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RESEARCH ARTICLE

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Cultural worldviews and the perception of natural hazard risk in Australia

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ABSTRACT

The cultural theory of risk proposes that risk perception is biased by sociality and the maintenance of four ways or life, or cultural worldviews: hierarchism, egalitarianism, individualism or communitarianism. This study examined whether cultural worldviews influenced the perception of the risk of bushfire, flood, storm and earthquake in Australia. A sample of 503 participants completed two questionnaires: cultural worldviews and natural hazard risk perception. Only 30% of respondents held strongly hierarchical, egalitarian, individualist or communitarian worldviews. Several aspects of natural hazard risk perception were predicted by cultural worldviews, but associations were weak. Individualists perceived greater risk of, and responsibility for, natural hazards possibly because they perceive them to be a disruptive threat that limits freedom. Egalitarians perceived greater risk from bushfire or storm, possibly because they understand the potential for social impacts from these events and favour collective response. Notions of control and mitigation of natural hazards were associated with hierarchism. Communitarianism was not a predictor of natural hazard risk perception. However, most people don't view natural hazards as a threat to their sociality and way of life. Single heuristics, such as the cultural theory of risk, are unlikely to capture the complexity of natural hazard risk perception in Australia.

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Risk perception; cultural theory; disaster risk reduction; cultural worldviews of risk

Introduction

Natural hazards are naturally occurring extreme earth, water or atmospheric processes such as storms, bushfires, earthquakes and floods. Where these processes intersect with human activities, they can cause loss of life, loss of livelihoods and social and economic disruption (Burton et al., 1978; UNISDR, 2009). Across the world in 2020, natural hazard events killed approximately 15,000 people, affected 98.4 million people, and cost 171.3 billion $US in total loss and 81 billion $US in insured loss (Bevere & Weigel, 2021; CRED, 2021). Exposure to natural hazards has risen markedly in the last 40 years due to population growth, urbanisation and the expansion of settlements into hazard prone

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environments such as floodplains, forests and hillslopes (CRED, 2021; Pesaresi et al., 2017). For example, 1 billion people are potentially exposed to 100 year return period flooding around the world, an increase of 100% since 1975 (Pesaresi et al., 2017). On top of these drivers of natural hazard exposure, climate change is predicted to increase the magnitude and frequency of some extreme weather events and to add 20% to the global costs of natural hazard events by 2040 (University of Cambridge, 2020). Thus, natural hazards present a significant and ongoing threat.

Despite the threat of loss and harm from natural hazards, the occurrence of natural hazard events is dispersed in space and time. In any location, events may not occur regularly and individuals and communities may experience long periods of non-exposure, or exposure to only high frequency, low magnitude events. When rarer low frequency, high magnitude events do occur, they often highlight loss and harm, and may take individuals and communities by surprise (e.g., Whittaker et al., 2013). Thus, the potential for exposure to any natural hazard event is embedded within a background of the general threat of natural hazards to which society is expected to acknowledge and respond. The policies and strategies of disaster risk reduction, emergency management and disaster resilience generally seek to encourage the identification and treatment of natural hazard threats with mitigation, preparation and loss minimisation activities.

Though the predictors of action for any behaviour are multifactorial, the perception of the threat of natural hazards by individuals is considered to be one of the most important precursors of the desirable behaviours of mitigation, preparation, and loss minimisation, given a potential threat must at least be perceived as such before a behavioural response can be initiated. As natural hazard events may or may not occur, individuals may not have an opportunity to accurately appraise the threats or risks they face (Paton & McClure, 2013). The threat of a natural hazard becomes open to interpretation (Paton & McClure, 2013). The interpretation of risk, or risk perception, is influenced by cognitive, affective and social factors (McIvor et al., 2009, 2007; McNeill et al., 2013; Slovic et al., 2004). People interpret risk in the context of their beliefs, experience and expectations (McIvor & Paton, 2007). While many theories can be used to explain the perception of risk, the cultural theory of risk proposes that views of risk are shaped by the nature of the social groups and cultural identities of which people are a part (Tansey & O'Riordan, 1999) and that 'individuals choose what to fear and how much to fear it in order to support their way of life' (Wildavsky & Dake, 1990, p. 43). In this paper, we used an application of the cultural theory of risk to examine whether aspects of cultural identity influence the perceptions of the general risk of bushfire, flood, storm and earthquake natural hazards in Australia.

Cultural theory and cultural worldviews of risk

Originating in the work of social anthropologist Mary Douglas in the 1960s through 1980s (Douglas, 1978), cultural theory is a representation of cultural diversity proposing that preferences organise people into ways of life that shape and reinforce social relations (Douglas & Wildavsky, 1982). Ways of life are a combination of cultural biases (shared values and beliefs) and social relations (patterns of interpersonal relations) that together designate the viability of a way of life (Thompson et al., 1990). Cultural theory argued that although 'nations and neighbourhoods, tribes and races, have their distinctive sets of values, beliefs and habits, their basic convictions

about life are reducible to only a few cultural biases' (Thompson et al., 1990, p. 5). These ways of life have been conveyed as a group-grid typology capturing two dimensions of sociality that allow people to impose order on reality. The group dimension is the extent to which an individual is incorporated into bounded units. Greater incorporation is associated with individuals being subject to greater group determination (Thompson et al., 1990). The grid dimension is the degree to which an individual's life is influenced by externally imposed conditions. The more binding and extensive these conditions, the less of life that is open to negotiation (Thompson et al., 1990). The group-grid typology subsequently forms four quadrants of sociality. Hierarchy occurs in the high-group, high-grid quadrant and characterises people with strong group boundaries and strong binding prescriptions in which individuals are subject to the control of other group members and the demands of socially imposed roles (Thompson et al., 1990). Egalitarianism occurs in the high-group, low-grid quadrant and characterises people with strong group determination but minimal prescriptions, with no individuals granted the authority to exercise authority over another by virtue of their position (Thompson et al., 1990). Individualism occurs in the low-group, low-grid quadrant and characterises people with neither group determination nor prescribed roles, with individuals free from control by others but often engaged in exerting control over others (Thompson et al., 1990). Fatalism occurs in the high-grid, low-group quadrant and characterises people excluded from group membership but controlled from without, with limited individual autonomy (Thompson et al., 1990).

Extensions of Mary Douglas' cultural theory translated the group-grid dimension into a cultural theory of risk, explaining how risk perception may be biased by sociality and the maintenance of the four ways of life, termed 'cultural worldviews' (Dake, 1992; Douglas & Wildavsky, 1982). Derived in relation to technological, war, social deviance and economic risks, the cultural theory of risk proposes that selective attention and preferences influenced by sociality engender distinctive beliefs about what constitutes a risk and what does not (Dake, 1991; Wildavsky & Dake, 1990). Individuals characterised by a particular cultural worldview are likely to hold beliefs about the risk that support their way of life. Hierarchists accept risks if they are justified by government authorities or experts and have associated rules and regulations, but fear risks that threaten the social order and disrupt their preferred (superior/subordinate) form of social relations (Rippl, 2002; Wildavsky & Dake, 1990). Egalitarians frame the risk in ethical terms (Dake, 1992), and oppose risks that may cause irreversible effects on people and the environment. Egalitarians distrust risks that are forced on them by elite experts and authorities because they dislike the inequality that ranked stations signify (Rippl, 2002; Wildavsky & Dake, 1990). Individualists may fear risks that limit their freedoms to bargain and prefer an un-regulated network (Dake, 1992). They may perceive risks, particularly from new technologies, as opportunities for self-advancement and profit (Rippl, 2002; Wildavsky & Dake, 1990). Fatalists are excluded and controlled from without, and do not engage with or worry about risk because they believe they can do nothing about it (Dake, 1992).

