'concerned'; the 'cautious'; the 'disengaged'; the 'doubtful'; to the 'dismissive', a segment which rejects climate science. Conceptual replications have revealed comparable segments in other nations, such as Australia (Hine et al., 2013; Metag et al., 2017; Morrison et al., 2013; Morrison et al., 2018; Neumann et al., 2021).

Most climate change audience segments, including the Six Americas, have been developed using a *top-down* approach. Specifically, the audience is statistically grouped across psychological characteristics known to correlate with climate change perceptions, policy support, and pro-environmental behaviour (for a review, see Hine et al., 2014). Alternatively, a *bottom-up* approach groups segments according to the audience's views of lay concepts of climate change, such as those found in social media discussions. This overcomes a disadvantage of top-down approaches—they may omit features of climate change salient to citizens, but not to researchers. However, bottom-up approaches are sorely lacking in the climate change domain. Thus, it is unknown to what degree current understandings of segmentation are limited by researchers' preconceptions. Here we addressed this shortcoming using a bottom-up audience segmentation approach.

We conducted bottom-up segmentation using the *Q methodology*—an analytical approach to representing viewpoints (Brown, 1980). It uses a Q sort task whereby participants rank statements about a topic, usually along a dimension of agreement. Statements can be generated using a bottom-up approach, where statements capture the breadth of conversational possibilities (Brown, 1980; Stephenson, 1986). Using factor analysis, participants are then segmented based on ranks assigned to statements. Applications of the Q methodology to climate change audiences are rare and limited to small non-representative samples (e.g., Hobson & Niemeyer, 2012; Wolf et al., 2009). The current research is the first to apply the Q methodology to nationally representative samples. Our statements for the Q methodology were derived from prevalent Australian social media discourse on climate change (Andreotta et al., 2019).

The Current Paper

We conducted two studies using representative samples of the Australian public. Study 1 sought to derive audience segments using the Q methodology with statements from social media, followed by measures of the above-mentioned psychological characteristics. The study provided evidence for three different segments: Acceptors, Fencesitters, and Sceptics. Analysis of psychological characteristics indicated segments differed in their mental models, climate change concern and scepticism, political ideology, and environmental worldviews. In Study 2, we replicated the three segments and examined if they differed in their receptivity to climate science information. Participants completed a belief-updating task in which they were asked for their beliefs about the contribution of different causes to climate change, the likelihood climate change will have specific impacts, and the effectiveness of Australia's mitigation policy. They were then given the actual scientific estimates for each event before submitting their revised belief estimates. We found considerable heterogeneity across segments in their belief-updating tendencies. These results provide insights into the effectiveness of communicating scientific information to each segment.

Study 1

Climate change views may arise from the interaction of cognitive representations, ideology, personality, and affect. Regarding cognitive representation, audience segments typically vary in climate change scepticism (e.g., Yale Program on Climate Change Communication, 2021), both epistemic (doubting climate science) and response scepticism (doubting mitigation is possible, Capstick & Pidgeon, 2014). Beyond general scepticism of human influence on climate, segments may hold specific causal beliefs *mental models*—internalised representations used to generate descriptions, explanations, and predictions (Granger et al., 2002; Jones et al., 2011; Rouse & Morris, 1986). Different causal beliefs can lead to different predictions. To illustrate, consider two common mental models: one features greenhouse gas emissions as the predominant cause of climate change, whereas the other features toxic air pollution as the predominant cause (Fleming et al., 2021; Kempton et al., 1995; Reynolds et al., 2010). Individuals with the second model may be most likely to suggest the ineffective strategy of mitigating climate change by additional filtering of factory smokestacks (Kempton et al., 1995). Thus, knowledge of segments' mental models provides insight into the logic by which trusted information will be transformed into action or knowledge (Granger et al., 2002), and which policies may be endorsed (Bostrom et al., 2012).

Deliberation through mental models and policy support may depend upon cognitive styles. For example, individuals with a high *need for cognition* engage in, and enjoy, effortful thinking (Cacioppo & Petty, 1982). Those high in need for cognition tend to think openly and critically about issues, potentially leading to greater acceptance of scientific perspectives on climate change (Sinatra et al., 2014). Conversely, individuals with high self-perceived climate change knowledge may be reluctant to seek out and accept scientific information (Stoutenborough & Vedlitz, 2014). Those with an elevated *considerations of future consequences* cognitive style are predisposed to orient themselves to long-term over short-term goals (Strathman et al., 1994), leading to higher support for mitigative policy (Wang, 2017).

Ideological characteristics may underscore the contents of mental models and whether mental models are used in deliberation (Fleming et al., 2021). For example, right-wing political ideologies de-emphasise climate change risks and concerns, thereby legitimising mental models that represent climate change as a natural fluctuation in climate (Campbell & Kay, 2014; Drews & van den Bergh, 2016; Leiserowitz, 2006; Zia & Todd, 2010). Similarly, individuals with high *system justification*, a tendency to perceive the prevailing social system as fair, legitimate, and justifiable (Kay & Jost, 2003), are motivated to deny the risks of climate change, as mitigative policies often challenge the status quo (Feygina et al., 2010; van der Linden, 2017). Some sceptical of climate change may demonstrate *conspiracist ideation* by believing climate change to be a 'hoax' and therefore reject anthropogenic climate change (Lewandowsky, Gignac, et al., 2013; Lewandowsky, Oberauer, et al., 2013; Sarathchandra & Haltinner, 2021).

Individuals differ in their environment worldviews, culturally shared values and beliefs about the environment (Douglas & Wildavsky, 1983; Thompson et al., 1990). For example, individuals may have an *environment-as-ductile* worldview that the environment is unable to recover from human impacts or an *environment-as-elastic* worldviews that the environment is readily able to recover from human impacts (Price et al., 2014). Individuals with greater environment-as-ductile worldviews, or reduced environment-as-elastic worldviews, demonstrate greater belief in anthropogenic climate change, environmental concern, and pro-environmental behaviour (Price et al., 2014). Lastly, values may influence climate change scepticism. Individuals with high *conservation* values (the motivation to preserve the past, respect order, and resist change) and low *self-transcendence* may be motivated to engage in climate change denial (Corner et al., 2014; Drews & van den Bergh, 2016; Schwartz, 2012).

Personality may have wide-reading effects on engagement with, and views of, climate change. Personality mediates the effects of risk perceptions, values, social norms, and environmental concern on pro-environmental attitudes (Yu & Yu, 2017). Emission-reducing behaviours are associated with the traits of openness (imaginative, curious), conscientiousness (reliable, organised), and extraversion (sociability, assertiveness; Brick & Lewis, 2014).

Affect, particularly worry about climate change, can influence climate change views and support for action (Fleming et al., 2021; N. Smith & Leiserowitz, 2014; van der Linden et al., 2019). For example, experimental and correlational research has supported a Gateway Belief Model, where the influence of the perceived scientific consensus on support for public action is mediated by cognitive (belief in climate change and human causation) and affective (worry about climate change; van der Linden et al., 2019). Worry about climate change is one the largest predictors of mitigative policy support, surpassing the predictive capacity of other emotions (N. Smith & Leiserowitz, 2014).

A complex myriad of psychological characteristics underpin tendencies to process and seek information and engage in pro-environmental behaviour. This study aimed to segment the audience using the Q methodology and examine segment differences in a range of psychological characteristics. Although we used a bottom-up approach to audience segmentation, we adopted a top-down approach to facilitate segment interpretation by incorporating auxiliary measures of psychological characteristics that may account for differences in segment membership. Critically, these auxiliary measures were used to facilitate interpretation of audience segments after they had been derived—they did not contribute to the segmentation process itself. We expected each segment would be underscored by a unique signature of psychological characteristics.

