Does extreme climate event exposure influence climate-related opinions? The case of the 2019–2020 Australian Black Summer bushfires

Matthew Andreotta[1], Fabio Boschetti[1], Simon Farrell[2], Cécile Paris[3], Iain Walker[4], and Mark J. Hurlstone[5]

[1]Environment, CSIRO, Australia

[2]School of Psychological Science, University of Western Australia, Australia

[3]Data61, CSIRO, Australia

[4]School of Psychological Sciences, University of Melbourne, Australia

[5]Department of Psychology, Lancaster University, UK

Author Note

Matthew Andreotta https://orcid.org/0000-0001-7511-2910

Fabio Boschetti https://orcid.org/0000-0001-8999-6913

Simon Farrell https://orcid.org/0000-0001-7452-8789

Cécile Paris https://orcid.org/0000-0003-3816-0176

Iain Walker https://orcid.org/0000-0002-1020-5873

Mark J. Hurlstone https://orcid.org/0000-0001-9920-6284

Correspondence concerning this article should be addressed to Matthew Andreotta, Environment, CSIRO, 54 Fairway, Crawley, Perth, Western Australia, 6009, Australia. e-mail: matthew.andreotta@csiro.au

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Abstract

Objective: We present the results of a study exploring the impact of Black Summer—the 2019–2020 Australian bushfires—on Australian citizens' climate-related opinions and their perceptions of the causes and impacts of the bushfires. ***Methods:*** Three online surveys examined Australians' opinions on climate change. Study 1 was undertaken before the peak of the bushfires, whereas Studies 2 and 3 were undertaken after the peak. In all surveys, respondents completed a Q-sort task, wherein they sorted a collection of statements about climate change according to their degree of endorsement. Study 3 incorporated an additional measure of bushfire perceptions. ***Results:*** Respondents were divided into different categories of climate-related opinions based on their responses on the Q-sort task. Across the three studies, we find consistent support for a three-segment solution, comprising climate change Acceptors, Fencesitters, and Sceptics. Although the proportion of Acceptors gradually declined over time, the proportion of Fencesitters increased, while Sceptics remained stable. However, overall, there was no reliable change in the segment distribution across studies. Perceptions of the causes and impacts of the bushfires varied across segments. Notably, Acceptors were uncertain whether arson attacks contributed to the bushfires, whereas Fencesitters and Sceptics were more certain than not that arson attacks contributed to the bushfires. ***Conclusions:*** The Black Summer bushfires did not trigger a shift in Australians' climate-related opinions towards greater acceptance and concern. Worryingly, misinformation from conservative media outlets attributing the bushfires to arson attacks may have influenced Australians' opinions about the causes of the bushfires, particularly amongst those undecided or sceptical about anthropogenic climate change.

Keywords: black summer bushfires · climate change · climate opinion · personal experience · extreme events

Does extreme climate event exposure influence climate-related opinions? The case of the 2019–2020 Australian Black Summer bushfires

In October 2019, lightning ignited the largest fire in Australia's recent history (Rural Fire Service, 2020). The 'megafire', so-called for its intensity, size, and difficulty to control, endured for fifteen weeks burning 512,000 hectares of land, including the Blue Mountains World Heritage Area (Rural Fire Service, 2020). Accompanying the megafire were bushfires in all Australian states and territories throughout the unprecedented (Boer et al., 2020) 2019-2020 bushfire season, which became known as the Black Summer. Together, these fires directly killed at least 33 people, burnt over 24 million hectares, destroyed over 3,000 homes, killed or displaced nearly three billion animals, and affected nearly 80% of Australians either directly or indirectly (Hughes et al., 2020; The Royal Commission into National Natural Disaster Arrangements, 2020). On a local scale, fires trapped thousands of Australians without essential goods and services (The Royal Commission into National Natural Disaster Arrangements, 2020). On a national and international scale, fires transformed the usually festive season into one of grief and vigilance (Head, 2020).

Given the extended time scale over which the bushfires raged, the harrowing and sustained media reporting of the devastation caused, and the large proportion of Australians affected by the events, a natural question to ask is whether this Black Summer crisis altered Australians' climate-related opinions. More generally, Black Summer presents an opportunity to examine how extreme events of this magnitude may shape public opinions about climate change. In this article, we address this question by presenting three studies comparing Australians' climate-related opinions before and after the peak of the Black Summer bushfires.

Effects of extreme climate events on climate-related opinion

There are several theoretical and empirical grounds for expecting that extreme climate events, such as megafires, may prompt a change in people's climate-related opinions. First, an often-cited barrier to climate change concern and action is psychological

distance (McDonald et al., 2015; Spence et al., 2012; van der Linden et al., 2015). It is frequently assumed that many people are unconcerned about climate change because they are uncertain about whether it is happening (hypothetical distance) and think that, if it is happening, it will affect other people (social distance), in other places (spatial distance), in the distant future (temporal distance; for critiques of this idea, see van Valkengoed et al., 2023; Wang et al., 2021). Thus, personal experience of extreme climate events may reduce the psychological distance of climate change and increase concern about the issue and willingness to act. Second, although belief in anthropogenic climate change is generally high amongst the public, there are indications that the issue is not as salient as other problems (Crawley et al., 2022). Personal experience of extreme climate events may trigger community discussions that place the issue "top-of-mind" in the public's consciousness (Boudet et al., 2020; Demski et al., 2017), making the problem more salient and increasing support for relevant policies (Bromley-Trujillo & Poe, 2020). Third, the personal experience of extreme climate events makes the abstract risks of climate change concrete and may provoke negative affective responses that could increase people's willingness to mitigate the problem (Bergquist et al., 2019; Marx et al., 2007; E. U. Weber, 2006). Indeed, it is well-established that the experience of negative affect associated with climate change is a key predictor of climate risk perceptions and policy support (Leiserowitz, 2006; van der Linden, 2014, 2015).

Over the past decade or so, a burgeoning literature has sought to establish whether personal experience of extreme climate events influences climate-related opinion (for reviews, see Howe, 2021; Howe et al., 2019; Reser & Bradley, 2020; Reser et al., 2014; Sambrook et al., 2021; Sisco, 2021). The results of this literature have been somewhat mixed. On the one hand, and consistent with the precedents just reviewed, several studies have shown that self reported or objectively recorded personal experience of extreme climate events, including drought (Carmichael & Brulle, 2017), flooding (Demski et al., 2017; Ogunbode et al., 2020; Osberghaus & Demski, 2019; Spence et al., 2011; Taylor et al.,

2014), heatwaves (Dai et al., 2015), storms (Bergquist et al., 2019; Lang & Ryder, 2016), and, notably, forest fires (Lacroix et al., 2020; Zanocco et al., 2018), increases belief in and concern about climate change. For example, Spence et al. (2011) found that UK households who reported experience of flooding were more concerned about climate change, perceived it as less uncertain, and felt more confident that their actions would make a difference, compared to households that did not experience flooding. On the other hand, other studies have failed to document an association between climate-related opinion measures and personal experience of climate extremes (Cutler et al., 2020; Shao & Hao, 2020), drought (Carlton et al., 2016), flooding (Albright & Crow, 2019; Whitmarsh, 2008), storms (Lyons et al., 2018), and multiple disasters including a bushfire, cyclone, and drought (Boon, 2016). A recent meta-analysis using data from 302 studies found that personal experience of climate events only has a weak positive association with climate change awareness, with effect sizes varying considerably across different climate events (Xia et al., 2022).

There are several known moderators of the effect of extreme climate events on climate-related opinions (see e.g., Sambrook et al., 2021; Sisco, 2021), two of which are especially relevant for the work we present here. First, it has been proposed that a necessary pre-condition for exposure to an extreme event to affect broader climate-related opinions may be whether an individual causally attributes that event to climate change (E. U. Weber, 2010). Empirical support for this proposition has been provided in numerous studies (McCright et al., 2014; Ogunbode et al., 2019, 2020; Wong-Parodi & Rubin, 2022). For example, Ogunbode et al. (2019) find that personal experience of flooding only predicted climate risk perceptions for individuals who attributed the flooding to climate change.

Second, extreme climate events can serve as "focusing events" (Birkland & Schwaeble, 2019) that attract increased media attention (Kirilenko et al., 2015; Marquart-Pyatt et al., 2014; Sisco et al., 2017), providing opportunities to highlight the links between such events and ongoing climate change for the public. Indeed, media

attention to climate change has been shown to influence climate change attitudes (Carmichael et al., 2017) and increase public conversations about the issue (King et al., 2017). However, the effect of media attention may depend on the frequency and prominence of media coverage, whether or not the extreme event is causally attributed to climate change, and the existence of competing narratives or misinformation dismissing the climate change and extreme event connection.

Divergent mass media and social media bushfire narratives

Mocatta and Hawley (2020) chartered the content and evolution of media coverage of Black Summer, which focused predominantly on the causes of the fires and what or who was to blame. Scientists had been quick to confirm that the scale and severity of the fires was unprecedented (Shine, 2020) and had been worsened by climate change (Gourlay et al., 2020). Accordingly, much mass media coverage initially attributed the cause of the fires to climate change and presented apocalyptic images and descriptions of the devastation caused. However, as the fires intensified, mass-media reporting of their causes quickly diverged along ideological lines. Public broadcasters and liberal media outlets continued to emphasise the climate change and bushfire connection, whereas conservative media outlets sought to downplay the severity of the fires and cast doubt on the link with climate change. A key argumentation strategy in the conservative media at this time was the claim that the fires were "nothing new" and in keeping with historic bushfires in terms of their severity (Johnstone, 2019). Additionally, some conservative media argued that Black Summer was worsened by to "Greens policies" that prevented firefighters from reducing fuel loads (G. Brown & Caisley, 2019), despite the Greens' platform overt support for hazard reduction (Australian Greens, 2020).

Coinciding with the emergence of these narratives in the conservative mass media, misinformation began to ferment on the social media platform formally known as Twitter (now X) in Australia and internationally. Under the hashtag #ArsonEmergency, false claims began to circulate that the bushfires were caused by arson, that preventative

backburning efforts had been reduced due to green activism, that Australia commonly experienced such bushfires, and that climate change is unrelated to the bushfires (D. Weber et al., 2020, 2022). Social media researchers agree that the activities were likely a deliberate disinformation campaign (Keller et al., 2020; D. Weber et al., 2020).