The cultural theory of risk was empirically expanded by Dake (1991, 1992), and later Kahan (2012), who merged the four cultural worldviews with a psychometric approach to measure cultural worldviews of risk. Dake (1992) developed a cultural worldviews questionnaire to identify individuals in relation to hierarchism, egalitarianism, individualism and fatalism, and to associate these cultural worldviews with public opinions of

different types of technological and environmental risks. The internal consistency of Dake's scale was often weak, and because worldviews were measured separately, individuals could have competing orientations on the group or grid dimensions (Kahan, 2012). In response, Kahan (2012) merged the cultural theory of risk with the psychometric paradigm of individual differences to conceptualise the Cultural Cognition of Risk assessment (Kahan et al., 2011). Two continuous attitudinal scales were developed to capture the group and grid dimensions. In this model, the grid dimension is a continuum of hierarchy (high grid) to egalitarianism (low grid). The group dimension is a continuum of communitarianism (high group) to individualism (low group). Studies of risk perception using the Kahan scales consistently produce larger effect sizes than those using the Dake scale (Xue et al., 2014). Thus, we used the Kahan cultural cognition scale in this study to assess cultural worldviews, then examined the relationships between cultural worldviews and the perception of different aspects of natural hazard risk in Australia (risk, responsibility, control, trust in information) for four types of natural hazards (bushfire, flood, storm, and earthquake).

Materials and methods

Participants

Study participants were recruited to undertake an online survey using a social research panel (Online Research Unit, Sydney, Australia) in February 2017. Participants received remuneration within a point-based reward system, commensurate with the time commitment (average 25 minutes) involved in completing the survey. Participants had to be over 18 years of age and reside in the state of New South Wales (NSW), Australia. Two *a-priori* sample stratifications guided recruitment. First, participants from major metropolitan (Greater Sydney; ABS, 2011) and regional/remote areas (Rest of NSW; ABS, 2011) were requested because exposure to and perceptions of natural hazards may vary by location (Parsons et al., 2021). Second, equal numbers of male and female participants were requested because risk perception often varies by sex (Bouyer et al., 2001). The study was conducted under the University of New England Human Research Ethics Committee approval HE15-332.

The final sample comprised 503 NSW residents. Of these, 60% were female and 40% were male, differing from the NSW population of 51% female and 49% male. Representation of major metropolitan and regional/remote participants was achieved: 64% were from major metropolitan areas and 36% were from regional/remote areas, consistent with the geographic distribution of the NSW population. The age of participants ranged from 18 to 87, with 12% aged 18-30, 59% aged 31–65 and 28% aged 66 or over. The education level of participants was 11% Year 10 or below, 11% Year 12, 31% trade certificate or diploma, 28% undergraduate degree and 19% postgraduate degree. More metropolitan than regional/remote area participants reported that they had never experienced a bushfire, flood or storm, whereas equal numbers had never experienced an earthquake (Figure 1). More regional/remote than metropolitan participants reported 5 or more experiences of bushfire, flood and storm (Figure 1). Most participants considered it somewhat unlikely or very unlikely that they may be affected by a bushfire, flood or earthquake where they live, but many acknowledged that they may be affected

by a storm (Figure 2). Expectations of being affected by a bushfire or storm were higher among regional/remote participants (Figure 2).

Measures

Participants completed two questionnaires: cultural worldviews and natural hazard risk. Cultural worldviews were assessed using the cultural cognition scale (Kahan, 2012), consisting of 30 items that form continuous Hierarchy-Egalitarianism (HE) and Individualism-Communitarianism (IC) scores. Natural hazard risk was assessed using a questionnaire of 140 risk perception items associated with four natural hazards: bushfire (also known as wildfire); flood; storm; and earthquake (Table 1). These natural hazards contributed 98% of economic losses from disasters in NSW between 1967 and 2013 (Handmer et al., 2018). The same items were used across the four natural hazards, but participants were presented the hazards in random order. Responses were recorded using 5-point Likert scales (i.e., strongly agree, agree, neither agree nor disagree, disagree, strongly disagree; or trust very much, trust somewhat, neither trust nor distrust, distrust somewhat, don't trust at all). Demographic factors indicating age, sex, level of education and residence in a metropolitan or regional/remote location (postcode) were also collected.

Hierarchy-Egalitarianism (HE) and Individualism-Communitarianism (IC) scores were computed by summing the corresponding survey items, applying reverse coding where necessary (Kahan, 2012). The HE score has a potential range of 13–65: higher HE scores represent the hierarchy worldview, lower scores the egalitarianism worldview.

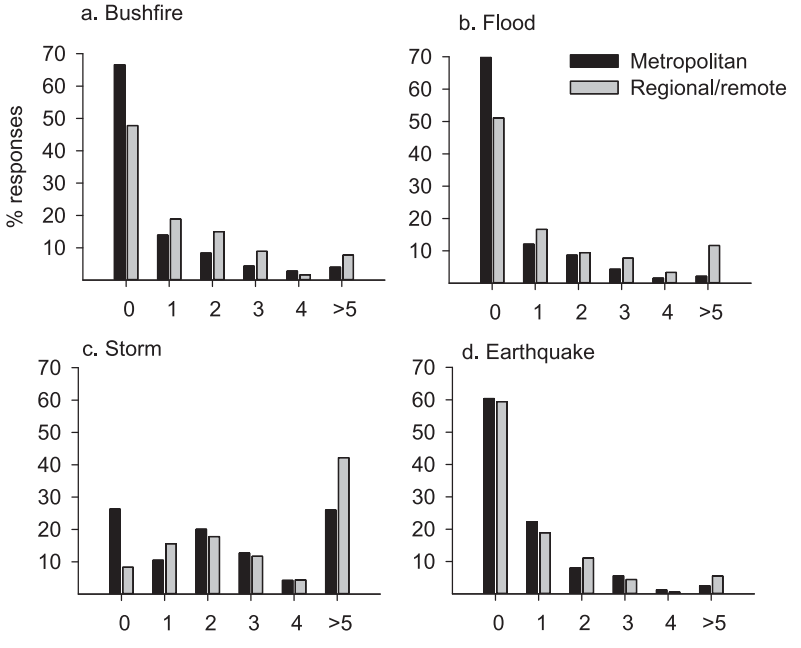

Figure 1. Metropolitan and regional/remote participant experience of natural hazards. 0 = never experienced the natural hazard type and > 5 = more than five experiences of the natural hazard type.