Method

This study was pre-registered using the Open Science Framework (https://osf.io/tc8v6/?view_only=c91a9e1cd22340378d13155129c804a6/).

Participants. Four-hundred and thirty-five Australian adults were recruited online by Qualtrics. A targeted and stratified sampling process was used, whereby the age (M = 46.71, SD = 17.77) and gender (female = 50.34%) were matched to the general population of Australian adults reported in the national 2016 census. We did not record the data of extremely fast responders, defined as those who completed the study in less than 873 seconds (a preregistered criterion based on pilot testing).

Materials and Procedure. Participants completed the Q sort followed by an inventory of psychological survey scales. Administration of scales was counterbalanced to control order effects (see Supplementary Material). The median time taken to complete the study was 26.17 minutes (interquartile range = 16.15 minutes).

Q sort. The Q sort requires a set of statements capturing the breadth of conversational possibilities of an issue (Stephenson, 1986). Previous work has used an inductive process to identify the structure of climate change commentary of Australian tweets (Andreotta et al., 2019). This research revealed five enduring themes of public discourse on climate change: climate change action, climate change consequences, climate change conversations, climate change denial, and the legitimacy of climate science and climate change. For each theme, we selected six tweets that captured the heterogeneity of the theme (see Supplementary Materials). The resulting 30 tweets were transcribed as statements that could be understood without the social context of the original tweet. Where possible, language, sentiment, and tone were preserved. Statements included: “it is important to vote for leaders who will combat climate change” (climate change action), “climate change is a threat to the health and safety of our children” (climate change consequences), “it is shameful that climate change, the greatest problem of our time, is barely discussed in the media” (climate change conversations), “climate change sceptics ignore basic climate science facts” (climate change denial), and “scientists should stop falsely claiming that climate change is a settled science” (legitimacy of climate science and climate change).

The Q sort comprised three phases. In phase 1, participants read each statement and assigned it to one of three categories: (1) like their point of view; (2) unlike their point of view; or (3) neutral or unsure. In phase 2, participants were required to rank statements from “most unlike my point of view” (-4) to “most like my point of view” (+4). The number of statements that could be placed at each rank was predetermined, such that more statements could be placed at the midpoint rather than the extremes (Figure 1). Thus, participants had to be selective in the statements used to represent their most extreme views. In phase 3, participants responded to open-ended questions prompting them to justify their placement of the statements ranked most extreme.

Scales. Twenty eight scales were used to measure cognitive, ideological, personality, and affective psychological characteristics. For brevity, the scales are summarised in Table 1.

Fig. 1. Schematic of the Q sort task. Participants progressed through a stack of unsorted statements (A) by dragging the top-most statement into the grey box that best corresponded to their point of view (B), as indicated by the blue solid line. Participants could re-arrange statements at any time during the task. To facilitate this process, statements could be placed in the orange temporary holding area (C), as indicated by the pink dashed line

Results and Discussion

Segments. To identify segments, we conducted a factor analysis on the Q sort data. Unlike traditional survey approaches which characterise factors of statements that generate common response patterns across people, the Q methodology reverses this statistical procedure to identify factors of people with common sorting styles (Brown, 1980; McKeown & Thomas, 2013; Watts & Stenner, 2012). We conducted a principal components analysis using varimax rotation. We extracted a single factor, as the first component accounted for a substantially larger proportion of variance (34.06% after rotation) than the second component. Broadly, this extracted factor represents a dimension of acceptance of anthropogenic climate change. We segmented individuals on the basis of their factor loading: (1) *Acceptors* whose positive load onto the factor is statistically significant ($n = 281$; 64.60%); (2) *Sceptics* whose negative load onto the factor is statistically significant ($n = 36$; 8.28%); and (3) *Fencesitters* whose loading onto the factor is not statistically significant ($n = 118$; 27.13%). Fencesitters are necessarily less homogeneous in their climate change views than Acceptors and Sceptics, otherwise Fencesitters would have emerged as a second factor.

To understand each segment's perspective, we constructed a 'representative' Q sort (Brown, 1980; Watts & Stenner, 2012). For each segment, the average ranking assigned to each statement by participants, weighted by participants' factor loading, was calculated. The weighted-averages of statements were then mapped onto the rankings enforced by the structure of the Q sort, known as factor scores (Table 2). Factor scores were not calculated for Fencesitters, as the segment's sorting style was necessarily heterogeneous. Next, we report the representative Q sorts for Acceptors and Sceptics further elaborated on with the participants' text justification of their rankings.

Acceptors believe anthropogenic climate change is occurring (statements: $3, 10, 11, 13, 28$), as indicated by an increased frequency of extreme weather and hotter days (statements: $5, 10, 11$). Acceptors reject the notion climate change is a hoax (statements: $2, 6$). Acceptors claim climate change will cause widespread changes: physical changes in weather (statements: $9, 10, 11$); biological changes to ecosystems, such as damage to the Great Barrier Reef (statement: 4); and changes to human systems, threatening agriculture (statement: 6), future generations (statement: 4), and to a lesser degree, the poor (statement: 21). According to Acceptors, these impacts are worse than scientists initially thought (statement: 8), though there are still opportunities to mitigate and adapt (statements: 12, 15, 25, 26). Although Acceptors believe action partly rests on collective society (statement: 27), they believe leaders must take charge (statement: 1, 25) as "there are too many weak and idiot politicians in parliament. we need to vote in people who will take action" otherwise "climate change will spiral out of control".

Sceptics reject the concept of anthropogenic climate change (statements: 3, 10, 11, 13, 28). According to Sceptics, there is conclusive evidence human activities do not influence climate. Scientists who say otherwise are viewed by Sceptics to rely on "dodgy modelling" and "bullshit thought up by some brain dead idiots in university". Thus, Sceptics claim climate scientists have overestimated the frequency and intensity of current extreme weather events (statements: 10, 11), and will be incorrect in their projections for the future (statements: 4, 7, 8). Consequently, Sceptics agree scientists changed the name of their area of study from "global warming" to "climate change", as the world is not warming (statement: 5). As anthropogenic climate change "has nothing to do with science and reality", Sceptics question the motives of institutions that endorse mitigative action (statements: 2, 5). For example, one Sceptic claimed "the United Nations is hiding behind climate change to acquire money". Similarly, Sceptics argue against voting for leaders who will combat climate change (statements: 1) as such leaders are only concerned "about what they can get". These leaders are "going to bankrupt Australia" by "chasing ghosts" as there is no way to "tame mother nature, money can't". Citizens who demand solutions for climate change are the usual 'torch-and-pitchfork' crowd (statement: 12).

Predictors of Segment Membership. Segments differed in their psychological attributes (Table 3). To explore statistical differences, we constructed a multinomial regression model that predicted segment membership as a function of the z-scores of psychological characteristics. Due to the large number of related predictors, we used a ridge regression. A ridge regression penalises the estimates of highly-correlated terms to achieve greater reliability (a bias-variance tradeoff). For each level of the penalty placed on highly-correlated terms (corresponding to a shrinkage parameter λ), different coefficients are estimated. A cross-validation process (k-fold) was used to determine the ideal penalty (λ). Confidence intervals of the coefficient were calculated using a bootstrap procedure (Efron & Tibshirani, 1994). One thousand samples were created by sampling participants (with replacement) from the study data. For each sample, coefficients were estimated using the aforementioned ridge regression and cross-validation processes. From the coefficient distributions, 95% confidence intervals were identified.