Online misinformation spread under the #ArsonEmergency hashtag, notably the claim that arsonists were a major cause of the fires, subsequently infected conservative mass-media reporting of the bushfires. A prominent example was an article published in The Australian under the title "Bushfires: firebugs fuelling crisis as national arson toll hits 183" claiming that "more than 180 alleged arson cases have been recorded since the start of the bushfire season" (Ross & Reid, 2020). The article played a prominent role in fuelling online climate change denial narratives and shared by prominent conservatives, such as by Donald Trump Jr. to his audience of four million followers on Twitter, thus propelling the misinformation to a much larger online audience. The arson claims were grossly exaggerated (NSW Bushfire Inquiry, 2020), calculated based on a range of fire-related offences other than arson, and relied on annual figures rather than the Black Summer bushfire season (Council, 2021).

In summary, media coverage of the Black Summer bushfires focused predominantly on the causes of the fires and was characterised by a power struggle between two competing narratives. One narrative emphasised a relationship between climate change and bushfires, supported by scientists' assessments of the bushfires (Boer et al., 2020; van Oldenborgh et al., 2021). The other narrative refuted the connection between climate change and the bushfires, partly by drawing upon misinformed exaggerations of arson. This polarised and divisive mass media and social media landscape could have persuaded those undecided about climate change to become more accepting or sceptical about the issue. Thus, whether the Black Summer bushfires and accompanying media narratives altered the climate-related opinions of those undecided about climate change is an open empirical question.

Current research

In what follows, we report the results of three audience segmentation studies of Australian climate-related opinions. The studies were undertaken to identify distinct sub-groups of the Australian population that harbour unique views about climate change. The studies employed the Q-methodology (S. R. Brown, 1982; Stephenson, 1986), wherein participants completed a Q-sort task which required them to rank-order a series of statements about climate change, derived from a large-scale analysis of Australian Twitter climate commentary Andreotta et al., 2019, 2022, according to how similar they are to their point of view. Participants' rank-orderings of the statements were then subjected to a Q-factor analysis to identify unique audience segments of climate-related opinion.

In Study 1 (September, 2019), which took place before the peak of the Black Summer bushfires, participants completed the Q-sort task along with a battery of measures of prominent psychological characteristics to help facilitate interpretation of the different audience segments. We found evidence for a three-segment solution comprising Acceptors, Fencesitters, and Sceptics—ordered from the highest to the lowest belief in anthropogenic climate change, trust in climate science, concern about the issue, and motivation to tackle it. Segments also differed in their climate change concern and scepticism, mental models of climate change, political ideology, and worldviews, as assessed using the auxiliary psychological characteristic measures. In Study 2 (February, 2020), which took place after the peak of the bushfires, participants completed the Q-sort task followed by a series of belief-updating tasks to determine whether segments differed in their receptivity to climate science information. We replicated the three-segment solution of Study 1 and found considerable heterogeneity in the belief-updating tendencies of the three segments. Acceptors updated their beliefs towards the scientific estimates the most, closely followed by Fencesitters, whereas Sceptics did not update their beliefs at all.

These two studies were part of a planned program of research that predated the bushfires but happened to coincide with their occurrence, affording us a natural

experiment, so to speak, to determine whether the bushfires catalysed a change in Australian climate-related opinions. The results of these two studies have been reported elsewhere (Andreotta et al., 2022), but have not yet been systematically compared to determine whether the occurrence of the bushfires influenced Australian climate-related opinions. In the current paper, we undertake this comparison, and we report the results of a third study conducted one month after our second study, near the end of Black Summer. In Study 3 (March, 2020), participants completed the Q-sort task and the same battery of psychological characteristic measures used in Study 1. Additionally, participants completed a measure of bushfire perceptions assessing their endorsement of various media and political claims about the bushfires (e.g., that climate change worsened the bushfires, that the bushfires were severe, that arsonists contributed to the occurrence of the bushfires), and a measure of the degree to which the bushfires warranted a change in Australia's climate policy.

Using data obtained from the three studies, we first confirmed that the three-segment solution and the pattern of psychological characteristic differences between segments reported by Andreotta et al. (2022) generalised to Study 3. Next, we explored whether climate change opinion varied in response to the Black Summer bushfires, by testing for between-study differences in the proportion of respondents assigned to each segment (Studies 1, 2, & 3) and in climate change cognition and affect (Study 1 vs. Study 3). Finally, to better understand any observed shifts or stability in climate-related opinion, we analysed segment-specific perceptions of—and preferred policy responses to—the Black Summer bushfires (Study 3).

Method

Data and analysis scripts for this research are available online at https://github.com/matt-lab/bushfire-audience-segmentation. This research was approved by the Human Research Ethics Committees of the University of Western Australia (reference: 2019/RA/4/20/5104) and the Commonwealth Scientific and Industrial

Table 1
Sample characteristics and materials for each of the three studies.

	Study		
Characteristics	1	2	3
Time	Before peak bushfire severity	After peak bushfire severity	After peak bushfire severity
Data collection dates			
Start	24-Sep-2019	25-Feb-2020	13-Mar-2020
End	09-Nov-2019	02-Mar-2020	26-Mar-2020
Sample characteristics			
n	435	413	213
Mean age in years (*SD*)	46.71 (17.77)	46.82 (18.04)	47.13 (17.29)
Number of women in sample (%)	213 (48.97%)	206 (49.88%)	107 (50.23%)
Materials			
Q-sort task	✔	✔	✔
Auxiliary psychological scales	✔	✖	✔
Fire Perception Scale	✖	✖	✔
Change in policy items	✖	✖	✔

Research Organisation (reference: 026/19).

Participants

Table 1 provides an overview of the key characteristics of the study samples and the materials they completed. Data were collected at three time periods. Study 1 was conducted in September ($n = 387$, 88.97% of Study 1 participants), October ($n = 42$, 9.66% of Study 1 participants), and November ($n = 6$, 1.38% of Study 1 participants) of 2019, prior to the peak of the Black Summer bushfires. Study 2 was conducted in February ($n = 403$, 97.58% of Study 2 participants) and March ($n = 10$, 2.42% of Study 2 participants) of 2020, after the peak of the bushfires. Study 3 was conducted in March 2020 ($n = 213$), approaching the end of the Black Summer bushfires.

In total, 1,061 Australian adults participated in the studies. Participants were recruited using Qualtrics' (Provo, UT) online research panel service using a targeted and stratified sampling approach to match the age and gender distribution of the general population (as per the national 2016 census). We excluded extremely fast responders who

were identified using a preregistered threshold (see Supplementary Materials).

Materials

Q-sort task

To segment participants into climate change audiences, we used the Q-sort task. Participants ranked a pool of 30 statements about climate change, such as "it is important to vote for leaders who will combat climate change" and "scientists should stop falsely claiming that climate change is a settled science", based on how closely they aligned with their own point of view. The statements were selected to reflect the breadth of the Australian climate change discourse on social media (Andreotta et al., 2022).

To encourage reflection, participants began the Q-sort by reading each statement and determining if it was: (1) like their point of view; (2) unlike their point of view; or (3) neutral or unsure. Next, participants ranked each statement according to how closely it matched their point of view, assigning a rank from -4 (most unlike their point of view) to +4 (most like their point of view). The distribution of possible ranks is forced and non-uniform, such that participants must consider the few statements to place at the extremes (see Figure 1). This encourages participants to carefully reflect on their views while completing the task (S. R. Brown, 1982; Stephenson, 1986).

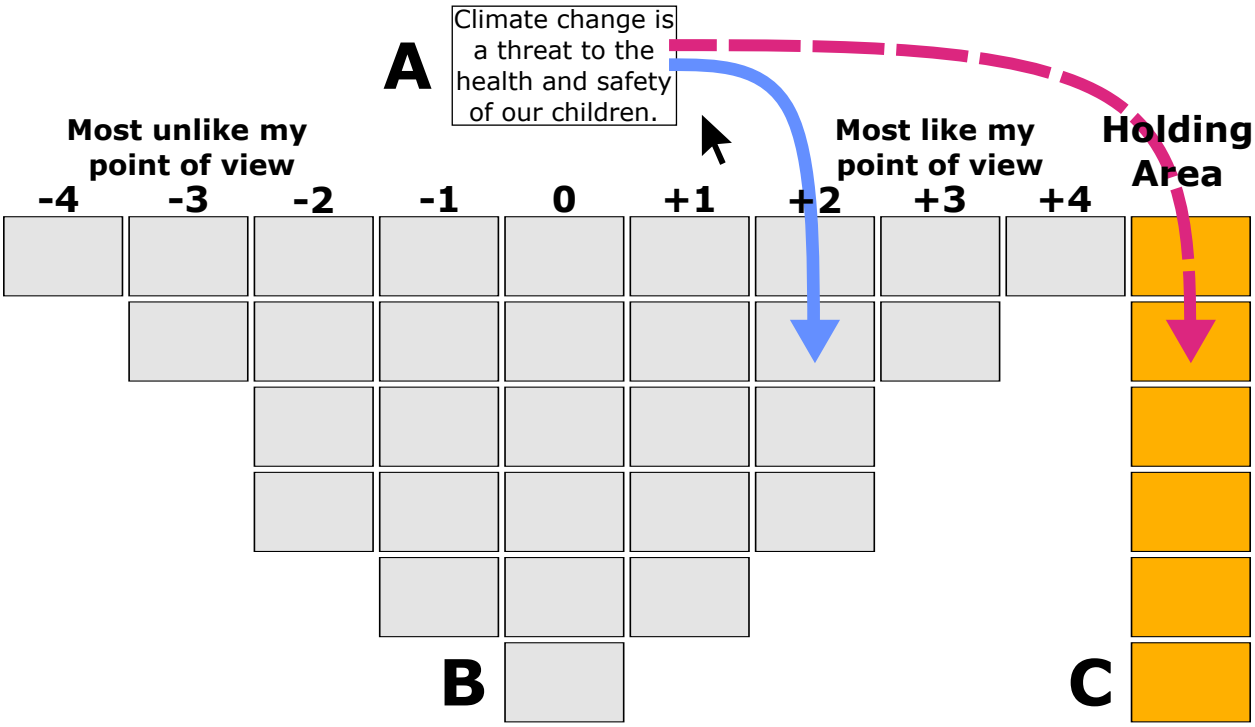
After completing the task, participants were asked to justify their placement of statements assigned extreme ranks.