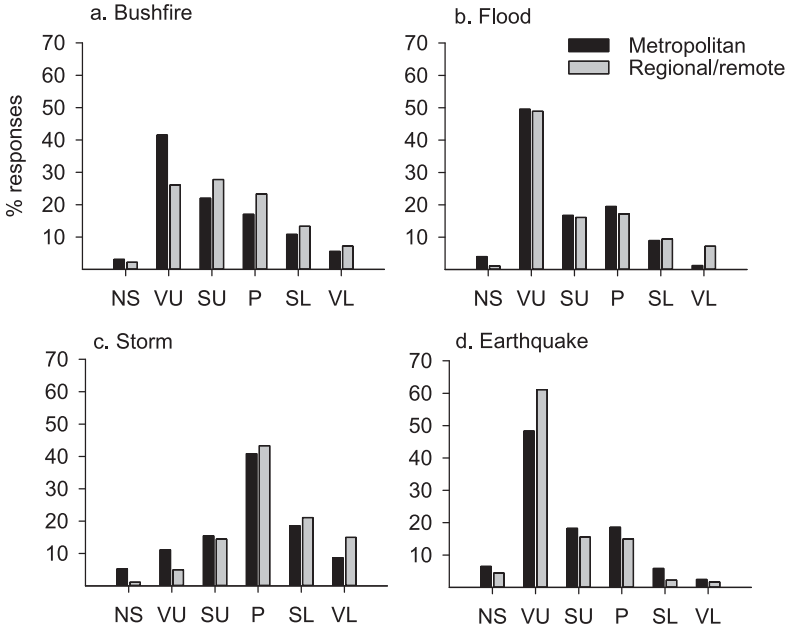

Figure 2. Metropolitan and regional/remote participant perceptions of how likely they are to be affected by natural hazards. NS = not sure, VU = very unlikely, SU = somewhat unlikely, P = possible, SL = somewhat likely and VL = very likely.

The IC score has a potential range of 17–85: higher IC scores represent the individualism worldview, lower scores the communitarianism worldview.

Five scales of natural hazard risk perception were computed for each natural hazard by summing the corresponding survey items, reverse coding where necessary (Table 1). The perceived risk scale examined the concern participants have about loss from natural hazard events. This scale can range from 6 to 30: higher scores represent greater perceived risk and concern about natural hazards. Internal consistency (Cronbach's Alpha) of the perceived risk scale across all hazard types was 0.91 (excellent). The perceived responsibility scale examined the propensity to view responsibility for natural hazard management as outside or within an individual's influence. This scale can range from 11 to 55: higher scores represent greater perceived self-responsibility for natural hazards and lower scores represent responsibility as belonging to others. Internal consistency of the perceived responsibility scale was 0.81 (good). The perceived control scale examined the views of participants about the inevitability of natural hazards in Australia and the value of mitigation. This scale can range from 7 to 35: higher scores represent greater perceived control of natural hazards. Internal consistency of the perceived control scale was 0.68 (questionable). The trust in personal information and trust in impersonal information scales examined the trust that participants have in information about natural hazards obtained from personal sources such as family and friends, or impersonal sources such as government agencies. The trust in personal information scale can range from 3 to 15 and the trust in impersonal information scale from 6 to 30: higher scores represent greater trust in that information source. Internal consistency of the trust in personal

Table 1. Questionnaire items about the perception of natural hazards. The items listed refer to bushfire: the word 'flood', 'storm' or 'earthquake' was inserted for the other natural hazard types. For example, "I'm worried that I might be killed or injured in a bushfire" became "I'm worried that I might be killed or injured in a flood". Items marked * were reverse coded. The exposure items were not computed as a scale.

Risk perception scale	Item
Risk	I'm worried that I might be killed or injured in a bushfire
	I'm worried that my home could be lost or badly damaged in a bushfire
	I'm worried that a bushfire could endanger me or my relatives or friends
	I'm worried that people in the area in which I live could be killed or injured, or lose their home, in a bushfire
	*People in Australia are more concerned about bushfires than they need to be
	*I don't really think much about the risks of bushfires
Responsibility	*The government shouldn't allow people to live where there is a high risk of bushfire
	People should be able to live where they like as long as they don't complain if their house is destroyed in a bushfire
	I'd happily live in a high risk bushfire zone, if that meant bearing the full costs of any losses that might occur in a bushfire
	*People should work together and help each other to reduce the risk of losses from bushfire in their area
	It's my own responsibility to find out whether the house I live in (or am about to rent or buy) is in a high risk bushfire zone
	*The government should inform me if the house I live in (or am about to rent or buy) is in a high risk bushfire zone
	If people die or have their house destroyed in a bushfire that's their own fault because they chose to live there
	Sometimes bushfires just happen in Australia, there is no one to blame for losses or deaths
	Learning lessons and improving the way bushfires are managed in the future is more important than finding someone or something to blame
	*I don't need to worry about preparing for a bushfire, the emergency services will come and help if I get into difficulty
	I can't expect to be rescued from a bushfire so I have to make sure I know what to do in advance
Control	Climate change is going to increase the severity and number of bushfires in the future
	Bushfires are a natural part of Australia's environment
	Bushfires are an inevitable part of life in Australia and we need to learn to live with them
	*There is a lot that can be done to minimise losses from bushfire in Australia
	There is nothing that can be done to minimise losses from bushfires in Australia
	There's not much I can do to protect my property from a bushfire
	*There is a lot I can do to protect my property from a bushfire
Trust in personal sources of information	How much would you trust your family to give you reliable information about the risk that a bushfire could occur in your area?
	How much would you trust your neighbours, friends and others in your community to give you reliable information about the risk that a bushfire could occur in your area?
	How much would you trust yourself to give you reliable information about the risk that a bushfire could occur in your area?
Trust in impersonal sources of information	How much would you trust your local council to give you reliable information about the risk that a bushfire could occur in your area?
	How much would you trust volunteer emergency service organisations (e.g., Rural Fire Service, State Emergency Service) to give you reliable information about the risk that a bushfire could occur in your area?
	How much would you trust federal and state government departments (e.g., Bureau of Meteorology, Police, Centrelink) to give you reliable information about the risk that a bushfire could occur in your area?
	How much would you trust the news media to give you reliable information about the risk that a bushfire could occur in your area?
	How much would you trust insurance companies to give you reliable information about the risk that a bushfire could occur in your area?

(*Continued*)

Table 1. Continued.

Risk perception scale	Item
	How much would you trust scientists to give you reliable information about the risk that a bushfire could occur in your area?
Exposure	How likely is it that you may be affected by a bushfire where you currently live?
	How many times have you experienced a bushfire anywhere that you have lived?

information scale was 0.95 (excellent) and the trust in impersonal information scale was 0.96 (excellent).

For each natural hazard, ordinal regression was used to examine the relationships between the four demographic factors (sex, age, regional or metropolitan location, education) and cultural worldviews (HE or IC scores). Two multilevel ordinal regression models were subsequently used to examine cultural worldviews and natural hazard risk perception. The first model tested whether natural hazard risk perception (perceived risk, perceived responsibility, perceived control, trust in personal sources of information, trust in impersonal sources of information scores) could be predicted by cultural worldviews (HE or IC scores). The second model added the four demographic variables to determine if demographic factors improved the prediction of natural hazard risk perception over cultural worldviews.