Regression coefficients are presented in Figure 2. Acceptors (Sceptics) were characterised by lower (greater) epistemic and response scepticism, greater (lower) belief in anthropogenic climate change, greater (lower) worry about climate change, lower (greater) endorsement of environment-as-elastic worldviews, less (more) conservative political ideology, lower (greater) knowledge volume, and greater (lower) belief carbon-emitting human activities cause climate change. High belief in societal consequences of climate change reliably distinguished Acceptors only, whereas low belief environmental harms causes of climate change and greater self-perceived climate change knowledge reliably predicted Sceptics only. Fencesitters were distinguished by greater levels of conspiratorial ideation. Fencesitters (Acceptors) were distinguished by higher (lower) belief in the effectiveness of engineering policies, though this may be a result of suppression via other predictors, as on average, Acceptors had numerically greater belief in the effectiveness of engineering policies than Fencesitters. Likewise, the relatively low coefficient of knowledge volume predicting Acceptor membership should also be cautiously interpreted, as on average, Acceptors had greater knowledge volume than Fencesitters. Personality, need for cognition, consideration of future consequences, system justification, and values were not reliable predictors of segment membership. Thus, each segment was associated with a unique pattern of psychological characteristics.

Study 2

Study 1 provided evidence for three audience segments that differ in psychological characteristics that transcend climate change (conspiratorial ideation, environmental worldviews, and political ideology) and specific climate change beliefs and mental models that may be more easily changed. However, the association between climate change scepticism and ideological variables suggest some climate change beliefs may be resistant to revision because of motivated reasoning (Bayes & Druckman, 2021). For example, the association between climate change scepticism and right-leaning ideology may be due to scepticism becoming a symbol of in-group membership for conservatives—a process known as identity-protective cognition (Kahan et al., 2013). If so, conservatives may be motivated to reject opposing beliefs as these would threaten the material and emotional benefits gained from in-group membership. Thus, segments may differ in their receptivity to climate science information.

To test this idea, in Study 2 we examined whether revision of climate change beliefs differed across segments. We used a *belief-updating paradigm* (Garrett & Sharot, 2017). In this paradigm, in each trial, individuals generate numerical estimates of an event or process, and then are shown an estimate and required to generate another estimate. Although not commonly used in climate change communication research (though, see Sunstein et al., 2017), the belief-updating paradigm allows researchers to quantify belief-updating tendencies in a rigorous manner, that generalises across beliefs and accounts for individual base rates (e.g., Garrett & Sharot, 2017; Ma et al., 2016).

Fig. 2. Ridge regression coefficients for each predictor of segment membership. The coefficients (dot) and 95% confidence intervals (error bars) are presented for Acceptors (blue), Fencesitters (yellow), and Sceptics (purple). Predictors are ordereded by the magnitude of coeffecients. The grey background highlights predictors where confidence intervals contains zero for all segments.

In the current study, we assessed updating across three mental model domains: climate change causes, climate change consequences, and effective mitigation of climate change (Bostrom et al., 2012). The dependent measure of interest was the direction and degree of belief updating following receipt of scientific estimates.

Additionally, we explored two cognitive mechanisms which may account for a relationship between segment membership and belief revision. The first is trust in the source of incoming information. Acceptors may be more likely to trust scientific institutions than Sceptics, due to observed differences in political ideology, environmental worldviews, and climate change scepticism (Cook & Lewandowsky, 2016; Sunstein et al., 2017). The second mechanism is optimism bias, where individuals tend to revise their beliefs to a greater degree when receiving good news (e.g., initially overestimating an event perceived as bad) than when receiving bad news (e.g., initially overestimating an event perceived as good; Garrett & Sharot, 2017; Ma et al., 2016). Sunstein et al. (2017) demonstrated that segments differ in their optimism bias—when revising future-warming estimates, Sceptics updated optimistically, whereas Acceptors updated pessimistically. Accordingly, we explored the possibility segment differences in belief-updating can be explained by group differences in an optimism bias. To determine which events were good or bad news, we included a sentiment inventory for participants to indicate their feelings towards each climate change outcome.

Finally, Study 2 was an opportunity to replicate the three segment solution from Study 1. However, the length of the belief-updating paradigm meant it was not practical to include the psychological scales from Study 1.

Method

Participants. Qualtrics was used to recruit Australian adults (N = 413) using the same targeted and stratified sampling process focussed on age (M = 46.82, SD = 18.04) and gender (female = 47.94%). Along these characteristics, the sample was representative of the Australian population. We did not record the data of extremely fast responders, defined as those who completed the study in less than 664 seconds (a preregistered criterion based on pilot testing).

Materials and Procedure. All materials were presented to participants on a computer screen via a web browser. After providing informed consent and demographic data, participants completed the Q sort task used in Study 1. Next, participants completed the trust inventory, belief-updating tasks (administered in a counterbalanced order, see Supplementary Materials), and sentiment inventory. The median completion time of the study was 25.02 minutes (interquartile range = 18.28 minutes).

Trust inventory. Participants were informed they would be shown information from two sources: the peer-reviewed climate science literature and Climate Action Tracker (an organisation that provides scientific analysis of government climate action). For each source, participants read a lay description and indicated their trust of the source on a seven-point Likert scale, ranging from "strongly distrust" (1) to "strongly trust" (7).

Belief-updating tasks. We tested belief updating across three domains with five belief-updating tasks: (1) belief in causes of climate change (three tasks); (2) belief in consequences of climate change (one task); and (3) belief in effectiveness of mitigative policies (one task). Each belief-updating task contained two stages. Firstly, participants provided estimates for climate change drivers or outcomes (see Supplementary Materials for more detail), by entering values from 0 to 100 into text boxes. Secondly, participants were shown their initial estimates alongside the scientific estimate. Participants then provided a new estimate. The presentation of belief-updating tasks was counterbalanced across participants (see Supplementary Materials).

The first three belief-updating tasks concerned causal beliefs. For the first task, participants estimated the percentage of human-driven and nature-driven causes of climate change between 1980–2011, separately. For the second task, participants estimated the percentage of climate change caused by each of six mechanisms (e.g., "carbon dioxide emissions" and "changes in solar activity") between 1750–2011. For the third task, participants estimated the percentage of warming caused by greenhouse gas emissions from six human activities (e.g., "electricity use in residential buildings").

Before supplying their estimates, participants were informed greenhouse gas emissions drive most climate change.

Another belief-updating task concerned consequence beliefs. Participants estimated the degree to which nine climate events (e.g., "the number of hot days globally between 1901–2005") occurred because of anthropogenic climate change.

The final belief-updating task concerned mitigation beliefs. Participants were given information about the Paris Agreement and the Emissions Reduction Fund (hereafter 'ERF'), Australia's central climate policy. Then, participants predicted the change in Australia's carbon dioxide emissions by the year 2030 (compared to 2005 levels) under Australia's current climate policies. Unlike other tasks, participants indicated the direction of change of emissions by using a drop-down menu (options: increase, decrease, no change) and the amount of change by entering a percentage (participants who indicated there would be no change had to enter "0"). Alongside both their initial and revised estimates, participants indicated their approval of the ERF on a seven-point Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (7); their level of approval of Australia's climate policies on the same seven-point Likert scale; and the likelihood Australia will meet the Paris Agreement (as a percentage, from 0 to 100).

Sentiment inventory. Participants indicated their feelings towards each climate change event presented in the belief-updating tasks, on a five-point Likert scale, ranging from "very negative" (1) to "very positive" (5). On the same scale, participants were asked "If Australia met its commitment to the Paris Agreement, how positive or negative would you feel about that?" Participants were not asked about their sentiment towards climate change causes, as responses would be difficult to interpret.