Auxiliary psychological scales

A battery of 28 auxiliary psychological characteristic measures was assembled (Table 2). Among these, the most relevant to the current research were state-based psychological scales of climate change cognition and affect. Specifically, we measured general belief in anthropogenic climate change, with scales concerning epistemic scepticism (doubt about anthropogenic climate change), response scepticism (doubt about the effectiveness of climate change mitigation), perceived human contribution (belief that humans have altered the global climate), knowledge volume (self-perceived confidence in climate change

Figure 1

Schematic of the Q-sort task. Participants read through a stack of statements (A) by dragging the top-most statement into the grey box that best corresponded to their point of view (B). As the majority of statements had to be placed around the midpoint, participants could only highlight a few statements that strongly reflect their point of view. Participants could re-arrange statements at any time during the task. To facilitate this process, participants could temporarily place statements in the yellow holding area (C). Figure reproduced without changes from Andreotta et al. (2022), under the Creative Commons license (CC BY 4.0).



knowledge), and worry about climate change. Additionally, we included higher-resolution inventories to quantify participants mental models of specific climate change causes, climate change consequences, and effectiveness of climate change mitigation policies.

Other psychological scales pertained to trait-based concepts found to be associated with climate change belief. This includes inventories of: cognitive styles; ideology, worldviews, and values; and personality.

Table 2

Summary of auxiliary psychological measures.

Psychological characteristic	Items	Cronbach's α	Range	Example item	Reference
Climate change cognition and affect					
Knowledge Volume	1	-	1 to 4	How much do you feel you know about climate change?	Malka et al. (2009)
Perceptions of Carbon Emission Causes	7	0.92	1 to 7	Please indicate to what extent each of the following is a cause of climate change, to the best of your knowledge: people driving their cars	Andreotta et al. (2022)
Perceptions of Environmental Harm Causes	4	0.87	1 to 7	Please indicate to what extent each of the following is a cause of climate change, to the best of your knowledge: air pollution from toxic chemicals	Andreotta et al. (2022)
Perceptions of Natural Causes	2	0.79	1 to 7	Please indicate to what extent each of the following is a cause of climate change, to the best of your knowledge: volcanic eruptions	Andreotta et al. (2022)
Perceived Personal Consequences	3	0.87	1 to 7	Please rate for each of the following how likely it is as a consequence of climate change by the year 2050: food shortages where you live	Bostrom et al. (2012)
Perceived Societal Consequences	8	0.96	1 to 7	Please rate for each of the following how likely it is as a consequence of climate change by the year 2050: food shortages in many parts of the world	Bostrom et al. (2012)
Perceived Human Contribution	1	-	1 to 7	How likely do you think it is that human actions have changed global climate?	Bostrom et al. (2012)
Perceived Effectiveness of Carbon Policies	3	0.75	1 to 7	Please rate for each step what effect you think it would have on climate change: requiring cars and trucks to have higher fuel efficiency (1 = Reduce or Stop Climate Change, 4 = Neither Reduce nor Increase, 7 = Increase Climate Change)	Bostrom et al. (2012)

(continued)

Psychological characteristic	Items	Cronbach's α	Range	Example item	Reference
Perceived Effectiveness of Engineering Policies	3	0.42	1 to 7	Please rate for each step what effect you think it would have on climate change: putting more dust in the atmosphere (1 = Reduce or Stop Climate Change, 4 = Neither Reduce nor Increase, 7 = Increase Climate Change)	Bostrom et al. (2012)
Perceived Effectiveness of Green Policies	5	0.91	1 to 7	Please rate for each step what effect you think it would have on climate change: planting trees (1 = Reduce or Stop Climate Change, 4 = Neither Reduce nor Increase, 7 = Increase Climate Change)	Bostrom et al. (2012)
Epistemic Scepticism	8	0.91	1 to 5	Climate change is just a natural fluctuation in Earth's temperatures	Capstick and Pidgeon (2014)
Response Scepticism	7	0.89	1 to 5	There is no point in me doing anything about climate change because no-one else is	Capstick and Pidgeon (2014)
Worry about Climate Change	1	-	1 to 4	How strongly do you feel worry when you think about the issue of climate change?	Smith and Leiserowitz (2014)
Cognitive style					
Orientation to Future Goals	4	0.72	1 to 5	I consider how things might be in the future	Enzler (2015)
Orientation to Immediate Goals	5	0.86	1 to 5	I mainly act to satisfy my immediate concerns, figuring the future will take care of itself	Enzler (2015)
Conspiracist Ideation	6	0.90	1 to 5	The Apollo moon landings never happened and were staged in a Hollywood film studio	Lewandowsky et al. (2013)
Need for Cognition	6	0.79	1 to 5	I would prefer complex to simple problems	Lins de Holanda Coelho et al. (2018)
Ideology, worldviews, and values					
Environment-as-Ductile Worldview	6	0.81	1 to 5	If the balance of the natural environment is upset the whole system will collapse	Price et al. (2014)
Environment-as-Elastic Worldview	6	0.85	1 to 5	The natural environment is capable of recovering from any damage humans may cause	Price et al. (2014)

(continued)

Psychological characteristic	Items	Cronbach's α	Range	Example item	Reference
Political Ideology	1	-	1 to 7	Please indicate the extent to which you identify yourself as politically left-wing or right-wing (1 = Very Left-Wing, 7 = Very Right-Wing)	-
System Justification	8	0.85	1 to 9	Everyone has a fair shot at wealth and happiness	Kay and Jost (2003)
Conservation Values	10	0.32	-2.94 to 5.54	Please, rate the importance of the following values as a life-guiding principle for you: CONFORMITY (obedience, honouring parents and elders, self-discipline, politeness)	Lindeman and Verkasalo (2005)
Self-Transcendence Values	10	0.55	-4.84 to 2.52	Please, rate the importance of the following values as a life-guiding principle for you: BENEVOLENCE (helpfulness, honesty, forgiveness, loyalty, responsibility)	Lindeman and Verkasalo (2005)
Personality					
Agreeableness	2	0.27	1 to 5	I see myself as someone who is generally trusting	Rammstedt and John (2007)
Conscientiousness	2	0.53	1 to 5	I see myself as someone who does a thorough job	Rammstedt and John (2007)
Extraversion	2	0.53	1 to 5	I see myself as someone who is outgoing, sociable	Rammstedt and John (2007)
Neuroticism	2	0.62	1 to 5	I see myself as someone who gets nervous easily	Rammstedt and John (2007)
Openness	2	0.14	1 to 5	I see myself as someone who has an active imagination	Rammstedt and John (2007)

Note:
Conservation and Self-Transcendence Value scores were a weighted average of ten items (rated along a nine-point scale). Table reproduced with updated Cronbach's α from Andreotta et al. (2022), under the Creative Commons license (CC BY 4.0).

Fire Perception Scale

To measure perceptions of the Black Summer bushfires, we developed the Fire Perception Scale, consisting of seven items derived from prominent media reports and political statements on the role of climate change in Black Summer. Items included "climate change made the 2019-20 Australian bushfires more severe" and "over one hundred arsonists have contributed to the 2019-20 Australian bushfires". Participants rated their agreement with each statement on a five-point Likert scale: (1) disagree, (2) slightly disagree, (3) neither agree nor disagree, (4) slightly agree, and (5) agree.

Policy direction preferences

To measure participants views on the policy consequences of the Black Summer bushfires, participants responded to two items. First, participants were asked: "Do the 2019-20 Australian bushfires justify a change in Australia's climate change policy?". Participants could respond with one of four options: (1) "yes, the Australian government should be taking further action to mitigate climate change"; (2) "no, the Australian government should not modify the current climate change policy"; (3) "yes, the Australian government should be taking less action to mitigate climate change"; and (4) "yes, the Australian government should be taking no action at all to mitigate climate change". Next, participants were asked to justify their response ("Why?") through writing an open-ended response.

Procedure

All studies were executed as online surveys using Qualtrics (Provo, UT). To begin, participants read an information sheet, provided informed consent, and supplied basic demographic information. The procedure subsequently varied across studies (summarised in Table 1). In Study 1, participants completed the Q-sort task followed by the auxiliary psychological scales. In Study 2, participants completed the Q-sort task followed by a belief-updating task unrelated to the current research. In Study 3, participants completed all materials: the Q-sort task, auxiliary psychological scales, the Fire Perception Scale, and

policy direction preferences items. To control for potential order effects, the presentation sequence of materials was counterbalanced across participants (see Supplementary Materials).

Sample size justification

Sample sizes and the statistical power of our analyses were determined by practical constraints (Lakens, 2022). Studies 1 and 2 were undertaken prior to the current research, with their sample sizes being chosen based on their original objectives (Andreotta et al., 2022). The sample size of Study 3 was constrained by financial resources and the need for rapid data collection following the bushfires. To determine the power of tests to detect study differences in climate change audience segments, cognition, and affect, we conducted a sensitivity power analysis with the G*Power program (Faul et al., 2007, 2009). We found our analyses had sufficient power ($\geq .80$) to detect the expected small effects of study differences in audience segment membership (for effect sizes of Cohen's $\omega \geq 0.106$ for a likelihood-ratio χ^2 test) and climate change cognition and affect measures (for effect sizes of Cohen's $d \geq 0.235$ for t tests of mean differences).

Results

The results are structured into three sections. First, we assess whether the three-segment solution and the pattern of psychological characteristic differences between segments documented in our original analysis of Studies 1 and 2 (Andreotta et al., 2022) generalise to Study 3. Next, we examine whether the proportion of respondents in each segment (Studies 1, 2, & 3) and their responses on the climate change cognition and affect measures (Studies 1 & 3) changed over time. Finally, we investigate segment differences in bushfire perceptions and policy preferences (Study 3). All analyses were completed with the *R* programming language (R Core Team, 2023).