Results

Cultural worldviews of the participants

Scores on the HE axis ranged from 14 to 46, and scores on the IC axis ranged from 22 to 65 (Figure 3). Most participants (around 70%) had scores within one standard deviation of the HE axis mean ($M = 37$, $SD = 8$) or the IC axis mean ($M = 54$, $SD = 9$), indicating that they did not hold strongly hierarchical, egalitarian, individualist or communitarian worldviews. However, the remainder of participants (around 30%) had scores outside one standard deviation of the mean, indicating stronger alignment with these worldviews.

Several demographic factors were predicted by worldviews. Female participants tended to have lower scores on the HE axis than men, and therefore stronger egalitarianism, but there was no significant association between sex and the IC axis (Table 2). Older age and living in a regional postcode were associated with higher HE axis scores and higher IC axis scores, and therefore stronger hierarchism and individualism, respectively (Table 2). Higher levels of education were associated with lower HE axis and IC axis scores, and therefore stronger egalitarianism and communitarianism, respectively (Table 2). However, R^2 values were low, indicating directional, but weak, associations (Table 2).

Participant perceptions of natural hazard risk

Participants' median scores for perceived risk, perceived responsibility and perceived control were clustered close to the neutral Likert scale answer 'neither agree nor disagree', indicating that most participants did not feel strongly about the risk of loss from natural hazards, or the positioning of responsibility for the occurrence or the mitigation of natural hazards (Figure 4). However, observed participant scores covered almost the full range of the possible scores, indicating that some people do hold strong views about natural

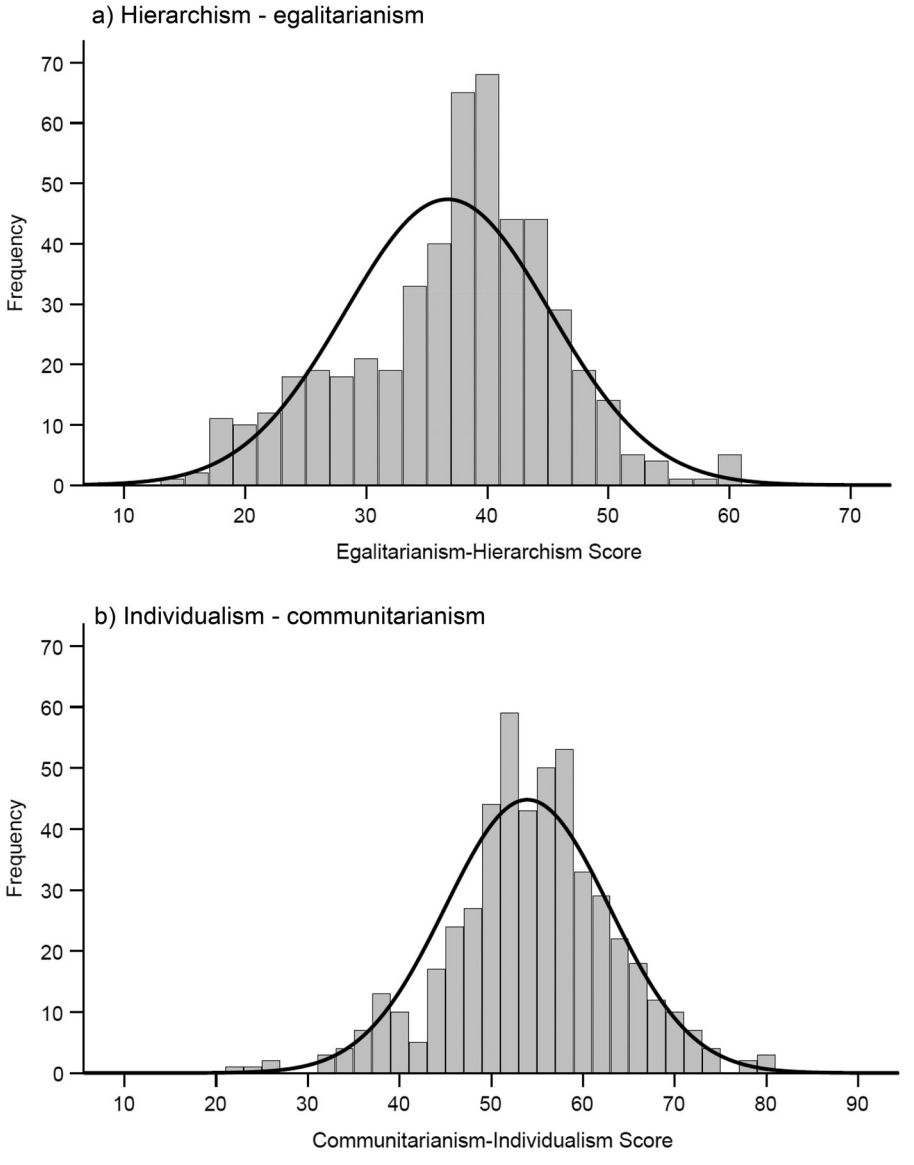

Figure 3. Range and frequency distribution of the: (a) hierarchism-egalitarianism (HE), and (b) individualism-communitarianism (IC) scores for all participants. The curve shows the normal distribution.

Table 2. Associations between demographic variables and the hierarchism-egalitarianism (HE) and individualism-communitarianism (IC) scores.

	HE Score		IC Score	
Demographic variable	R^2	Beta	R^2	Beta
Sex	0.071**	−4.615	0.004	−1.133
Age group	0.034**	0.073	0.022**	0.062
Location	0.019*	2.449	0.028**	3.118
Education	0.029**	−1.188	0.031**	−1.297

* $p < .05$; ** $p < .001$.

hazard risk, responsibility and/or control (Figure 4). This was generally consistent across all hazard types, except for the slightly lower perceived risk of flood and earthquake compared to bushfire and storm (Figure 4(a)). Median scores for trust in impersonal and personal sources of natural hazard information were higher than the neutral answer for all hazard types, indicating that most participants have trust in both these sources of