Results and Discussion

Segmentation Solution. Following the analysis steps of Study 1, we replicated the Acceptor, Fencesitter, and Sceptics segments. The factor scores of each statement was near-identical for Acceptors and Sceptics (see Supplementary Material for factor scores). Of the sample, 256 participants were Acceptors (61.99%), 114 were Fencesitters (27.60%), and 43 were Sceptics (10.41%).

Belief Updating. The dependent variable of interest is *update*—the degree to which a participant revised their estimate following exposure to scientific information, as a proportion of their initial error. An update score was calculated for each participant and for each belief. The magnitude of an update score is the difference between the initial and revised estimate, divided by the magnitude of difference between the initial and scientific estimate. The sign of the update score conveys whether the update was towards (positive) or away (negative) from the scientific estimate. Thus, an update score of one indicates a revision to match the scientific estimate. Using this formula, update scores could not be defined when the initial estimate equalled the scientific estimate (293 of 9888 updates; 2.96%) and such cases were therefore excluded from further analysis.

Linear mixed-effects modelling was used to determine whether update varied as a function of segment, trust in source information, or an optimism bias. Each domain of belief (cause, consequence, and mitigation) was modelled separately. The general strategy involved constructing several models, each with a different combination of predictors (known as fixed effects). We then compared the consistency between data and each model, via the Akaike Information Criterion (AIC), to determine the best fitting models (detailed in the Supplementary Materials). For models of cause and consequence beliefs, intercepts were assumed to randomly vary across participants, belief items, and task administration orders (known as random effects). For mitigation beliefs, intercepts were assumed to randomly vary across only task administration orders; as only a single belief was measured, within-unit and between-unit variability cannot be partitioned. All models were fit using maximum likelihood estimation. Predictor coefficients are reported with a 95% confidence interval (CI), estimated using the Wald method. One participant was excluded from analysis, as their data prevented model convergence due to a belief update score several magnitudes higher than other participants.

Updating varied as a function of segment (Figure 3). Models with a main effect of segment (and no other predictors) had better fit than models with no main effects. For cause beliefs, Acceptors updated more than Fencesitters (difference = 0.25, $CI = [0.12, 0.38]$), and Fencesitters updated more than Sceptics (difference = 0.39, $CI = [0.19, 0.59]$). For consequence beliefs, Acceptors again updated more than Fencesitters (difference = 0.25, $CI = [0.15, 0.34]$), who again updated more than Sceptics (difference = 0.24, $CI = [0.09, 0.40]$). For mitigation beliefs, Fencesitters updated the most, although they did not statistically differ from Acceptors (difference = 0.07, $CI = [-0.20, 0.34]$). However, Acceptors updated more than Sceptics (difference = 0.53, $CI = [0.13, 0.92]$). Thus, the patterns of segment updating for cause and consequence beliefs are not reflected in mitigation beliefs.

Segments may have differed in belief updating solely due to differences in trust in the source of information. However, this is not well supported by the evidence. For all domains, models with only a main effect of segment had considerably better fit than models with only a main effect of trust. Thus, trust alone cannot account for the effect of segment on belief update.

Generally, the best fitting models for update of cause and consequence beliefs were those including effects for both trust and segment membership. Additionally, there was substantial evidence for interactions. For cause beliefs, greater trust was associated with greater update for Acceptors (0.09 more update per point of trust, $CI = [0.01, 0.16]$) and Sceptics (0.18 more update per point of trust, $CI = [0.08, 0.28]$), but not for Fencesitters (0.02 less update per point of trust, $CI = [-0.06, 0.10]$). For consequence beliefs, greater trust was associated with greater update for Acceptors (0.10 more update per point of trust, $CI = [0.04, 0.16]$), but not for Sceptics (0.04 more update per point of trust, $CI = [-0.04, 0.12]$) or Fencesitters (0.04 more update per point of trust, $CI = [-0.02, 0.10]$). For mitigation beliefs, there was little evidence for

***Fig. 3*.** Mean update for each domain and segment: Acceptor (blue), Fencesitter (yellow), and Sceptic (purple). Error bars represent one between-participants standard error of the mean

an interaction.

Segment differences in updating may be due to differences in optimistic revisions. To explore this possibility, we determined which scientific messages were good news and bad news on the basis of participants' emotional appraisals of events and their first estimates. For example, if a participant indicated an event was negative and was exposed to a scientific estimate greater than their first estimate, the event is bad news; conversely, if this scientific estimate was instead less than a participant's first estimate, the event is good news. Combinations of effects for segment and news type (coded as good or bad) were entered into mixed-effects models. We did not model participant update of neutral belief/news, which included 1420 of 3708 consequence belief updates (38.30%) and 90 of 412 mitigation belief updates (21.84%). Of note, we did not model optimistic updating for cause beliefs as we did not collect sentiment data for causes.

For consequence and mitigation beliefs, the best fitting models were those containing main effects for segment and news type, but no interactions. There was a tendency towards a pessimistic updating for all segments, such that updating is larger for bad news than good news (Figure 4). As the best fitting models contained an effect for segment, segment differences in update could not be solely accounted for by differences in an optimism or pessimism bias.

Change in Policy Support. Additionally, we identified the predictors of changes in policy support. To do so, we determined the fit of linear mixed-effects models with combinations of main effects and interactions of: segment; change in perceived mitigation effectiveness (positively-signed when policy perceived to be more effective); and change in perceived likelihood of Australia satisfying the Paris Agreement (positively-signed change when the Paris Agreement is perceived to be more likely to be satisfied).

Fig. 4. Mean update for (a) consequence beliefs and (b) mitigation belief, as a function of news and segment: Acceptor (blue), Fencesitter (yellow), and Sceptic (purple). Error bars represent one between-participants standard error of the mean

For both support of the ERF and Australia's policy, two models had considerably better fit. The first model contained a main effect of segment, a main effect of perceived likelihood Australia will satisfy its Paris Agreement commitment, and an interaction between these two variables. The second model contained the same effects as the first, with an additional main effect of change in perceived mitigation effectiveness. For these models, the coefficient for the interaction between segment and perceived likelihood of meeting the Paris Agreement was only reliability signed (positive) for Acceptors (that is, the confidence interval did not intersect zero). Additionally, participants who updated towards greater perceived effectiveness of the ERF increased their support for the ERF (0.00378 change on the scale per 1% increment of carbon dioxide reduction, $CI = [0.00065, 0.00692]$), and their support for Australia's mitigation policies, although not reliably (0.00185 change on the scale per 1% increment of carbon dioxide reduction, $CI = [-0.00172, 0.00542]$). Overall, these models indicate participants of all segments who reduce their belief in a policy's effectiveness also reduce their support for that specific policy, but not general policy action. Additionally, Acceptors lowered their support for specific policy to the degree that it harmed Australia's likelihood of meeting the Paris Agreement. However, detrimental impacts on the Paris Agreement were unrelated to changes in policy support of Fencesitters and Sceptics.

General Discussion

We used a novel bottom-up approach to segment climate change views. Across two studies, we find consistent evidence for three distinct audience segments: Acceptors, Fencesitters, and Sceptics. In Study 1, we combined our bottom-up approach to segmentation based on the Q sort with a top-down approach to segment interpretation by incorporating auxiliary measures of potentially relevant psychological characteristics. Importantly, these auxiliary measures were used to help interpret the segments once they had been derived—they did not contribute to the segmentation process itself. This combination of approaches revealed the three segments differ in their mental models of climate change and other psychological characteristics. Study 2 demonstrated segments differ in their belief-updating tendencies when exposed to scientific information. Overall, our studies indicate the Australian public are divisible into three audience segments with unique psychological characteristics and belief-updating tendencies. Next, we summarise the characteristic differences between segments, how these can inform communication strategies, and how our segmentation solution differs from previous research.