Replication of the three-segment solution

As per our previous research, we used the Q-methodology to identify distinct views on climate change (S. R. Brown, 1982). The Q-methodology transposes traditional dimension reduction techniques, to reduce the dimensions of *people* rather than *items*. For each study, we used principal components analysis with varimax rotation to group individuals with similar Q-sort ranks. We extracted a single factor, as the second

component accounted for only a minor amount of variance in each study. The extracted factor represented a dimension of anthropogenic climate change acceptance. Based on factor loadings, we divided individuals into one of three segments: (1) *Acceptors* ($n = 653$, 61.55%), whose positive factor loading was statistically significant from zero ($p < .05$); (2) *Sceptics* ($n = 97$, 9.14%), whose negative factor loading was statistically significant from zero ($p < .05$); and (3) *Fencesitters* ($n = 311$, 29.31%), whose factor loading was not statistically significant from zero ($p \geq .05$).

Although the number of segments was consistent across studies, the nature of segments may vary. To explore this possibility, we constructed an average Q-sort for Acceptors and Sceptics in each study (S. R. Brown, 1982). The ranks assigned to each statement were averaged (weighted by participants' factor loading). These averages were then ranked to align with the Q-sort structure, generating a set of values known as factor scores. For example, the statement with the lowest average corresponded to a factor score of -4 and the statement with the highest average corresponded to a factor score of +4 (see Supplementary Material for all factor scores). We did not build a representative Q-sort for Fencesitters as the sorting behaviour of this segment is more heterogenous than the other two segments (otherwise Fencesitters would have emerged as a separate factor). In all three studies, the greatest factor score for Acceptors corresponded to the statement "It is important to vote for leaders who will combat climate change", whereas the greatest factor score for Sceptics corresponded to the statement "Scientists should stop falsely claiming that climate change is a settled science."

We found minimal differences in each segment's factor scores across studies. Acceptor factor ranks from the three studies were strongly correlated (all Spearman's ρ correlations $> .95$, all p's $< .001$). Likewise, Sceptic factor ranks across studies were strongly correlated (all Spearman's ρ correlations $> .94$, all p's $< .001$). Consistently across studies, Acceptors and Sceptics held divergent views (all Spearman's ρ correlations $< -.81$, all p's $< .001$). In sum, the number and nature of segments' climate change views were

consistent across time.

We also explored whether segments were distinguished by a consistent pattern of psychological characteristics by replicating the regression analysis of Andreotta et al. (2022). This analysis was complicated by multicollinearity, which can lead to unstable estimates of coefficients in traditional regression approaches. Instead, we sought to produce stable estimates with a ridge regression model. A ridge regression reduces the variance of estimates, caused by multicollinearity, by shrinking the coefficients towards zero (a bias-variance tradeoff; James et al., 2021). With the *glmnet* package (Friedman et al., 2010), we fitted a multinomial logistic ridge regression model to predict segment membership as a function of psychological characteristics for Study 1 and Study 3. The degree of shrinkage, controlled by a hyperparameter λ, was chosen by a cross-validation process (k-fold) that minimised multinomial deviance. Prior to analysis, we converted responses to z scores for each predictor in each study. Confidence intervals were estimated by repeating the modelling procedure via bootstrapping with 10,000 samples (sampled with replacement; Efron & Tibshirani, 1994).

The ridge regression model demonstrated good fit for both Study 1 (83.22% accuracy, accounting for 49.07% of null deviance) and Study 3 (88.26% accuracy, accounting for 66.39% of null deviance). As seen in Table 3, the models' coefficients were generally consistent (same sign) across studies, indicating a robust association between psychological characteristics and segment membership. Regarding climate change cognition and affect, Acceptors and Sceptics were distinguished by opposing patterns of climate change scepticism and belief in anthropogenic climate change. In contrast, the Fencesitters of Study 3 were characterised by response scepticism and perceptions that carbon-emitting activities cause climate change. Turning to cognitive styles, conspiracist ideation was positively associated with Fencesitter membership, and negatively associated with Acceptor membership (both studies), whereas Sceptics were characterised by a reduced orientation towards future consequences (Study 3). Generally, Acceptors and Sceptics were

distinguished by opposing patterns of ideologies, worldviews, and values. Lastly, personality tended not to be a robust predictor of segment membership, although evidence from Study 3 indicated that Fencesitters were characterised by greater extraversion and conscientiousness, whereas Sceptics were characterised by greater introversion.

Table 3

Effect of psychological characteristics on segment membership, as estimated by a multinomial logistic ridge regression for Studies 1 and 3.

	Acceptors		Fencesitters		Sceptics	
Predictors	Study 1	Study 3	Study 1	Study 3	Study 1	Study 3
Intercept						
	+1.64^	**+1.66^**	**+0.56^**	**+1.03^**	**-2.20^**	**-2.69^**
	[1.64, 2.18]	**[1.44, 2.09]**	**[0.44, 0.99]**	**[0.71, 1.32]**	**[-3.06, -2.19]**	**[-3.22, -2.36]**
Climate change cognition and affect						
Epistemic Scepticism	**-0.33^**	**-0.46^**	+0.11	+0.13	**+0.23^**	**+0.33^**
	[-0.59, -0.26]	**[-0.72, -0.25]**	[-0.05, 0.30]	[-0.08, 0.39]	**[0.16, 0.43]**	**[0.19, 0.46]**
Worry about Climate Change	**+0.31^**	+0.13	-0.06	+0.10	**-0.25^**	**-0.23^**
	[0.23, 0.60]	[-0.09, 0.38]	[-0.25, 0.11]	[-0.12, 0.36]	**[-0.50, -0.19]**	**[-0.44, -0.07]**
Response Scepticism	**-0.29^**	**-0.55^**	+0.08	**+0.34^**	**+0.21^**	**+0.21^**
	[-0.55, -0.19]	**[-0.75, -0.37]**	[-0.09, 0.28]	**[0.14, 0.56]**	**[0.15, 0.40]**	**[0.09, 0.35]**
Perceived Human Contribution	**+0.20^**	**+0.27^**	+0.12	-0.06	**-0.32^**	**-0.22^**
	[0.08, 0.41]	**[0.12, 0.51]**	[-0.02, 0.35]	[-0.29, 0.16]	**[-0.59, -0.23]**	**[-0.42, -0.07]**
Perceived Societal Consequences	**+0.19^**	+0.11	-0.09	+0.06	-0.10	**-0.16^**
	[0.06, 0.39]	[-0.08, 0.38]	[-0.30, 0.05]	[-0.21, 0.25]	[-0.23, 0.04]	**[-0.33, -0.02]**
Perceptions of Environmental Harm Causes	+0.08	+0.04	+0.08	+0.19	**-0.16^**	**-0.22^**
	[-0.09, 0.26]	[-0.18, 0.24]	[-0.08, 0.28]	[0.00, 0.43]	**[-0.32, -0.05]**	**[-0.37, -0.10]**
Knowledge Volume	-0.10	-0.05	-0.06	-0.01	**+0.15^**	+0.06
	[-0.34, 0.01]	[-0.25, 0.13]	[-0.24, 0.10]	[-0.22, 0.19]	**[0.04, 0.43]**	[-0.11, 0.26]
Perceptions of Carbon Emission Causes	**+0.15^**	+0.15	+0.04	**+0.29^**	**-0.19^**	**-0.44^**
	[0.00, 0.35]	[-0.02, 0.32]	[-0.11, 0.23]	**[0.09, 0.49]**	**[-0.36, -0.11]**	**[-0.59, -0.29]**
Perceived Effectiveness of Engineering Policies	**-0.13^**	+0.09	**+0.14^**	-0.10	-0.01	+0.01
	[-0.36, -0.01]	[-0.11, 0.31]	**[0.01, 0.36]**	[-0.31, 0.11]	[-0.14, 0.15]	[-0.15, 0.16]
Perceived Personal Consequences	+0.12	+0.12	-0.02	-0.09	-0.10	-0.03
	[-0.03, 0.30]	[-0.09, 0.36]	[-0.19, 0.14]	[-0.31, 0.15]	[-0.23, 0.02]	[-0.21, 0.11]
Perceived Effectiveness of Carbon Policies	+0.11	-0.13	-0.03	+0.17	-0.08	-0.03
	[-0.03, 0.35]	[-0.34, 0.09]	[-0.23, 0.15]	[-0.07, 0.36]	[-0.27, 0.02]	[-0.16, 0.13]
Perceived Effectiveness of Green Policies	+0.10	-0.04	-0.04	+0.10	-0.06	-0.06
	[-0.02, 0.30]	[-0.24, 0.17]	[-0.20, 0.14]	[-0.12, 0.31]	[-0.27, 0.05]	[-0.20, 0.08]
Perceptions of Natural Causes	-0.08	-0.15	+0.05	+0.10	+0.02	+0.05
	[-0.26, 0.08]	[-0.40, 0.05]	[-0.10, 0.24]	[-0.12, 0.36]	[-0.15, 0.20]	[-0.16, 0.25]
Cognitive style						
Orientation to Future Goals	+0.05	+0.21	+0.06	+0.10	-0.11	**-0.31^**
	[-0.11, 0.25]	[0.00, 0.38]	[-0.10, 0.26]	[-0.09, 0.30]	[-0.33, 0.04]	**[-0.47, -0.11]**
Conspiracist Ideation	**-0.15^**	**-0.49^**	**+0.15^**	**+0.33^**	+0.00	+0.16
	[-0.36, -0.02]	**[-0.70, -0.32]**	**[0.02, 0.36]**	**[0.15, 0.55]**	[-0.18, 0.17]	[-0.02, 0.34]
Need for Cognition	-0.12	-0.07	+0.01	-0.02	+0.10	+0.09
	[-0.32, 0.01]	[-0.25, 0.15]	[-0.15, 0.18]	[-0.23, 0.19]	[-0.03, 0.31]	[-0.12, 0.27]
Orientation to Immediate Goals	+0.02	-0.16	0.00	+0.15	-0.02	+0.02
	[-0.12, 0.25]	[-0.42, 0.00]	[-0.20, 0.17]	[-0.04, 0.41]	[-0.21, 0.10]	[-0.18, 0.21]