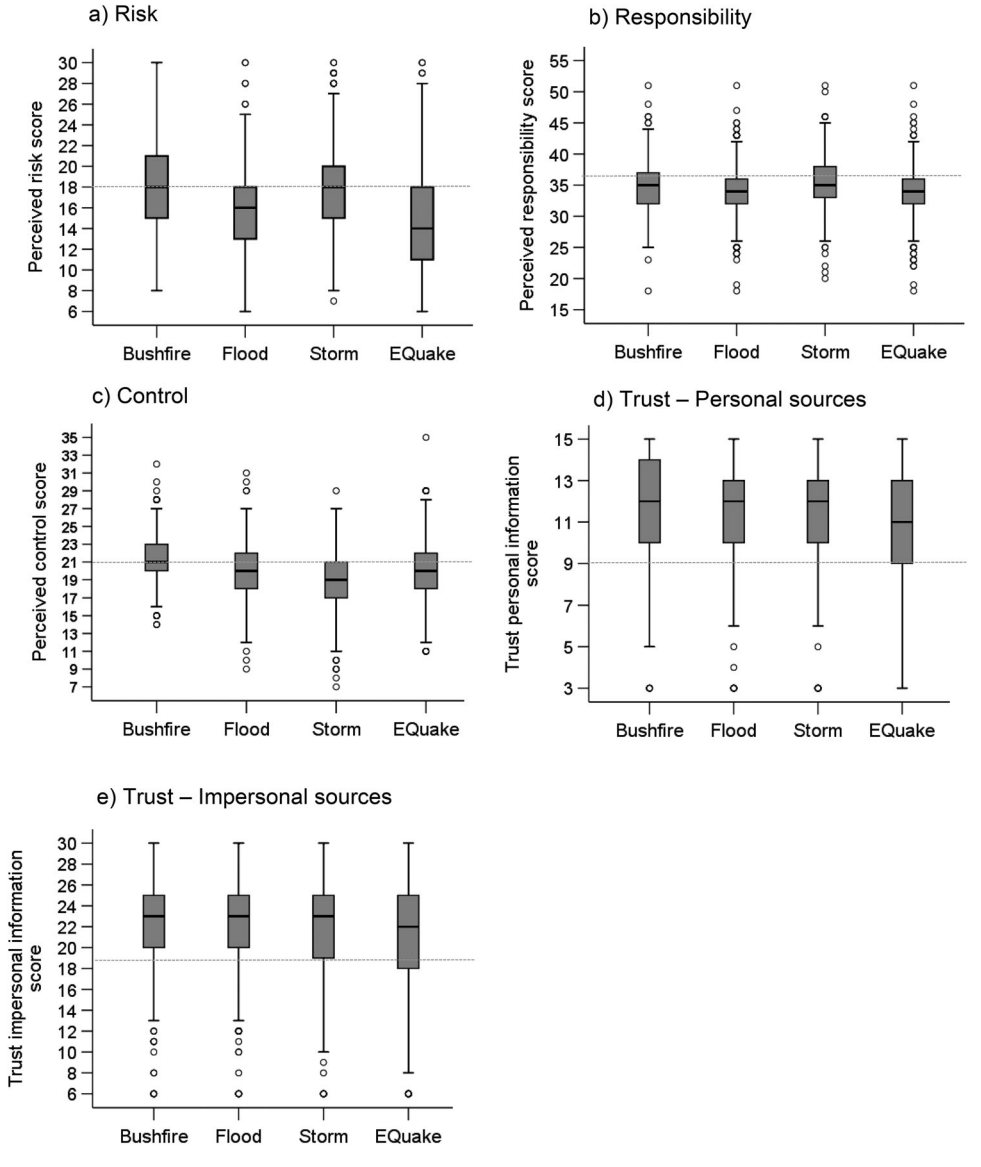

Figure 4. Participant scores for the: (a) risk, (b) responsibility, (c) control, (d) trust in personal sources of information and (e) trust in impersonal sources of information scales of natural hazard perception for bushfire, flood, storm and earthquake (EQuake). The Y-axis shows the full range of each scale. The dashed line shows the value corresponding to an average overall Likert scale answer of 'neither agree nor disagree' (risk, responsibility and control scales) or 'neither trust nor distrust' (trust scales). Boxplots show median, first and third quartiles, range and outliers.

natural hazard information (Figure 4(d,e)). Again, participant scores covered almost the full range of the scale, indicating that some people do distrust personal or impersonal sources of information (Figure 4(d,e)).

Cultural worldviews and perceptions of natural hazard risk

Several aspects of natural hazard risk perception were predicted by cultural worldviews (Table 3). R^2 values were low, indicating that although significant and directional, these associations were weak (Table 3). This is likely related to the proportion of the sample not displaying either strong cultural worldviews (Figure 3) or risk perceptions (Figure 4).

Perception of greater risk of bushfire or storm was associated with stronger egalitarianism, as well as stronger individualism. There was no significant association between cultural worldviews and perception of the risk of floods or earthquakes.

Perception of greater self-responsibility for bushfire, flood, storm and earthquake was significantly associated with stronger individualism. In contrast, there was no significant association between hierarchism or egalitarianism and perceived responsibility for natural hazards.

Perception of greater control and mitigation of bushfire and flood was significantly associated with stronger hierarchism, while perception of greater control of earthquake was significantly associated with stronger egalitarianism. There was no association between perception of greater control of storms and hierarchism or egalitarianism. Likewise, there was no association between perceived control of natural hazards and the individualism or communitarianism worldviews.

Greater trust in personal sources of information about bushfires, floods and storms was significantly associated with stronger egalitarianism. However, this relationship was not significant for personal sources of information about earthquake. Greater trust in personal sources of information about bushfire was significantly associated with stronger individualism. However, there was no association between trust in personal sources of information about floods, storms and earthquakes and individualism or communitarianism.

Greater trust in impersonal sources of information about bushfires, floods, storms and earthquake was significantly associated with stronger egalitarianism. There were no associations between trust in impersonal sources of information and individualism or communitarianism.

Inclusion of demographic factors in the regression model alongside the HE and IC axis scores changed the model fit, but the prediction of risk perception remained generally weak (Table 4). Younger participants perceived less risk of bushfire, flood, storm and earthquake. Participants in regional/remote locations perceived greater risk of loss from bushfires than metropolitan participants, but participants in metropolitan postcodes perceived greater risk of loss from earthquakes than the regional/remote participants. Participants in regional/remote locations also perceived greater self-responsibility for bushfires and storms. Demographic associations with perceived control varied markedly across hazard types. Increasing age and lower levels of education were associated with perceptions of greater control and mitigation of bushfire, while younger males perceived greater control and mitigation of earthquakes. Younger age was also associated with perceptions of greater control and mitigation of storms. Female participants living in a regional/remote location and who were of a younger age reported greater trust in personal

Table 3. Associations between perception of natural hazards and the hierarchism-egalitarianism (HE) and individualism-communitarianism (IC) worldviews, for bushfire, flood, storm and earthquake.