Characteristic Differences Between Segments

Segment differences can be understood by referring to their sorting behaviour in the Q sort task, responses on the psychological characteristics measures, and updating tendencies in the belief-updating paradigm. From the Q sorts, it is apparent Acceptors strongly believe in the urgency and reality of climate change. They recognise climate change will have wide-ranging impacts on environment and society, and these impacts may be worse than climate scientists expect. They reject conspiratorial notions of climate change as a hoax, and they want to see political leadership and climate action. By contrast, Sceptics have an alternative perception of reality—one where the science suggests human actions are not influencing climate. Instead, climate change is a hoax manufactured to serve a hidden agenda. Accordingly, climate scientists are thought to use questionable research practices to create the illusion climate change is occurring. They think climate scientists' forecasts of global warming have been proved wrong and that, because of this, they deliberately changed the name of their field of study from "global warming" to "climate change". We cannot say anything specific about Fencesitters other than that their sorting responses are more heterogeneous than the other two segments.

Turning to psychological characteristics measures, Acceptors strongly believe climate change is occurring and that carbon-emitting human activities cause climatic changes. They are more worried about the issue than other segments and strongly support climate action. This segment is politically liberal with an environment-as-ductile worldview, meaning they think the natural environment has a limited capacity to recover from damage. By contrast, Sceptics are less likely to believe climate change is occurring and that carbon-emitting human activities cause climatic changes—yet, Sceptics have the greatest self-confidence in their knowledge about climate change. They are therefore sceptical of the need for climate action. This segment is politically conservative with an environment-as-elastic worldview, meaning they think the environment easily recovers from damage. Surprisingly, Sceptics did not show the highest levels of dispositional conspiratorial ideation of all segments, despite their strong endorsement of climate-conspiracy related items in the Q sort. Instead, Fencesitters were the highest in dispositional conspiratorial ideation.

Our finding that dispositional conspiratorial ideation was elevated in Fencesitters, but not Sceptics, seemingly contradicts an extensive literature showing conspiratorial ideation predicts climate change scepticism (Hornsey et al., 2018; Kaiser & Puschmann, 2017; Lewandowsky, Oberauer, et al., 2013). However, Lewandowsky (2020) recently suggested individuals may deploy conspiratorial explanations for two different reasons: (1) they have a general disposition towards engaging in conspiratorial ideation; and/or (2) they seek to guard against worldview-incongruent information. In the latter case, conspiracy theories may not reflect people's real attitudes to climate change but may instead be a pragmatic tool to indicate a person's political stance on the issue. Consistent with this, Fencesitters showed greater general disposition toward conspiracism in the absence of a specific tendency toward climate change conspiracy theorising, and have moderate political ideology and environmental worldviews. By comparison, Sceptics do not show an increased general disposition toward conspiracism, but they do show a specific tendency toward climate change conspiracy theorising, accompanied by politically conservative ideology and environment-as-elastic worldviews. Thus, unlike Fencesitters, Sceptics may be ideologically motivated to believe conspiratorial accounts of climate change.

Finally, segments differed in the degree they revised their beliefs towards scientific information. Specifically, for climate change causes and consequences, Acceptors updated their beliefs more than Fencesitters, who in turn updated their beliefs more than Sceptics. For mitigation, Acceptors and Fencesitters revised their beliefs to a comparable degree, and more so than Sceptics. The segment differences in belief updating could not be fully accounted for by trust in information source or an optimism bias. In general, Acceptors and Fencesitters showed high degrees of willingness to revise their beliefs, whereas Sceptics were highly resistant to revising their beliefs. The willingness of Fencesitters but not Sceptics to update their beliefs in response to scientific information confers further support for the notion the two segments may deploy conspiracy theories for different reasons.

We found all segments updated optimistically, meaning their belief update in response to scientific information was greater for good news than bad news. We do not find evidence for a general pessimism bias in Acceptors, as suggested by previous research (Sunstein et al., 2017). This discrepancy may be due to differences in the classification of bad news. Unlike Sunstein et al. (2017) who assumed the belief of interest (a change in temperature) was perceived by all participants to be equally negative, we measured participant sentiment for each event and accounted for individual differences in sentiment. Though, other factors could have accounted for differences with previous research, such as the operationalisation of Acceptors or the specific beliefs measured in studies.

Communicating with the Different Segments

To bolster public support for mitigative policies, our findings suggest communicators should focus on Fencesitters. Acceptors already trust climate science and support strong leadership to address climate change, whereas Sceptics are few in number and politically-motivated to oppose mitigative policy, and are thereby resistant to belief updating. In contrast, Fencesitters show potential for belief change, as they update their beliefs in response to scientific findings and were not characterised by extreme environmental worldviews or political ideology. However, just as Fencesitters could be tipped towards greater climate change acceptance by exposure to scientific information, they could be tipped toward scepticism by exposure to disinformation.

To protect Fencesitters from climate change disinformation, communicators could preemptively use inoculation techniques to build psychological resistance to disinformation before it is perceived (McGuire & Papageorgis, 1961). Inoculation involves warning individuals they may be exposed to disinformation and explaining to them the deceptive strategies and rhetorical techniques used by those that seek to mislead (van der Linden et al., 2017). For example, Cook et al. (2017) found climate change disinformation could be successfully inoculated by alerting individuals to the use of 'fake experts' by the fossil fuel industry. Alternatively, if disinformation has already informed belief, communicators may use various best-practice debunking strategies to correct the disinformation (Lewandowsky et al., 2020; Lewandowsky et al., 2017). For example, communicators could provide clear explanations for the established knowledge that undermines the misinformation alongside an explanation of what is true instead (Ecker et al., 2020; Lewandowsky et al., 2020; Paynter et al., 2019).

Although we emphasise Fencesitters, public support for mitigation policy can be bolstered within Acceptors and potentially Sceptics. Despite worry about climate change and having knowledge on its causes, many Acceptors fail to distinguish effective and ineffective policies (Kempton et al., 1995; Read et al., 1994; Reynolds et al., 2010). To reduce support for ineffective policies, communicators could encourage Acceptors to apply their causal knowledge of greenhouse gases to the policy domain. Alternatively, communicators could directly highlight the ineffectiveness of a policy and the adverse impacts on international agreements. In contrast, changes in policy support of Fencesitters and Sceptics was not associated with the consequences of ineffective policy on international agreements. Lastly, messages from climate scientists could be persuasive, as climate scientists are trusted by Acceptors.

Of all segments, Sceptics were most resistant to belief revision when contradicted by science. Thus, communicators may need to deploy unique strategies to foster more positive attitudes towards climate science and policy in this segment. One approach is to leverage people's motivations to maintain cognitive consistency in attitudes. For example, Gehlbach et al. (2019) found conservatives asked to rate the generally accepted contributions of science to society, such as discovering germs cause disease, had more positive attitudes towards climate science than conservatives asked solely about their climate science attitudes. Alternatively, communicators may avoid climate science entirely by appealing to the benefits of mitigation policy to improve policy endorsement, such as communicating the moral or economic co-benefits (Bain et al., 2015). Though, communicators should be weary of Sceptics' aversion to commonly discussed climate change mitigation policies, which may conflict with more conservative political ideology (Campbell & Kay, 2014).