(continued)

	Acceptors		Fencesitters		Sceptics	
Predictors	Study 1	Study 3	Study 1	Study 3	Study 1	Study 3
Ideology, worldviews, and values						
Environment-as-Ductile Worldview	+0.18 [-0.01, 0.44]	**+0.40^ [0.23, 0.62]**	-0.11 [-0.36, 0.05]	**-0.21^ [-0.43, -0.01]**	-0.07 [-0.21, 0.10]	**-0.19^ [-0.36, -0.04]**
Conservation Values	-0.11 [-0.32, 0.02]	**-0.26^ [-0.46, -0.06]**	+0.01 [-0.17, 0.18]	-0.02 [-0.22, 0.22]	+0.11 [-0.05, 0.32]	**+0.27^ [0.06, 0.45]**
Environment-as-Elastic Worldview	**-0.20^ [-0.43, -0.05]**	**-0.37^ [-0.58, -0.20]**	+0.05 [-0.15, 0.23]	+0.07 [-0.12, 0.33]	**+0.15^ [0.03, 0.38]**	**+0.30^ [0.12, 0.46]**
System Justification	+0.04 [-0.12, 0.25]	**+0.20^ [0.04, 0.39]**	+0.06 [-0.12, 0.23]	**-0.23^ [-0.44, -0.04]**	-0.09 [-0.30, 0.07]	+0.03 [-0.16, 0.22]
Self-Transcendence Values	+0.04 [-0.10, 0.21]	+0.17 [-0.04, 0.36]	-0.10 [-0.28, 0.05]	+0.02 [-0.20, 0.21]	+0.06 [-0.12, 0.24]	**-0.19^ [-0.33, 0.00]**
Political Ideology	**-0.18^ [-0.41, -0.04]**	-0.10 [-0.35, 0.12]	+0.03 [-0.17, 0.19]	-0.16 [-0.38, 0.06]	**+0.16^ [0.02, 0.40]**	**+0.26^ [0.09, 0.47]**
Personality						
Extraversion	-0.01 [-0.15, 0.14]	+0.03 [-0.21, 0.22]	+0.03 [-0.11, 0.19]	**+0.23^ [0.04, 0.45]**	-0.02 [-0.18, 0.11]	**-0.26^ [-0.43, -0.07]**
Conscientiousness	+0.03 [-0.09, 0.20]	-0.14 [-0.33, 0.01]	-0.06 [-0.21, 0.09]	**+0.19^ [0.01, 0.39]**	+0.03 [-0.15, 0.16]	-0.05 [-0.19, 0.11]
Neuroticism	+0.11 [-0.01, 0.30]	+0.03 [-0.15, 0.22]	-0.02 [-0.17, 0.14]	-0.08 [-0.30, 0.10]	-0.09 [-0.29, 0.01]	+0.05 [-0.09, 0.23]
Agreeableness	+0.04 [-0.11, 0.20]	+0.01 [-0.18, 0.24]	+0.02 [-0.13, 0.17]	-0.03 [-0.27, 0.16]	-0.06 [-0.21, 0.10]	+0.03 [-0.18, 0.23]
Openness	0.00 [-0.16, 0.14]	+0.01 [-0.18, 0.23]	-0.07 [-0.24, 0.06]	0.00 [-0.22, 0.19]	+0.07 [-0.05, 0.25]	-0.01 [-0.22, 0.17]

Note:
Square brackets indicate 95% confidence intervals, estimated using bootstrapping with 10,000 samples. Coefficients with confidence intervals that do not include zero are marked with a caret (^) and are bolded.

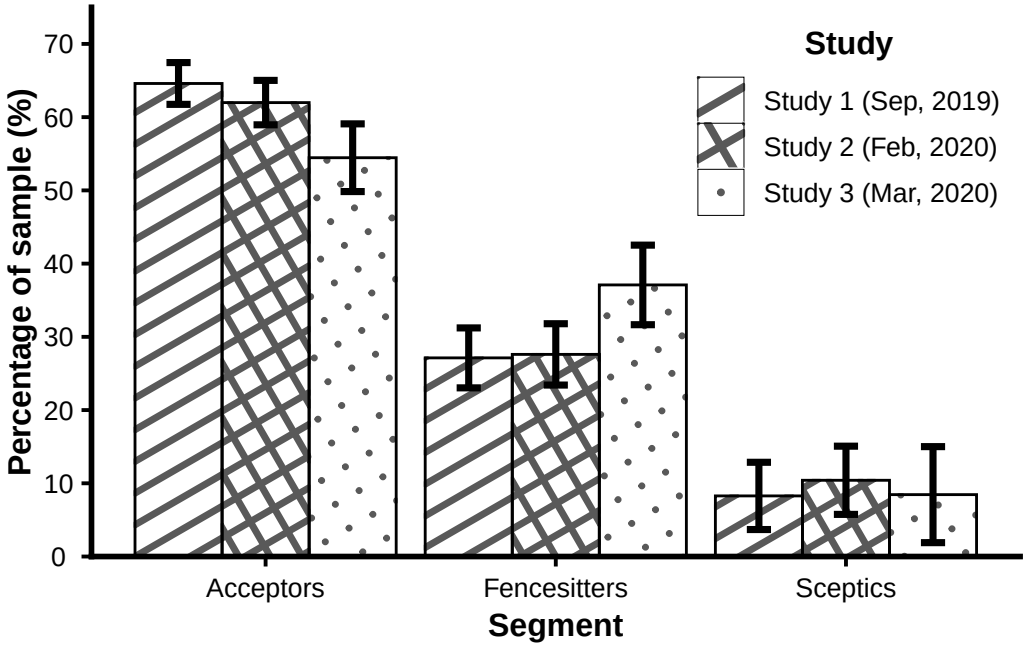
Change in climate change segment membership, cognition, and affect

To explore whether climate change views changed during the Black Summer bushfires, we investigated the relative proportions of segments across studies (Figure 2). Numerically, the proportion of Acceptors fell across time (from 64.60% of Study 1 sample to 54.46% of Study 3 sample), whereas the proportion of Fencesitters increased across time (from 27.13% of Study 1 sample to 37.09% of Study 3 sample). In comparison, the proportion of Sceptics was relatively stable across studies (from 8.28% of Study 1 sample to 8.45% of Study 3 sample). To investigate whether the relative proportion of segments differed across studies, we created a multinomial logistic regression model to predict segment membership as a function of study (coefficients reported in Supplementary Material), using the *multinom* function from the *nnet* package (Venables & Ripley, 2002). A likelihood-ratio test did not indicate an improvement in model fit when study was included as a predictor, compared to a model with only an intercept term (χ^2 (4) = 8.85, p = .07, Cohen's $\omega = 0.09$). Thus, segment membership did not reliably differ across study samples.

In addition to segment membership, we tested for differences in climate change cognition and affect between Study 1 (September, 2019) and Study 3 (March, 2020) using t tests. To guard against Type I errors, we applied a Holm (1979) p value adjustment (Table 4). Participants in Study 3 showed a significantly greater mean endorsement of natural cycle causes of climate change (e.g., volcanic eruptions, solar fluctuations) than those in Study 1 (Cohen's $d = 0.25$). However, no other climate change cognition and affect characteristics reliably differed between Study 1 and Study 3. Furthermore, there was no evidence that participants from Study 1 and Study 3 reliably differed in their dispositional attributes of: cognitive styles; ideology, worldviews and values; or personality (all $p > .05$; see Supplementary Material for t tests).

Figure 2

The segment membership of each study, as a proportion (percentage) of the sample. Error bars indicate one standard error of the proportion.



Bushfire perceptions and policy direction preferences

To explore perceptions of the Black Summer bushfires, we performed a principal components analysis with varimax rotation on the Fire Perception Scale (see Table 5). We extracted three factors, as these accounted for the majority of scale variance (78.31%; see Supplementary Materials for scree plot). The first factor, labelled *Climate Processes*, was characterised by four items (items 1, 3, 5, 6) which linked climate change to the bushfires and accounted for 41.22% of scale variance. The second factor, labelled *Fire Realities*, was characterised by two items (items 2 and 4) with the two most extreme (maximum and minimum) mean item scores and accounted for 19.97% of scale variance. The third factor, labelled *Arson Causes*, was characterised by a single item (item 7) stating that Black Summer was caused by hundreds of arsonists and accounted for 17.12% of scale variance. We created subscales corresponding to each factor by averaging item scores. Items that negatively loaded onto factors were reverse coded. The multi-item factors of Climate

Table 4

Difference in means of climate change cognition and affect characteristics between Study 1 and Study 3.

	$M_{Study\ 3} - M_{Study\ 1}$				
Psychological characteristics	Estimate	95% *CI*	*t*	*p*	$p_{adjusted}$
Perceptions of Natural Causes	0.39	[0.13, 0.65]	2.95	.003	.04*
Response Scepticism	0.19	[0.03, 0.35]	2.29	.022	.27
Perceived Effectiveness of Green Policies	-0.20	[-0.45, 0.05]	-1.60	.110	1.00
Worry about Climate Change	-0.11	[-0.28, 0.05]	-1.35	.178	1.00
Perceptions of Carbon Emission Causes	-0.15	[-0.38, 0.08]	-1.29	.197	1.00
Perceived Human Contribution	-0.18	[-0.46, 0.11]	-1.22	.222	1.00
Epistemic Scepticism	0.09	[-0.08, 0.25]	1.04	.300	1.00
Knowledge Volume	0.06	[-0.06, 0.19]	0.99	.325	1.00
Perceived Personal Consequences	0.12	[-0.12, 0.36]	0.97	.331	1.00
Perceptions of Environmental Harm Causes	-0.10	[-0.35, 0.16]	-0.75	.457	1.00
Perceived Effectiveness of Engineering Policies	-0.04	[-0.22, 0.14]	-0.43	.670	1.00
Perceived Effectiveness of Carbon Policies	-0.04	[-0.25, 0.18]	-0.33	.742	1.00
Perceived Societal Consequences	-0.01	[-0.25, 0.22]	-0.11	.914	1.00

Note:

*$p_{adjusted} < .05$;

p values were adjusted using the Holm (1979) method.