Hazard Type	Predictor	B	SE B	Beta	*t*	*p*
Perceived risk						
Bushfire	HE Score	−0.073	0.028	−0.139	−2.634	.009*
	IC Score	0.071	0.026	0.143	2.711	.007*
Flood	HE Score	−0.027	0.026	−0.056	−1.046	.296
	IC Score	0.016	0.025	0.034	0.631	.598
Storm	HE Score	−0.070	0.026	−0.141	−2.657	.008*
	IC Score	0.037	0.025	0.077	1.462	.144
Earthquake	HE Score	0.011	0.029	0.019	0.364	.716
	IC Score	−0.043	0.028	−0.083	−1.552	.121
Perceived responsibility						
Bushfire	HE Score	0.007	0.025	0.015	0.285	.776
	IC Score	0.123	0.023	0.270	5.277	.000**
Flood	HE Score	0.000	0.023	0.000	0.005	.996
	IC Score	0.132	0.022	0.305	6.003	.000**
Storm	HE Score	−0.031	0.023	−0.608	−1.340	.181
	IC Score	0.156	0.022	0.357	7.078	.000**
Earthquake	HE Score	−0.010	0.023	−0.021	−0.419	.676
	IC Score	0.166	0.022	0.372	7.481	.000**
Perceived control						
Bushfire	HE Score	0.044	0.017	0.135	2.576	.010*
	IC Score	0.028	0.016	0.091	1.738	.083
Flood	HE Score	0.049	0.018	0.142	2.673	.008*
	IC Score	−0.020	0.017	−0.061	−1.160	.246
Storm	HE Score	0.009	0.020	0.026	0.480	.631
	IC Score	−0.032	0.019	−0.091	−1.713	.087
Earthquake	HE Score	−0.044	0.020	−0.113	−2.147	.032*
	IC Score	−0.018	0.019	−0.049	−0.934	.351
Trust in personal information						
Bushfire	HE Score	−0.043	0.015	−0.153	−2.895	.004*
	IC Score	0.035	0.014	0.131	2.481	.013*
Flood	HE Score	−0.036	0.015	−0.123	−2.328	−.074
	IC Score	0.025	0.015	0.090	1.706	.023*
Storm	HE Score	−0.034	0.015	−0.120	−2.254	.025*
	IC Score	0.027	0.014	0.100	1.882	.060
Earthquake	HE Score	−0.031	0.017	−0.100	−1.884	.060
	IC Score	0.006	0.016	0.021	0.398	.691
Trust in impersonal information						
Bushfire	HE Score	−0.139	0.027	−0.266	−5.214	.000**
	IC Score	−0.022	0.025	−0.045	−0.855	.377
Flood	HE Score	−0.137	0.027	−0.262	−5.177	.000**
	IC Score	−0.019	0.025	−0.039	−0.761	.447
Storm	HE Score	−0.105	0.028	−0.198	−3.819	.000**
	IC Score	−0.036	0.026	−0.071	−1.367	.172
Earthquake	HE Score	−0.132	0.029	−0.235	−4.604	.000**
	IC Score	−0.045	0.027	−0.084	−1.647	.100

* $p < .05$; ** $p < .001$.

sources of information about floods, storms and earthquakes, while female participants perceived greater trust in impersonal sources of information about earthquakes.

Discussion

Reducing the risks of natural hazards such as bushfires, storms, floods and earthquakes is a key challenge for communities worldwide. Implicit in this strategic intent for disaster risk reduction is that hazard risks can be identified and treated, thereby saving lives, reducing loss and increasing preparedness (UNDRR, 2015). Much of this activity is achieved through

Table 4. Associations between perception of natural hazards and the hierarchism-egalitarianism (HE) and individualism-communitarianism (IC) worldviews in a model including demographic factors age, location (metropolitan or regional/remote), sex and education level.

Hazard Type	Predictor	B	SE B	Beta	*t*	*p*
Perceived risk						
Bushfire	HE Score	−0.047	0.028	−0.091	−1.660	0.098
	IC Score	0.063	0.026	0.128	2.241	0.016*
	Age	−0.026	0.010	−0.0128	−2.700	0.007*
	Location	1.019	0.425	0.111	2.395	0.017*
	Sex	0.947	0.424	0.105	2.232	0.026*
	Education	0.083	0.165	0.023	0.503	0.615
Flood	HE Score	−0.015	0.027	−0.030	−0.551	0.582
	IC Score	0.022	0.025	0.047	0.887	0.376
	Age	−0.051	0.009	−0.265	−5.621	0.000**
	Location	0.235	0.400	0.027	0.588	0.557
	Sex	−0.189	0.399	−0.022	−0.474	0.636
	Education	−0.126	0.155	−0.037	−0.814	0.416
Storm	HE Score	−0.061	0.028	−0.123	−2.226	0.026*
	IC Score	0.035	0.025	0.074	1.379	0.169
	Age	−0.024	0.009	−0.122	−2.554	0.011*
	Location	0.367	0.412	0.042	0.891	0.373
	Sex	0.163	0.411	0.019	0.397	0.691
	Education	−0.127	0.160	−0.037	−0.793	0.428
Earthquake	HE Score	0.040	0.030	0.072	1.333	0.183
	IC Score	−0.026	0.029	−0.049	−0.932	0.352
	Age	−0.033	0.010	−0.151	−3.222	0.001*
	Location	−1.393	0.447	−0.143	−3.117	0.002*
	Sex	0.364	0.446	0.038	0.816	0.415
	Education	0.297	0.173	0.078	1.715	0.087
Perceived responsibility						
Bushfire	HE Score	−0.0006	0.026	−0.011	−0.216	0.829
	IC Score	0.117	0.023	0.259	5.018	0.000**
	Age	0.012	0.009	0.062	1.339	0.181
	Location	1.037	0.381	0.122	2.720	0.007*
	Sex	−0.312	0.380	−0.038	−0.820	0.412
	Education	0.118	0.148	0.036	0.799	0.425
Flood	HE Score	−0.005	0.024	−0.011	−0.197	0.844
	IC Score	0.130	0.022	0.299	5.785	0.000**
	Age	0.002	0.008	0.010	0.213	0.831
	Location	0.324	0.365	0.040	0.887	0.375
	Sex	−0.124	0.365	−0.016	−0.340	0.734
	Education	−0.042	0.142	−0.013	−0.299	0.765
Storm	HE Score	−0.042	0.024	−0.091	−1.738	0.083
	IC Score	0.150	0.022	0.344	6.807	0.000**
	Age	0.019	0.008	0.107	2.367	0.018*
	Location	0.961	0.360	0.118	2.668	0.008*
	Sex	−0.148	0.359	−0.019	−0.411	0.681
	Education	0.203	0.140	0.063	1.454	0.146
Earthquake	HE Score	−0.012	0.025	−0.024	−0.468	0.640
	IC Score	0.161	0.023	0.361	7.158	0.000**
	Age	0.015	0.008	0.078	1.738	0.083
	Location	0.410	0.367	0.049	1.116	0.265
	Sex	0.196	0.367	0.024	0.536	0.592
	Education	0.101	0.142	0.031	0.712	0.477
Perceived control						
Bushfire	HE Score	0.035	0.018	0.107	1.980	0.048*
	IC Score	0.018	0.016	0.059	1.132	0.258
	Age	0.011	0.006	0.084	1.801	0.072
	Location	0.600	0.264	0.104	2.274	0.023*
	Sex	0.035	0.263	0.006	0.134	0.894
	Education	−0.220	0.102	−0.097	−2.150	0.032*
Flood	HE Score	0.042	0.019	0.121	2.175	0.030*

(*Continued*)

Table 4. Continued.