Comparison to Previous Segmentation Research

Our studies found evidence for three segments, a number on the lower range of segments reported in the literature (Hine et al., 2014). Though, the number of segments derived in studies is an inherently subjective process. Therefore, the characteristics underlying segments should be emphasised when comparing studies. Despite using a bottom-up approach, our segmentation solution is broadly consistent with the literature (e.g., Hine et al., 2016; Maibach et al., 2009; Morrison et al., 2013). Specifically, we identified segments of Acceptors and Sceptics, consolidated on a continuum of climate change scepticism, worry about climate change, and political ideology. We extend the literature by identifying the conspiratorial disposition of Fencesitters and the typical mental models held by each segment. Further, we identified the belief-updating tendencies of segments, demonstrating that in some contexts, Fencesitters may be more receptive to climate change science than Acceptors.

Limitations

The use of Internet panel services introduced methodological limitations to our studies with effects for generalisation. The samples used in the study are not truly representative of all Australians, as we sampled Australians who participated in panel services, and matched the sample to Australian demographics only on gender and age. Additionally, short-form scales were used in the first study to measure psychological constructs. By virtue of minimal items, some scales had poor internal consistency (e.g., personality). However, we only selected short-form scales which had demonstrably good psychometric properties, such as retest reliability (Rammstedt & John, 2007).

Conclusion

The predominant approach to segmentation of climate change audiences has been top-down, which privileges researcher preconceptions over audience conceptions of climate change. In contrast, we used a bottom-up approach to ensure segmentation reflects lay views on climate change, as defined by the public. However, we did not disregard theory—we complimented our segmentation by examining the psychological characteristics of segments. We found the Australian public is composed of three segments—Acceptors, Fencesitters, and Sceptics—with unique psychological characteristics and belief-revision tendencies. Communication can be enhanced, our results suggest, by conceptualising the public as relatively homogeneous segments, rather than a heterogeneous whole. Yet, many communicators rely on a 'one-size-fits-all' approach. For these communicators, our research outlines a comprehensive profile of segments along with recommendations for communicating with each. We suggest communicators should target Fencesitters who hold moderate views and are receptive to belief revision. Care must nevertheless be taken since, although Fencesitters are receptive to scientific information, they are also potentially vulnerable to misinformation and conspiratorial thinking.

References

Andreotta, M., Nugroho, R., Hurlstone, M. J., Boschetti, F., Farrell, S., Walker, I., & Paris, C. (2019). Analyzing Social Media Data: A Mixed-Methods Framework Combining Computational and Qualitative Text Analysis. *Behav. Res. Methods*, *51*(4), 1766–1781. https://doi.org/10.3758/s13428-019-01202-8

Bain, P. G., Milfont, T. L., Kashima, Y., Bilewicz, M., Doron, G., Garðarsdóttir, R. B., Gouveia, V. V., Guan, Y., Johansson, L.-O., Pasquali, C., Corral-Verdugo, V., Aragones, J. I., Utsugi, A., Demarque, C., Otto, S., Park, J., Soland, M., Steg, L., González, R., … Saviolidis, N. M. (2015). Co-Benefits of Addressing Climate Change can Motivate Action Around the World. *Nat. Clim. Change*, *6*(2), 154–157. https://doi.org/10.1038/nclimate2814

Bayes, R., & Druckman, J. N. (2021). Motivated Reasoning and Climate Change. *Curr. Opin. Behav. Sci.*, *42*, 27–35. https://doi.org/10.1016/j.cobeha.2021.02.009

Bostrom, A., O'Connor, R. E., Böhm, G., Hanss, D., Bodi, O., Ekström, F., Halder, P., Jeschke, S., Mack, B., Qu, M., Rosentrater, L., Sandve, A., & Sælensminde, I. (2012). Causal Thinking and Support for Climate Change Policies: International Survey Findings. *Glob. Environ. Change*, *22*(1), 210–222. https://doi.org/10.1016/j.gloenvcha.2011.09.012

Brick, C., & Lewis, G. J. (2014). Unearthing the "Green" Personality: Core Traits Predict Environmentally Friendly Behavior. *Environment and Behavior*, *48*(5), 635–658. https://doi.org/10.1177/0013916514554695

Brown, S. R. (1980). *Political Subjectivity: Applications of Q Methodology in Political Science*. Yale University Press.

Cacioppo, J. T., & Petty, R. E. (1982). The Need for Cognition. *J. Pers. Soc. Psychol.*, *42*(1), 116–131.

Campbell, T. H., & Kay, A. C. (2014). Solution Aversion: On the Relation Between Ideology and Motivated Disbelief. *J. Pers. Soc. Psychol.*, *107*(5), 809–824. https://doi.org/10.1037/a0037963

Capstick, S. B., & Pidgeon, N. F. (2014). What is Climate Change Scepticism? Examination of the Concept Using a Mixed Methods Study of the UK Public. *Glob. Environ. Change*, *24*, 389–401. https://doi.org/10.1016/j.gloenvcha.2013.08.012

Cook, J., & Lewandowsky, S. (2016). Rational Irrationality: Modeling Climate Change Belief Polarization Using Bayesian Networks. *Top. Cogn. Sci.*, *8*(1), 160–179. https://doi.org/10.1111/tops.12186

Cook, J., Lewandowsky, S., & Ecker, U. K. H. (2017). Neutralizing Misinformation Through Inoculation: Exposing Misleading Argumentation Techniques Reduces Their Influence. *PLOS ONE*, *12*(5), 1–21. https://doi.org/10.1371/journal.pone.0175799

Corner, A., Markowitz, E., & Pidgeon, N. (2014). Public Engagement with Climate Change: The Role of Human Values. *Wiley Interdiscip. Rev. Clim. Change*, *5*(3), 411–422. https://doi.org/10.1002/wcc.269

Corner, A., & Randall, A. (2011). Selling Climate change? The Limitations of Social Marketing as a Strategy for Climate Change Public Engagement. *Glob. Environ. Change*, *21*(3), 1005–1014. https://doi.org/10.1016/j.gloenvcha.2011.05.002

Douglas, M., & Wildavsky, A. (1983). *Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers*. University of California Press.

Drews, S., & van den Bergh, J. C. (2016). What Explains Public Support for Climate Policies? A Review of Empirical and Experimental Studies. *Clim. Policy*, *16*(7), 855–876. https://doi.org/10.1080/14693062.2015.1058240

Ecker, U. K. H., O'Reilly, Z., Reid, J. S., & Chang, E. P. (2020). The Effectiveness of Short-Format Refutational Fact-Checks. *Br J Psychol*, *111*(1), 36–54. https://doi.org/10.1111/bjop.12383

Efron, B., & Tibshirani, R. (1994). *Introduction to the Bootstrap*. Chapman & Hall.

Enzler, H. B. (2015). Consideration of Future Consequences as a Predictor of Environmentally Responsible Behavior: Evidence From a General Population

Study. *Environ. Behav.*, *47*(6), 618–643. https://doi.org/10.1177/0013916513512204

Feygina, I., Jost, J. T., & Goldsmith, R. E. (2010). System Justification, the Denial of Global Warming, and the Possibility of "System-Sanctioned Change". *Pers. Soc. Psychol. Bull.*, *36*(3), 326–338. https://doi.org/10.1177/0146167209351435

Fleming, W., Hayes, A. L., Crosman, K. M., & Bostrom, A. (2021). Indiscriminate, Irrelevant, and Sometimes Wrong: Causal Misconceptions about Climate Change. *Risk Anal.*, *41*(1), 157–178. https://doi.org/10.1111/risa.13587

Garrett, N., & Sharot, T. (2017). Optimistic Update Bias Holds Firm: Three Tests of Robustness Following Shah et al. *Conscious. Cogn.*, *50*, 12–22. https://doi.org/10.1016/j.concog.2016.10.013

Gehlbach, H., Robinson, C. D., & Vriesema, C. C. (2019). Leveraging Cognitive Consistency to Nudge Conservative Climate Change Beliefs. *J. Environ. Psychol.*, *61*, 134–137. https://doi.org/10.1016/j.jenvp.2018.12.004

Granger, M. M., Fischhoff, B., Bostrom, A., & Atman, C. J. (2002). *Risk Communication: A Mental Models Approach* (First). Cambridge University Press.