Processes and Fire Realities had an internal consistency of Cronbach's $\alpha = .86$ (four items; mean inter-item $r = .60$) and Cronbach's $\alpha = .42$ (inter-item $r = .29$), respectively.

To test segment differences in bushfire perceptions, we built linear regression models predicting Climate Processes, Fire Realities, and Arson Causes as a function of segment membership (coefficients reported in Supplementary Materials). All linear regression models accounted for a significant amount of bushfire perception variance compared to intercept-only models, indicating that segment membership was a significant predictor of Climate Processes (F (2, 210) = 47.44, $p < .001$, $R^2 = .31$, $R^2_{adjusted} = .30$), Fire Realities (F (2, 210) = 30.31, $p < .001$, $R^2 = .22$, $R^2_{adjusted} = .22$), and Arson Causes (F (2, 210) = 12.69, $p < .001$, $R^2 = .11$, $R^2_{adjusted} = .10$).

To quantify specific segment differences, we conducted pairwise comparisons of marginal means using the *marginaleffects* package (Arel-Bundock et al., Forthcoming),

Table 5

Items of the Fire Perception Scale, their loadings onto each factor, their mean score, and their standard deviation.

Item	Factors			Descriptives	
	Climate Processes	Fire Realities	Arson Causes	*M*	*SD*
1. Climate change made the 2019-20 Australian bushfires more severe	**0.78**	0.34	-0.22	3.62	1.40
2. Climate change made the 2019-20 Australian bushfires less likely to occur	0.27	**-0.70**	**0.42**	2.19	1.27
3. The 2019-20 Australian bushfires have accelerated climate change	**0.84**	0.05	-0.14	3.16	1.30
4. The 2019-20 Australian bushfires are severe	0.17	**0.86**	0.23	4.50	0.79
5. If the government increased taxes on all fossil fuels (e.g., gasoline, oil, coal, kerosene), Australia would be less likely to experience extreme bushfires	**0.84**	-0.19	0.13	2.55	1.32
6. If we changed our lifestyles to reduce our consumption, Australia would be less likely to experience bushfires	**0.86**	-0.06	0.08	3.05	1.39
7. Over one hundred arsonists have contributed to the 2019-20 Australian bushfires	-0.10	0.04	**0.94**	3.47	1.20

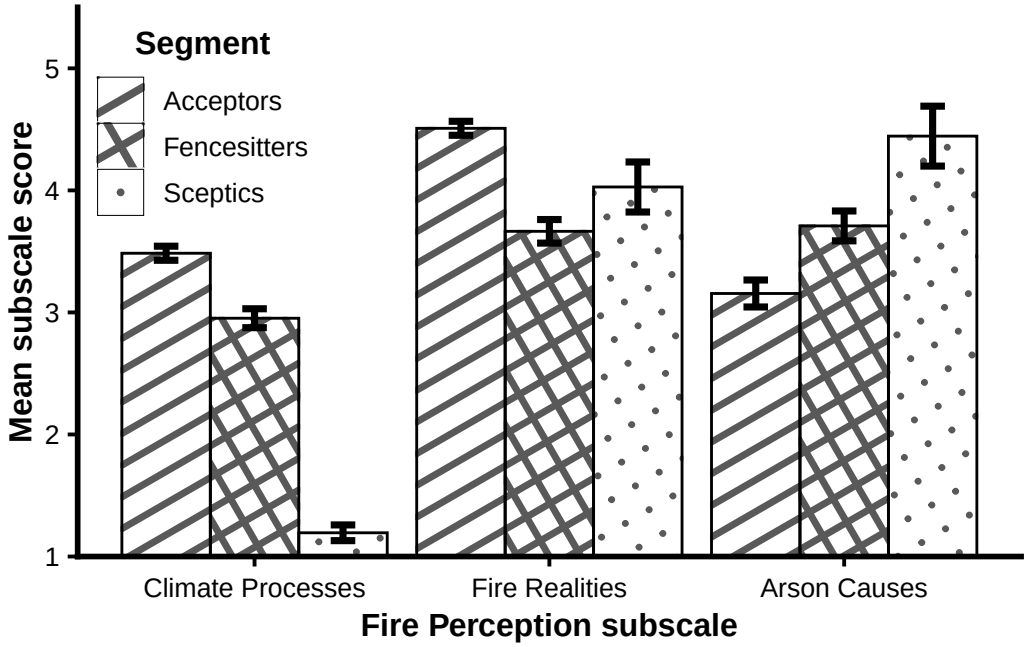
Note:

Bolded loadings are greater than .40 in magnitude.

with a Holm (1979) p value adjustment for multiple comparisons. As seen in Figure 3, Acceptors had a higher mean Acceptors had a higher mean endorsement of Climate Processes than Fencesitters (difference = 0.53, $SE = 0.14$, 95% $CI = [0.26, 0.80]$, $z = 3.87$, $p < .001$, $p_{adjusted} < .001$), who in turn, had a higher mean endorsement than Sceptics (difference = 1.76, $SE = 0.25$, 95% $CI = [1.28, 2.24]$, $z = 7.14$, $p < .001$, $p_{adjusted} < .001$). For Fire Realities, Acceptors had a greater mean endorsement than Sceptics (difference = 0.48, $SE = 0.19$, 95% $CI = [0.11, 0.85]$, $z = 2.54$, $p = .011$, $p_{adjusted} = .022$) and Fencesitters (difference = 0.84, $SE = 0.11$, 95% $CI = [0.63, 1.06]$, $z = 7.75$, $p < .001$, $p_{adjusted} < .001$). However, Fencesitters did not reliably differ from Sceptics in their mean endorsement of Fire Realities (difference = -0.36, $SE = 0.20$, 95% $CI = [-0.75, 0.02]$, $z =$

Figure 3

Mean Fire Perception subscale scores as a function of segment. Error bars indicate one standard error above and below the mean.



-1.86, $p = .063$, $p_{adjusted} = .063$). The pattern of Climate Processes endorsement was reversed for Arson Causes, with Sceptics having a higher mean endorsement than Fencesitters (difference = 0.74, $SE = 0.30$, 95% $CI = [0.15, 1.32]$, $z = 2.47$, $p = .014$, $p_{adjusted} = .014$), who in turn, had a higher mean endorsement than Acceptors (difference = 0.55, $SE = 0.17$, 95% $CI = [0.23, 0.88]$, $z = 3.32$, $p < .001$, $p_{adjusted} = .002$).

We investigated causal perceptions by examining responses to claims that mass arson (item seven of the Bushfire Perception scale) and climate change (item one of the Bushfire Perception Scale) contributed to the Black Summer bushfires. Despite segment differences, participants seldom rejected the claim that over one hundred arsonists contributed to the Black Summer bushfires ($n = 38$; 17.84% responded with 'disagree' or 'strongly disagree' to item seven). Many Acceptors ($n = 45$; 38.79%), and a majority of Fencesitters ($n = 45$; 56.96%) and Sceptics ($n = 16$; 88.89%), agreed (responded with 'agree' or 'strongly agree') with mass arson causal claims. In contrast, a majority of Acceptors ($n = 101$; 87.07%), some Fencesitters ($n = 33$; 41.77%), and no Sceptics agreed

that climate change worsened the severity of the Black Summer bushfires. Overall, endorsement of the mass arson causal account was negatively associated with endorsement of the climate change causal account (r = -.21, 95% CI = [-.33, -.08], p = .002).

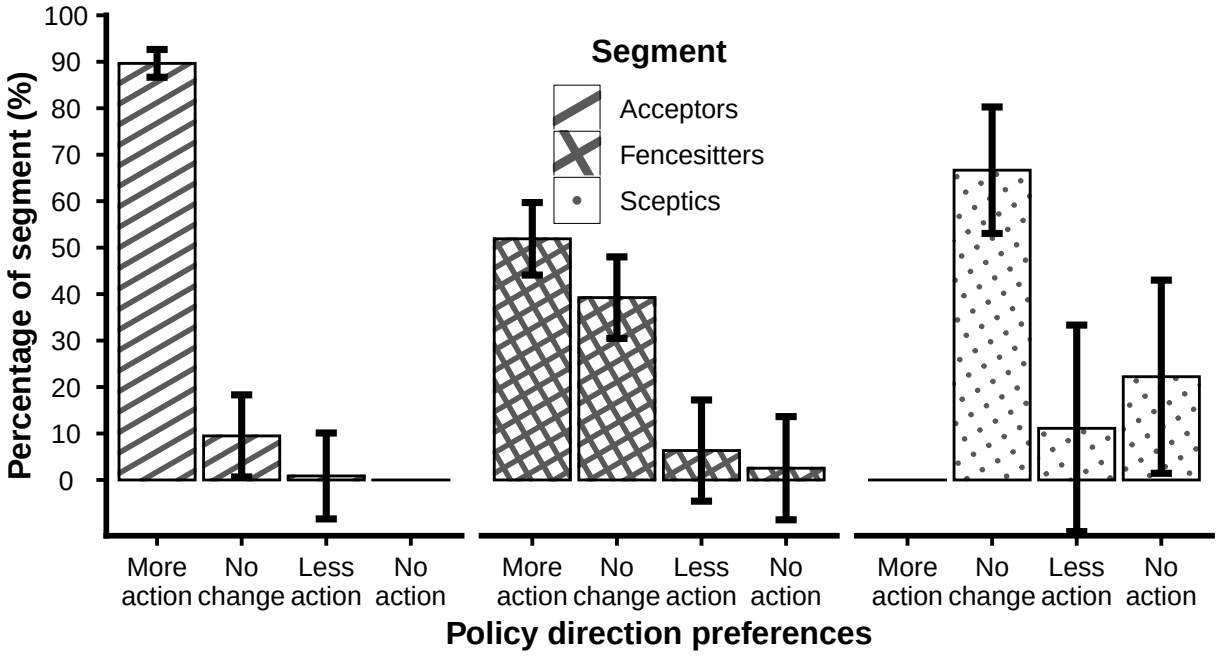
Participants differed in their policy direction preferences in response to the Black Summer bushfires. Most participants desired more governmental climate change mitigation policies (n = 145, 68.08%), or no changes to governmental climate change mitigation policies (n = 54, 25.35%). On aggregate, few participants desired less or no governmental climate change mitigation policies (totalling n = 14, 6.57%). However, policy direction preferences differed across segments, with the majority of Acceptors and Fencesitters desiring more governmental climate change mitigation policies, and the majority of Sceptics desiring no changes to governmental climate change mitigation policies (Figure 4).