Hazard Type	Predictor	B	SE B	Beta	*t*	*p*
	IC Score	−0.018	0.018	−0.054	−1.010	0.313
	Age	−0.003	0.007	−0.021	−0.426	0.670
	Location	0.168	0.288	0.028	0.585	0.559
	Sex	−0.409	0.287	−0.068	−1.426	0.154
	Education	0.022	0.122	0.009	0.197	0.844
Storm	HE Score	0.007	0.021	0.018	0.327	0.744
	IC Score	−0.025	0.019	−0.072	−1.345	0.179
	Age	−0.016	0.007	−0.111	−2.302	0.022*
	Location	−0.371	0.306	−0.057	−1.210	0.227
	Sex	−0.451	0.306	−0.071	−1.476	0.141
	Education	−0.098	0.119	−0.038	−0.828	0.408
Earthquake	HE Score	−0.054	0.021	−0.141	−2.558	0.011*
	IC Score	−0.012	0.020	−0.032	−0.602	0.547
	Age	−0.016	0.007	−0.104	−2.188	0.029*
	Location	0.222	0.318	0.032	0.697	0.486
	Sex	−0.814	0.317	−0.122	−2.567	0.011*
	Education	−0.007	0.123	−0.002	−0.053	0.958
Trust in personal information						
Bushfire	HE Score	−0.036	0.016	−0.127	−2.295	0.022*
	IC Score	0.032	0.014	0.120	2.245	0.025*
	Age	−0.007	0.005	−0.061	−1.266	0.206
	Location	0.374	0.233	0.075	1.604	0.109
	Sex	0.301	0.233	0.062	1.292	0.197
	Education	0.033	0.090	0.017	0.366	0.715
Flood	HE Score	−0.028	0.016	−0.097	−1.756	0.080
	IC Score	0.021	0.015	0.078	1.445	0.149
	Age	−0.007	0.005	−0.063	−1.304	0.193
	Location	0.507	0.241	0.099	2.106	0.036*
	Sex	0.317	0.240	0.063	1.321	0.187
	Education	0.052	0.093	0.026	0.552	0.581
Storm	HE Score	−0.021	0.016	−0.073	−1.331	0.184
	IC Score	0.023	0.014	0.085	1.604	0.109
	Age	−0.013	0.005	−0.113	−2.378	0.018*
	Location	0.536	0.236	0.106	2.272	0.024*
	Sex	0.506	0.235	0.102	2.151	0.032*
	Education	0.059	0.091	0.029	0.642	0.521
Earthquake	HE Score	−0.019	0.017	−0.063	−1.133	0.258
	IC Score	0.004	0.016	0.014	0.254	0.800
	Age	−0.014	0.006	−0.113	−2.367	0.018*
	Location	0.547	0.256	0.100	2.137	0.033*
	Sex	0.365	0.255	0.068	1.428	0.154
	Education	0.102	0.099	0.048	1.032	0.302
Trust in impersonal information						
Bushfire	HE Score	−0.136	0.028	−0.261	−4.864	0.000**
	IC Score	−0.023	0.026	−0.047	−0.897	0.320
	Age	0.008	0.010	0.040	0.866	0.387
	Location	−0.280	0.419	−0.030	−0.669	0.504
	Sex	0.231	0.418	0.026	0.552	0.581
	Education	0.013	0.162	0.003	0.078	0.938
Flood	HE Score	−0.130	0.028	−0.247	−4.601	0.000**
	IC Score	−0.023	0.026	−0.046	−0.888	0.375
	Age	0.008	0.010	0.038	0.808	0.419
	Location	−0.081	0.421	−0.009	−0.193	0.847
	Sex	0.507	0.420	0.056	1.207	0.228
	Education	0.025	0.163	0.007	0.153	0.878
Storm	HE Score	−0.089	0.029	−0.168	−3.095	0.002*
	IC Score	−0.040	0.026	−0.079	−1.506	0.133
	Age	0.005	0.010	0.023	0.483	0.629
	Location	−0.139	0.431	−0.015	−0.323	0.747
	Sex	0.836	0.430	0.091	1.944	0.052
	Education	0.063	0.167	0.017	0.375	0.708

(*Continued*)

Table 4. Continued.

Hazard Type	Predictor	B	SE B	Beta	*t*	*p*
Earthquake	HE Score	−0.111	0.030	−0.197	−3.684	0.000**
	IC Score	−0.050	0.028	−0.093	−1.802	0.072
	Age	−0.003	0.010	−0.012	−0.268	0.789
	Location	0.126	0.449	0.013	0.281	0.779
	Sex	0.994	0.448	0.102	2.217	0.027*
	Education	0.122	0.174	0.031	0.701	0.483

* $p < .05$; ** $p < .001$.

the implementation of policies and programmes that address natural hazard threats and assist communities, households and individuals to prepare for these events. However, there is a diversity of interactions among people, the hazard, and their protective decision-making (McIvor et al., 2009). Understanding the relationships between people's beliefs and the risk of natural hazards can support the development of programmes that achieve better disaster risk reduction, resilience, and/or public safety outcomes because activities can be made consistent with individual values (McIvor et al., 2009). In this article, we examined the perception of natural hazards using the cultural theory of risk. The cultural theory of risk proposes that membership of social groups – cultural worldviews – is associated with preferences that maintain sociality and which subsequently engender beliefs about what constitutes risk (Wildavsky & Dake, 1990). Associations between cultural worldviews and natural hazard risk perception identify the range of beliefs and values that might influence protective decision making.

We found some, but limited, evidence of relationships between cultural worldviews and natural hazard risk perception in a sample of the general population of New South Wales, Australia. Individualists perceived greater risk from natural hazards and greater personal (self) responsibility in the face of natural hazards. Individualists may perceive the risks of flood, bushfire, storm and earthquake natural hazards to be a disruptive threat that limits freedoms and disrupts markets, and take responsibility for minimising the disruptive effects of natural hazard events because they prefer to 'fend for themselves without interference' (Kahan, 2012). Egalitarians perceived greater risk from natural hazards, possibly because they may recognise the 'naturalness' of these processes, as well as the potential for social impacts of natural hazard events, and favour an ethical and collective response to natural hazard risk awareness. The notion of control and mitigation of natural hazards was associated with hierarchism, likely because hierarchists believe that risks are acceptable if regulated by experts and authorities. However, this association was only significant for bushfire and flood, possibly reflecting the way that government and emergency service agencies in Australia are mandated to conduct bushfire and flood risk management activities such as hazard reduction burning, firefighting, flood evacuation, land use planning and the construction of dams and levees. Oddly, egalitarians perceived greater control of earthquake, possibly because the risk of major earthquakes is low in Australia, or because this is a geophysical, as opposed to a climate-influenced, hazard. Egalitarians discredit existing authority for ignoring the welfare of its citizens (Thompson et al., 1990), and climate change influences on the severity of natural hazards may be perceived as a failure of the state to care for its citizens.

Trust in both personal and impersonal sources of information about natural hazards was associated with egalitarianism for most hazards. Egalitarians have strong group

bounding and determination (Thompson et al., 1990). Social trust may arise from individual choices by egalitarians subject to group determination, because cooperation and sharing of information with others is part of group participation. Egalitarians would be expected to be distrustful of information from authoritative powers (Marris et al., 1998); however, in this study, there was an association between egalitarianism and trust in impersonal sources of information from sources such as emergency service agencies, the Bureau of Meteorology and local councils. Wachinger et al. (2013) showed that trust in authorities and experts was a substantial influence on risk perception and protective actions for natural hazards. Australian emergency service authorities are highly trusted by and engaged with the public, and have a volunteer base drawn from communities. This may explain the egalitarian trust in impersonal sources of information where experts, authorities, and services are considered as bounded within the group, with a clear mandate to assist everyone in preparing for and responding to emergencies, supported by a long-established ethos of volunteerism. Individualists trusted personal sources of information about bushfires from family and friends. Individualists value personal responsibility, do not like to be controlled by others, and may not believe that experts and authorities can be trusted to maintain freedoms. Individualists appear to rely on bushfire information from within a circle of those that they control or reinforce. Consistent with this interpretation, in a recent study of COVID-19 health measures, individualists had lower social trust, higher interpersonal trust and lower levels of acceptance of the implementation of health measures (Siegrist & Bearth, 2021).