Hart, P. S., & Nisbet, E. C. (2012). Boomerang Effects in Science Communication: How Motivated Reasoning and Identity Cues Amplify Opinion Polarization About Climate Mitigation Policies. *Commun. Res.*, *39*(6), 701–723. https://doi.org/10.1177/0093650211416646

Hine, D. W., Phillips, W. J., Cooksey, R., Reser, J. P., Nunn, P., Marks, A. D. G., Loi, N. M., & Watt, S. E. (2016). Preaching to Different Choirs: How to Motivate dismissive, Uncommitted, and Alarmed audiences to Adapt to Climate Change? *Glob. Environ. Change*, *36*, 1–11. https://doi.org/10.1016/j.gloenvcha.2015.11.002

Hine, D. W., Reser, J. P., Morrison, M., Phillips, W. J., Nunn, P., & Cooksey, R. (2014). Audience Segmentation and Climate Change Communication: Conceptual and Methodological Considerations. *Wiley Interdiscip. Rev. Clim. Change*, *5*(4), 441–459. https://doi.org/10.1002/wcc.279

Hine, D. W., Reser, J. P., Phillips, W. J., Cooksey, R., Marks, A. D. G., Nunn, P., Watt, S. E., Bradley, G. L., & Glendon, A. I. (2013). Identifying Climate Change Interpretive Communities in a Large Australian Sample. *J. Environ. Psychol.*, *36*, 229–239. https://doi.org/10.1016/j.jenvp.2013.08.006

Hobson, K., & Niemeyer, S. (2012). "What Sceptics Believe": The Effects of Information and Deliberation on Climate Change Scepticism. *Public Underst. Sci.*, *22*(4), 1–17. https://doi.org/10.1177/0963662511430459

Hornsey, M. J., Harris, E. A., & Fielding, K. S. (2018). Relationships Among Conspiratorial Beliefs, Conservatism and Climate Scepticism across Nations. *Nat. Clim. Change*, *8*(7), 614–620. https://doi.org/10.1038/s41558-018-0157-2

Jones, N. A., Ross, H., Lynam, T., Perez, P., & Leitch, A. (2011). Mental Models: An Interdisciplinary Synthesis of Theory and Methods. *Ecol. Soc.*, *16*(1).

Kahan, D. M. (2012). Cultural Cognition as a Conception of the Cultural Theory of Risk. In S. Roeser (Ed.), *Handbook of Risk Theory* (pp. 725–759). Springer.

Kahan, D. M., Peters, E., Dawson, E. C., & Slovic, P. (2013). Motivated Numeracy and Enlightened Self-Government. *Behav. Public Policy*, *1*(1), 54–86. https://doi.org/10.1017/bpp.2016.2

Kaiser, J., & Puschmann, C. (2017). Alliance of Antagonism: Conunterpublics and Polarization in Online Climate Change Communication. *Commun. Public*, *2*(4), 1–17. https://doi.org/10.1177/2057047317732350

Kay, A. C., & Jost, J. T. (2003). Complementary Justice: Effects of "Poor But Happy" and "Poor but Honest" Stereotype Exemplars on System Justification and Implicit Activation of the Justice Motive. *J Pers Soc Psychol*, *85*(5), 823–837. https://doi.org/10.1037/0022-3514.85.5.823

Kempton, W., Boster, J. S., & Hartley, J. A. (1995). *Environmental Values in American Culture*. MIT Press.

Leiserowitz, A. (2006). Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values. *Clim. Change*, *77*(1-2), 45–72. https://doi.org/10.1007/s10584-006-9059-9

Lewandowsky, S. (2020). Hannah Arendt and the Contemporary Social Construction of Conspiracy Theorists. *PsyArXiv*. https://doi.org/10.31234/osf.io/fm8yg

Lewandowsky, S., Cook, J., Ecker, U. K. H., Albarracín, D., Amazeen, M. A., Kendeou, P., Lombardi, D., Newman, E. J., Pennycook, G., Porter, E., Porter, E., Rapp, D. N., Reifler, J., Roozenbeek, J., Schmid, P., Seifert, C. M., Sinatra, G. M., Swire-Thompson, B., van der Linden, S., … Zaragoza, M. S. (2020). *The Debunking Handbook 2020* (tech. rep.). https://doi.org/10.17910/b7.1182

Lewandowsky, S., Ecker, U. K., & Cook, J. (2017). Beyond Misinformation: Understanding and Coping with the "Post-Truth" Era. *J. Appl. Res. Mem. Cogn.*, *6*(4), 353–369. https://doi.org/10.1016/j.jarmac.2017.07.008

Lewandowsky, S., Gignac, G. E., & Oberauer, K. (2013). The Role of Conspiracist Ideation and Worldviews in Predicting Rejection of Science. *PLOS ONE*, *8*(10). https://doi.org/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. *Psychol. Sci.*, *24*(5), 622–633. https://doi.org/10.1177/0956797612457686

Lindeman, M., & Verkasalo, M. (2005). Measuring Values With the Short Schwartz's Value Survey. *J. Pers. Assess.*, *85*(2), 170–178. https://doi.org/10.1207/s15327752jpa8502_09

Lins de Holanda Coelho, G., Hanel, P. H., & Wolf, L. J. (2018). The Very Efficient Assessment of Need for Cognition: Developing a Six-Item Version. *Assessment*, *27*(8), 1870–1885. https://doi.org/10.1177/1073191118793208

Ma, Y., Li, S., Wang, C., Liu, Y., Li, W., Yan, X., Chen, Q., & Han, S. (2016). Distinct Oxytocin Effects on Belief Updating in Response to Desirable and Undesirable Feedback. *PNAS*, *113*(33), 9256–9261. https://doi.org/10.1073/pnas.1604285113

Maibach, E. W., Leiserowitz, A., Roser-Renouf, C., & Mertz, C. K. (2011). Identifying Like-Minded Audiences for Global Warming Public Engagement Campaigns: An

Audience Segmentation Analysis and Tool Development. *PLOS ONE*, *6*(3). https://doi.org/10.1371/journal.pone.0017571

Maibach, E. W., Roser-Renouf, C., & Leiserowitz, A. (2009). Global Warming's Six Americas 2009.

Malka, A., Krosnick, J. A., & Langer, G. (2009). The Association of Knowledge with Concern about Global Warming: Trusted Information Sources Shape Public Thinking. *Risk Anal.*, *29*(5), 633–647. https://doi.org/10.1111/j.1539-6924.2009.01220.x

Markus, A. (2021). *Mapping Social Cohension* (tech. rep.).

McGuire, W. J., & Papageorgis, D. (1961). The Relative Efficacy of Various Types of Prior Belief-Defense in Producing Immunity Against Persuasion. *J. Abnorm. Soc. Psychol.*, *62*(2), 327–337.

McKeown, B., & Thomas, D. B. (2013). *Q Methodology* (Second). SAGE Publications Ltd.