We investigated the statistical significance of segment differences using a binomial logistic regression model estimating the odds of desiring more governmental climate change mitigation policies as a function of segment membership (reported in full in Supplementary Materials). Sceptics were excluded from analysis, as none desired more governmental climate change mitigation policies. A likelihood-ratio test indicated that segment membership significantly predicted policy direction preferences (χ^2 (1) = 35.45, $p < .001$, Cohen's $\omega = 0.43$). Specifically, we found that the odds of Acceptors (n = 104, 89.66% of Acceptors, odds = 8.67) indicating a preference for more governmental climate change mitigation policies were approximately eight times greater (odds ratio = 8.03, 95% CI = [3.92, 17.49], $p < .001$) than Fencesitters (n = 41, 51.90% of Fencesitters, odds = 1.08).

We explored the text justification of policy direction preferences using an emotion analysis. We detected the emotional association of each word using the NRC Word-Emotion Association Lexicon (Mohammad & Turney, 2013). This lexicon is a list of words manually annotated (via crowdsourcing) for their association with eight emotions: anger, fear, anticipation, trust, surprise, sadness, joy, and disgust. For each response, we assigned a dichotomous code (present/not present) if the response contained at least one

Figure 4

Policy direction preferences as a proportion of each segment. Error bars indicate one standard error of the proportion.



word associated with an emotion, for each emotion.

The most common emotion evoked by participants was fear ($n = 67$, 31.46%), found in both justification for more action (e.g., one participant wrote "the recent bushfire is a wakupe call. how much more *worse* do we want to experience?", fear words italicised) and for no changes or less action (e.g., one participant wrote "…100 arsonists were charged as a starter and the it was the fuel left on the ground for decades that made the fires so much *worse* and caused the *disaster*", fear words italicised). To test whether emotions varied across segments, we made a binomial logistic regression model for each emotion with segment membership as a predictor (reported in full in Supplementary Materials). Generally, we found no statistically significant differences in the use of emotions across segments, except for fear, where the odds of Acceptors using a fear word ($n = 47$, 40.52% of Acceptors, odds = 0.68) were approximately three times higher (odds ratio = 3.16, 95% $CI = [1.59, 6.28]$, $p = .001$) than Fencesitters using a fear word ($n = 14$, 17.72% of Fencesitters, odds = 0.22). Sceptics did not reliably differ in their use of fear words ($n = 6$,

527 33.33% of Sceptics, odds = 0.50) from Acceptors or Fencesitters.

Discussion

In this paper, we reported three audience segmentation studies of Australian climate-related opinions employing the Q-methodology that were undertaken at different stages of the Australian Black Summer bushfires. Study 1 was conducted before the peak of the bushfires (September 2019), whereas Studies 2 and 3 took place after the peak (February and March 2020, respectively). This afforded us a natural experiment to determine whether the occurrence of the bushfires catalysed a change in Australian climate-related opinions. All studies required participants to complete a Q-sort task, wherein they ranked a series of statements about climate change according to how similar they are to their own point of view. Studies 1 and 3 additionally incorporated auxiliary measures of prominent psychological characteristics, including measures of climate change cognition and affect. Study 3 also incorporated measures of bushfire perceptions and climate policy support. We examined whether the three-segment solution and pattern of psychological characteristic differences between segments reported previously (Andreotta et al., 2022) replicated across studies, whether the proportion of respondents in each segment and their climate change cognition and affect differed before versus after the peak of the Black Summer bushfires, and how segments differed in their bushfire perceptions and policy preferences.

Summary of key findings

Across all three studies, we find consistent support for a three-segment solution of Australian climate-related opinions. The three segments are the Acceptors, Fencesitters, and Sceptics—ordered from the highest to the lowest belief in anthropogenic climate change, trust in climate science, concern about the issue, and motivation to tackle it. The segments are remarkably robust, with near-perfect correlations between the archetypal sorting styles of Acceptors of all studies and Sceptics of all studies. This is impressive given that we the archetypal sorting styles depend on the correlations between the rank orderings of 30 statements, which have several thousand unique permutations. It seems the Black

Summer bushfires did not change the definitional point of view of an Acceptor, Fencesitter, or Sceptic.

Further evidence for the stability of audience segments across studies was derived from the consistent relationship between segments and psychological characteristics in Studies 1 and 3. Acceptors were characterised by low epistemic and response scepticism, high worry about climate change, a high belief that carbon-emitting human activities cause climate change, a high belief in the societal consequences of climate change, a politically liberal ideology, and an "environment-as-ductile" worldview, meaning they think the environment has a limited capacity to recover from damage. Sceptics, by contrast, were characterised by high epistemic and response scepticism, low worry about climate change, a low belief in the environmental harms of climate change, high confidence in their knowledge about climate change, a politically conservative ideology, and an "environment-as-elastic" worldview, meaning they think the environment can easily recover from damage. In comparison to these two segments, Fencesitters were more neutral concerning political ideology and environmental worldviews. However, they scored higher on a measure of general conspiratorial thinking than both Acceptors and Sceptics.

We found little evidence to suggest that the Black Summer bushfires catalysed a shift in climate-related opinions toward greater acceptance and concern. Across the three studies, the percentage of Acceptors decreased slightly, the percentage of Fencesitters increased, while Sceptics remained largely stable. However, critically, there was no statistically reliable evidence of a shift in the proportion of respondents in the three segments over time.

The auxiliary measures of psychological characteristics incorporated in Studies 1 and 3 included several measures of climate change knowledge (viz., knowledge volume, mental models of climate change, epistemic and response scepticism) and affect (viz., worry about climate change), affording us an additional set of indicators to determine if the bushfires provoked a change in beliefs about, and emotional responses towards, climate change.

However, consistent with the results derived from the Q-sort task, we generally found no statistically reliable change in responses on these measures between Studies 1 and 3. The only exception was a small increase in Australians' perceptions of natural cycles (e.g., volcanic eruptions, solar fluctuations) as a cause of climate change. Again, this evidence contradicts the claim that the Black Summer bushfires catalysed greater acceptance and concern about anthropogenic climate change. It is unclear why the Black Summer bushfires might have strengthened belief in the role of natural cycles in climate change. One possibility is that participants recognised the greenhouse gases released by the bushfires and perceived them—along with weather events more broadly—as part of a natural fluctuation, leading to greater endorsement of natural cycles as a cause of climate change.

We did not find any statistically reliable differences between Studies 1 and 3 in a range of dispositional measures of cognitive style, ideology, worldviews, values, and personality. This outcome was not unexpected as these are measures of more enduring psychological traits that tend to remain stable over time.

Perceptions of the bushfires and support for climate policy in Study 3 varied across segments. Starting with bushfire perceptions, although all segments acknowledged that the bushfires were harmful, a majority of Acceptors, a minority of Fencesitters, and no Sceptics thought that they were worsened by climate change. In contrast, participants were generally reluctant to disagree with the claim that mass arson caused the bushfires—on average, Acceptors were unsure if arsonists contributed to the bushfires, whereas Fencesitters and Sceptics agreed and strongly agreed, respectively, that arsonists contributed to the bushfires. Turning to support for climate policy, Acceptors almost universally agreed that the bushfires warranted more action by Australia to address climate change, whereas Fencesitters were roughly evenly split between favouring more action and no change in action. Sceptics mostly favoured no change in action by Australia to address climate change. Fear was routinely used by all segments, but in particular, Acceptors, to justify their policy position.

Why Black Summer did not lead to greater climate change concern

Our results add to the mixed findings on the relationship between climate-related opinions and personal experience of extreme climate events (Howe, 2021; Howe et al., 2019; Xia et al., 2022). However, at the outset, we identified two known moderators of the effect of extreme-event exposure on climate-related opinions which may help to explain why the Black Summer bushfires did not lead to greater acceptance and concern about climate change. The first moderator is extreme event attribution—several studies have shown that exposure to an extreme climate event only influences climate-related opinions amongst those individuals that causally attribute that event to climate change (McCright et al., 2014; Ogunbode et al., 2019, 2020; Wong-Parodi & Rubin, 2022). Responses on the bushfire perceptions measure in Study 3 indicate that the pre-condition of causal attribution was not met for most Fencesitters and no Sceptics—neither of these segments causally attributed the bushfires to climate change. Indeed, Fencesitters and Sceptics rejected the notion that climate change causally contributed to the bushfires and were instead more likely to attribute the bushfires to the actions of arsonists. In contrast, Acceptors tended to agree in a causal role of climate change, although a sizeable minority also believed arsonists causally contributed to the bushfires.

The failure of the Fencesitters to attribute a causal role for climate change in worsening the bushfires can potentially be understood in terms of a second known moderator of the effect of extreme event exposure on climate-related opinions—namely, media attention. Extreme climate events can serve as "focusing events" (Birkland & Schwaeble, 2019) that attract increased media attention (Kirilenko et al., 2015; Marquart-Pyatt et al., 2014; Sisco et al., 2017), providing teachable moments for highlighting the links between such events and ongoing climate change for the public. However, as noted at the outset, although the Black Summer bushfires garnered significant media attention, media coverage of the fires was characterised by competing narratives regarding the role, or lack thereof, of climate change in worsening them. Although initial

media coverage emphasised the climate change and bushfire association, the issue quickly became politicised and fragmented along ideological lines—liberal media outlets continued to highlight the role of climate change in exacerbating the fires, whereas conservative media outlets were dismissive of this connection (Mocatta & Hawley, 2020). During the peak of the bushfires (December 2019 and January 2020), misinformation became prevalent on social media and in conservative media outlets. In particular, misinformation that exaggerated the role of arsonists and detracted from the causal relationship between climate change and the bushfires. We know that misinformation is incredibly "sticky" and difficult to correct (Ecker et al., 2022; Lewandowsky et al., 2012), and it is possible that despite the efforts of police, bushfire services, and the media to dismiss the arson claims (Knaus, 2020; Readfearn, 2019), this misinformation had firmly taken root in the public consciousness by the time Studies 2 and 3 were undertaken. The general acceptance of mass arson as a cause for Black Summer across segments, combined with the fact that most Fencesitters and all Sceptics dismissed climate change as a factor in worsening the fires, supports this notion. Our results, therefore, tentatively suggest that misinformation influenced Australians' perceptions of the causes of the fires, and this may be a potential reason why the fires were not attributed to climate change and a shift in climate-related opinions towards greater acceptance and concern was not observed.

Although misinformation may have obfuscated the climate change and bushfire connection, there is another potential explanation for why the segments did not attribute a causal role for climate change in the bushfires. A content analysis of Australian media coverage of the fires between September 2019 and January 2020 by Burgess et al. (2020) revealed that almost 50% of articles mentioned climate change, yet only 16% attributed the fires to climate change, with fewer still explaining how climate change worsened the fires. Similar results were obtained in a study examining how Australian climate action non-governmental organisations framed the link between the Black Summer bushfires and climate change on the social media platform Twitter (now X; Ettinger et al., 2023). These

analyses suggest that climate communication stakeholders may not have made clear enough to the public how the bushfires were connected with climate change.

Finally, whilst on the issue of media attention, we must also acknowledge that Studies 2 and 3 were undertaken after the World Health Organisation (WHO) declared the COVID-19 outbreak a Public Health Emergency of International Concern in January 2020, and Study 3 coincided with the WHO characterising the outbreak as a pandemic in March 2020. The abrupt nature of the pandemic meant that it quickly became the centre of global media and public attention, diverting attention away from the bushfires and climate change (Evensen et al., 2021; Loureiro & Alló, 2021; Rauchfleisch et al., 2023; Smirnov & Hsieh, 2022; Stoddart et al., 2023). Accordingly, our failure to observe a shift in climate-related opinions in Studies 2 and 3 might be a consequence of people redirecting their worry and concern about the bushfires and climate change towards the unfolding pandemic.

It is important to conclude this section by acknowledging that these explanations remain tentative, as our study was not a true experiment. Specifically, we lack the relevant counterfactual conditions to facilitate causal inference——such as the absence of the Black Summer bushfires, a less polarised media environment, or a scenario where the bushfires did not coincide with a global pandemic.

Implications for climate change communication

Our results have implications for the framing of extreme climate events by climate communication stakeholders. Providing clear statements attributing such events to climate change is important, given the evidence that event attribution is a key moderator of the effect of extreme event exposure on climate-related opinions. However, what may be more important is to explain, in simple terms, the causal role of climate change in the occurrence of the extreme event. Doing so makes the causal claim more credible and memorable because the underlying mechanism is understood (Hastie, 1984) and may help to stave off misconceptions caused by misinformation. Thus, if individuals know that the causal role of climate change in the fires was that it created hot and dry weather conditions that

facilitated the spread of those fires, rather than being the source of ignition of the fires, then they may be less likely to be misled by claims that the fires were caused by arson, rather than climate change. That is, they will recognise that the source of ignition is inconsequential—climate change does not start bushfires, it creates conditions that worsen them once they have been ignited. It is clear from the mass media and social media content analyses of the bushfires by Burgess et al. (2020) and Ettinger et al. (2023), respectively, described earlier, that more could have been done to communicate to the public the causal role of climate change in worsening the fires.

When misinformation about the causes of an extreme climate event circulates in mass and social media, timely correction may be crucial to prevent it from taking root. In the context of the Black Summer bushfires, state fire services, the police, and journalists all played a role in countering misinformation about the fires. However, not all corrections are equally effective in debunking misinformation. Cognitive psychologists have identified numerous best practices for debunking misinformation (Ecker et al., 2022; Lewandowsky et al., 2012), and these strategies have been distilled into an accessible handbook for non-experts (Lewandowsky et al., 2020). For example, one key component of a debunking correction is to provide an alternative explanation for the cause of an event (Ecker et al., 2022). Thus, when debunking the claim that "the bushfires were caused by arsonists", providing an alternative causal explanation of the event ("the bushfires were ignited by lightning") is more effective than a mere retraction of the falsehood ("there is no evidence of arson"). Stakeholders involved in commentating on extreme climate events should incorporate these best-practice insights into their communications to increase the effectiveness of their debunking efforts. Even members of the public can help limit the spread of misinformation. For example, in their analysis of the #ArsonEmergency tweets on Twitter, Weber and colleagues (D. Weber et al., 2020, 2022) identified two different communities, one involved in the propagation of the false claims and another that sought to debunk those claims.

Finally, our results have implications for engaging with the three audience segments. Acceptors and Sceptics may be low priorities for public engagement campaigns. Acceptors already strongly believe in anthropogenic climate change, are highly trusting of climate science, and are strongly supportive of climate action. Accordingly, messages that target this segment are likely to have only a limited impact as these individuals are already highly concerned about, and motivated to tackle, climate change. Although Sceptics are the polar opposites of Acceptors, implying they should be a high priority for public engagement efforts, they are politically motivated to reject climate science—given their conservative political ideology and environment-as-elastic worldviews—and highly resistant to belief revision in the face of climate science information (Andreotta et al., 2022). This, combined with the fact they are relatively few in number, suggests there may be little merit in trying to shift the opinions of this segment (although see Andreotta et al., 2022, for a more nuanced account). By contrast, Fencesitters are more neutral in terms of political ideology and environmental worldviews, meaning they are not politically motivated to oppose climate science like Sceptics. Indeed, Fencesitters update their beliefs in response to climate science information almost as much as Acceptors do (Andreotta et al., 2022). They are a relatively large segment with more intermediate climate-related opinions, meaning that with the right messaging strategy, they could perhaps be transformed into Acceptors.

Accordingly, we suggest that public engagement campaigns should target the Fencesitters. Unfortunately, we do not know much about the characteristics of this segment. This is, in part, because, given the inherent variability of individuals within this segment, we cannot, or rather it does not make sense to, construct an archetypal Q-sort of their statement rankings. However, what we do know is that, compared to the Acceptors and Sceptics, they are more likely to endorse conspiracy theories. This curious result, first documented in our original report of Studies 1 and 2 (Andreotta et al., 2022), was replicated in Study 3, suggesting it is a robust feature of this segment. Given that much climate misinformation is grounded in terms of conspiracy theories (Coan et al., 2021;

Cook, 2020), our main piece of advice for climate communication stakeholders is that debunking efforts should pay particular attention to exposing how climate misinformants use conspiracy theories and related deception techniques to mislead the public. Such refutation techniques may be crucially necessary to prevent climate misinformation from transforming Fencesitters into Sceptics.

Potential limitations

Before closing, some potential limitations of the current work warrant comment. First, Studies 2 and 3 were undertaken after the peak in the bushfires, which occurred between December 2019 and January 2020. Therefore, we cannot rule out the possibility that, had one or both studies been undertaken during this period, an increase in climate change acceptance and concern may have been detected. Nevertheless, even if this were so, our results suggest such a change in opinions would have been temporary and short-lived.

Second, although around 80% of the Australian population was affected either directly or indirectly by the fires (Hughes et al., 2020), we did not ask respondents about the nature of their experiences. The distinction between direct and indirect experience is important because studies have shown that direct experience of an extreme event is more predictive of climate-related opinions than indirect experience (Ogunbode et al., 2020; Zanocco et al., 2019). Accordingly, changes in climate-related opinions are more likely to be observed amongst individuals who had severe direct negative experiences of the fires, such as those who suffered property damage. However, we note that even if we had measured the nature of our respondents' experiences, individuals who had severe personal experience of the fires are likely under-represented in Studies 2 and 3, as the disaster's impact would have precluded them from responding to our web-panel surveys (Howe, 2021).

Lastly, we note that power is always a concern when retaining the null hypothesis. Our sample size had sufficient power to detect even very weak omnibus effects, such as study differences in segment membership and climate change cognition and affect. We had less power to detect post hoc effects between specific segments and specific studies, such as

the increase in Fencesitters between Study 1 and Study 3. However, our studies detected some key segment differences, such as Fencesitters endorsing arson causes of the Black Summer bushfires at a greater rate than Acceptors.

Conclusions

Previous research examining the association between personal experience of extreme climate events and climate-related opinions has revealed contradictory findings. Therefore, it may not be considered surprising that we found no evidence that the Black Summer bushfires prompted a shift toward greater acceptance and concern. Attribution of an extreme event to climate change may be a key determinant of the effect of extreme-event exposure on climate-related opinions. Accordingly, the failure of Fencesitters to attribute the bushfires to climate change is the most credible explanation for the lack of a positive shift in climate-related opinions following the Black Summer bushfires. This lack of attribution of the fires to climate change may be a consequence of the divergent mass media and social media narratives surrounding the bushfires. Notably, misinformation dismissing the climate change and bushfire connection may have "crowded out" messages linking the bushfires with climate change. That misinformation influenced Australians' perceptions of the fires is perhaps best evidenced by the failure of Acceptors to dismiss the arson claim, and the tendency for Fencesitters and Sceptics to endorse this claim. However, although some mass media coverage of the bushfires mentioned climate change, relatively few articles directly linked the bushfires to climate change, and fewer still explained the mechanism by which climate change intensifies bushfires. This is another potential explanation for why some Fencesitters failed to attribute the fires to climate change. The implications of these observations are two-fold. First, climate communication stakeholders may need to emphasise not only the connection between an extreme event and climate change but crucially explain how climate change contributed to that event. Second, where misinformation about the cause of an extreme event is circulated, proactive efforts must be undertaken to debunk the misleading claims. This requires that climate communication

stakeholders are aware of best practices for refuting misinformation so that their interventions can achieve maximal impact.

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