Metag, J., Füchslin, T., & Schäfer, M. S. (2017). Global Warming's Five Germanys: A Typology of Germans' Views on Climate Change and Patterns of Media Use and Information. *Public Underst Sci*, *26*(4), 434–451. https://doi.org/10.1177/0963662515592558

Morrison, M., Duncan, R., Sherley, C., & Parton, K. (2013). A Comparison Between Attitudes to Climate Change in Australia and the United States. *Australas. J. Environ. Manag.*, *20*(2), 87–100. https://doi.org/10.1080/14486563.2012.762946

Morrison, M., Parton, K., & Hine, D. W. (2018). Increasing belief but Issue Fatigue: Changes in Australian Household Climate Change Segments Between 2011 and 2016. *PLOS ONE*, *13*(6), 1–18. https://doi.org/10.1371/journal.pone.0197988

Neumann, C., Stanley, S. K., Leviston, Z., & Walker, I. (2021). *The Six Australias: Concern About Climate Change (and Global Warming) is Rising* (Unpublished Manuscript).

Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does Tailoring Matter? Meta-Analytic Review of Tailored Print Health Behavior Change Interventions. *Psychol. Bull.*, *133*(4), 673–693. https://doi.org/10.1037/0033-2909.133.4.673

Paynter, J., Luskin-Saxby, S., Keen, D., Fordyce, K., Frost, G., Imms, C., Miller, S., Trembath, D., Tucker, M., & Ecker, U. (2019). Evaluation of a Template for Countering MisinformationReal-World Autism Treatment Myth Debunking. *PLOS ONE*, *14*(1), 1–13. https://doi.org/10.1371/journal.pone.0210746

Pew Research Center. (2022). *Public's Top Priority for 2022: Strengthening the Nation's Economy* (tech. rep.). Pew Research Center.

Price, J. C., Walker, I. A., & Boschetti, F. (2014). Measuring Cultural Values and Beliefs about Environment to Identify their Role in Climate Change Responses. *J. Environ. Psychol.*, *37*, 8–20. https://doi.org/10.1016/j.jenvp.2013.10.001

Rammstedt, B., & John, O. P. (2007). Measuring Personality in One Minute or Less: A 10-Item Short Version of the Big Five Inventory in English and German. *J. Res. Personal.*, *41*(1), 203–212. https://doi.org/10.1016/j.jrp.2006.02.001

Read, D., Bostrom, A., Morgan, M. G., Fischhoff, B., & Smuts, T. (1994). What Do People Know About Global Climate Change? 2. Survey Studies of Educated Laypeople. *Risk Anal.*, *14*(6), 971–982. https://doi.org/10.1111/j.1539-6924.1994.tb00066.x

Reynolds, T. W., Bostrom, A., Read, D., & Morgan, M. G. (2010). Now What Do People Know About Global Climate Change? Survey Studies of Educated Laypeople. *Risk Anal.*, *30*(10), 1520–1538. https://doi.org/10.1111/j.1539-6924.2010.01448.x

Rouse, W. B., & Morris, N. M. (1986). On Looking into the Black Box: Prospects and Limits in the Search for Mental Models. *Psychol. Bull.*, *100*(3), 349–363. https://doi.org/10.1037/0033-2909.100.3.349

Sarathchandra, D., & Haltinner, K. (2021). How Believing Climate Change is a "Hoax" Shapes Climate Skepticism in the United States. *Environ. Sociol.*, *7*(3), 225–238. https://doi.org/10.1080/23251042.2020.1855884

Schwartz, S. H. (2012). An Overview of the Schwartz Theory of Basic Values. *Online Read. Psychol. Cult.*, *2*(1), 1–20.

Sinatra, G. M., Kienhues, D., & Hofer, B. K. (2014). Addressing Challenges to Public Understanding of Science: Epistemic Cognition, Motivated Reasoning, and Conceptual Change. *Educ. Psychol.*, *49*(2), 123–138. https://doi.org/10.1080/00461520.2014.916216

Smith, N., & Leiserowitz, A. (2014). The Role of Emotion in Global Warming Policy Support and Opposition. *Risk Anal.*, *34*(5), 937–948. https://doi.org/10.1111/risa.12140

Smith, W. R. (1956). Product Differentiation and Market Segmentation as Alternative Marketing Strategies. *J. Mark.*, *21*(1), 3–8. https://doi.org/10.2307/1247695

Stephenson, W. (1986). Protoconcursus: The Concourse Theory of Communication. *Operant Subj.*, *9*(2), 37–58.

Stoutenborough, J. W., & Vedlitz, A. (2014). The Effect of Perceived and Assessed Knowledge of Climate Change on Public Policy Concerns: An Empirical Comparison. *Environ. Sci. Policy*, *37*, 23–33. https://doi.org/10.1016/j.envsci.2013.08.002

Strathman, A., Gleicher, F., Boninger, D. S., & Edwards, C. S. (1994). The Consideration of Future Consequences: Weighing Immediate and Distant Outcomes of Behavior. *J. Pers. Soc. Psychol.*, *66*(4), 742–752. https://doi.org/10.1037/0022-3514.66.4.742

Sunstein, C. R., Bobadilla-Suarez, S., Lazzaro, S. C., & Sharot, T. (2017). How People Update Beliefs about Climate Change: Good News and Bad News. *Cornell Law Rev.*, *102*(6), 1431–1444.

Thompson, M., Ellis, R., & Wildavsky, A. (1990). *Cultural Theory*. Westview Press.

United Nations. (2015). *Paris Agreement* (tech. rep.).

van der Linden, S., Leiserowitz, A. A., Feinberg, G. D., & Maibach, E. W. (2015). The Scientific Consensus on Climate Change as a Gateway Belief: Experimental Evidence. *PLOS ONE*, *10*(2), 1–8. https://doi.org/10.1371/journal.pone.0118489 van der Linden, S. (2017). Determinants and Measurement of Climate Change Risk Perception, Worry, and Concern. In M. C. Nisbet, M. Schafer, S. Markowitz, S. O'Neill, & J. Thaker (Eds.), *The Oxford Encyclopedia of Climate Change Communication. Oxford University Press, Oxford*. Oxford University Press.

van der Linden, S. (in press). The Gateway Belief Model (GBM): A Review and Research Agenda for Communicating the Scientific Consensus on Climate Change. *Curr. Opin. Psychol.* https://doi.org/10.1016/j.copsyc.2021.01.005

van der Linden, S., Leiserowitz, A., & Maibach, E. (2019). The Gateway Belief Model: A Large-Scale Replication. *J. Environ. Psychol.*, *62*, 49–58. https://doi.org/10.1016/j.jenvp.2019.01.009

van der Linden, S., Leiserowitz, A., Rosenthal, S., & Maibach, E. (2017). Inoculating the Public Against Misinformation about Climate Change. *Glob. Chall.*, *1*(2), 1600008. https://doi.org/10.1002/gch2.201600008

Wang, X. (2017). Understanding Climate Change Risk Perceptions in China: Media Use, Personal Experience, and Cultural Worldviews. *Sci. Commun.*, *39*(3), 291–312. https://doi.org/10.1177/1075547017707320

Watts, S., & Stenner, P. (2012). *Doing Q Methodological Research Theory, Method and Interpretation*. SAGE Publications Ltd.

Wolf, J., Brown, K., & Conway, D. (2009). Ecological Citizenship and Climate Change: Perceptions and Practice. *Environ. Polit.*, *18*(4), 503–521. https://doi.org/10.1080/09644010903007377

Yale Program on Climate Change Communication. (2021). Global Warming's Six Americas.

Yu, T.-Y., & Yu, T.-K. (2017). The Moderating Effects of Students' Personality Traits on Pro-Environmental Behavioral Intentions in Response to Climate Change. *Int. J. Environ. Res. Public. Health*, *14*(12), 1–20. https://doi.org/10.3390/ijerph14121472

Zia, A., & Todd, A. M. (2010). Evaluating the Effects of Ideology on Public Understanding of Climate Change Science: How to Improve Communication

Across Ideological Divides? *Public Underst. Sci.*, *19*(6), 743–761.
https://doi.org/10.1177/0963662509357871