The weak, but directional, relationships between cultural worldviews and natural hazard risk perception shown in this study are commensurate with the findings of other studies. In a test of cultural theory in France, the highest correlation between cultural worldviews and risk factors was 0.20, but many correlations were significant (Brenot et al., 1998). In another study in the United Kingdom, the highest correlation between cultural worldviews and risk factors was 0.34, many correlations were not significant, and cultural worldviews explained only 14% of the variance in risk perceptions (Marris et al., 1998). That study also found that only 32% of their sample could be clearly allocated to a cultural worldview, similar to the 30% of people in our study with strongly held cultural worldviews. A meta-analysis of 21 studies of cultural worldviews of risk showed that few studies produced effect sizes above 0.30 (Xue et al., 2014). That our test also had similar weak relationships suggests that there is also much middle-ground in the Australian sample. Sociality was generally weakly defined, with 70% of participants not holding strong grid or group sociality. It appears that for some individuals, their group or grid sociality is then related to their views of what constitutes risk associated with natural hazards in Australia; however, for others, there appears to be no relationship to sociality and it is likely that other cues influence risk perception (Sjoberg, 2000; Xue et al., 2014). It is worth noting that when creating the online survey, we included a middle-ground response option (neither agree nor disagree), which does not appear in the original measure. It is possible that offering this non-committal answer may have allowed participants to cluster around the scale mean in ways unintended by the scale's authors. However, given the consistent findings with previous studies showing a general lack of extreme viewpoints on this scale in Australia and other non-American countries, we would argue that any effect this may have had is likely to

have been low, and thus we can have some confidence that the results would have been similar even had we not included this response option.

The lack of associations between cultural worldviews and natural hazard risk perception in this study might be explained by two factors: first, limitations of cultural theory, and second, cognitive, behavioural and affective influences on risk perception. Tests of cultural theory generally explore the perception of risk associated with a range of man-made, technological and natural hazards. Associations between cultural worldviews and risk often reflect the origin of the hazard as voluntary or created by man (Brun, 1992), with egalitarian worldviews correlated with environmental threats, and hierarchical worldviews with social threats (Brenot et al., 1998; Dake, 1991; Marris et al., 1998; Xue et al., 2014). Differences in the perception of risk among dichotomous cultural worldviews in this study may have been obscured by the inclusion of only one broad risk type – that of voluntary natural hazards. Critics of the use of cultural theory in risk research question whether individual data can be used to infer group properties (Rippl, 2002). Alignment to ways of life might change through time in response to individual circumstances (Thompson et al., 1990), but there is little to no understanding of whether such changes might coincide with a change in risk perceptions that reinforce the new way of life. Further, although the original intent of cultural theory was to theorise how culture was central to explaining social life using the grid and group dimensions, applications such as the cultural cognition of risk (the variant of cultural theory used in this study) remain problematic and have been criticised as being American-centric (van der Linden, 2016), with North American studies consistently producing larger effect sizes than those found in studies conducted on other populations (Xue et al., 2014). The weak delineation of cultural worldviews, and weak associations between cultural worldviews and the perception of natural hazard risks observed in this study, may reflect these limitations of cultural theory. Most likely, cultural worldviews are a poor fit for understanding sociality of Australian society.

The second explanation for the lack of associations between cultural worldviews and natural hazard risk perception in this study might be cognitive and affective factors that determine risk awareness and decisions to address and prepare for natural hazards. The literature on cognitive and affective aspects of disaster preparation is large (see Paton & McClure, 2013), and suggests that a variety of cognitive processes influence the perception of risk and subsequent adoption of protective actions (Ejeta et al., 2015; Eiser et al., 2012). McNeill et al. (2013) showed that preparedness actions were positively associated with the perception of bushfire risk and protection responsibility. In the same sample, lack of preparedness was associated with higher indecisiveness and higher trait anxiety (McNeill et al., 2016). Strahan et al. (2019) found that the decision to self-evacuate prior to a bushfire was predicted by official warnings, threat to property, and the perception that self-evacuation is protective to safety. In the same sample, Strahan et al. (2018) identified seven self-evacuation archetypes based on factors influencing appraisal of bushfire threat and subsequent evacuation response. The archetypes include threat deniers, responsibility deniers, experienced independents, dependent evacuators and community guided (Strahan et al., 2018), suggesting that the characteristics of cultural worldviews of risk might be similar to those that explain evacuation intents, but that the relationships are stronger when examined in a community in a bushfire prone area and in relation to a specific risk reduction action such as evacuation. Further research could explore

associations between evacuation archetypes as an alternative framing of natural hazard risk and threat perception, and the sociality of cultural worldviews.

Much of the research on risk perception and protective action focuses on at-risk populations in relation to specific hazards such as bushfires or cyclones, often post-event (see reviews in Kellens et al., 2013; Koksal et al., 2019). However, understanding generalised risk perception is pertinent to the ways that disaster risk is managed through strategic, policy and operational intents. McLennan and Handmer (2012) proposed a responsibility continuum for the management of risk, with the sharing of responsibility for natural hazard risk influenced by position on the continuum. At the self-reliance end of the continuum, those at-risk decide what to do and use their own means to take action. At the central authority end of the continuum, those in authority direct all actions to manage risk. These axes potentially correspond to the hierarchism (central authority) and individualism (self-reliance) cultural worldviews. Another framing of values trade-offs for shared responsibility in bushfire management proposed two axes of public-private interests and control/choice (McLennan & Eburn, 2015). Paternal communitarian (public values/control), autonomous communitarian (public values/choice), autonomous individual (private interests/choice) and paternal individual (private interests/control) scenarios influence responsibility for bushfire risk in legal and governance systems (McLennan & Eburn, 2015). For example, in the paternal communitarian scenario, responsibility would likely be vested in a government authority with the power to compel compliance, with advantages of firm risk mitigation decisions for all, but disadvantages of high transaction costs (McLennan & Eburn, 2015). In the autonomous communitarian scenario, communities would be free to make collective risk management decisions, with advantages of informed citizenry, but disadvantages of local conflicts and accountability (McLennan & Eburn, 2015). Although the axes proposed by McLennan and Handmer (2012) and McLennan and Eburn (2015) align with characteristics of cultural worldviews, the present study suggests that views or values may not be strongly held and only about 30% of people might clearly align onto these heuristic axes. Combined with the archetypes uncovered by Strahan et al. (2018), the generalised picture of who fears natural hazards and why, and how they perceive natural hazard risk in Australia, is likely to be complex, bringing together sociality, experience, hazard type, cognition and affect. Single heuristics, including the present application of cultural theory, are unlikely to capture such complexity (Tierney, 1999). Further research on integrating risk perception heuristics, including testing in the general population, would be of great benefit given the potential for increasing natural hazard losses in Australia.

Conclusion

This paper proposed that perception of the risk of bushfire, flood, storm and earthquake might be associated with cultural worldviews and the support for maintaining preferred ways of life. The findings suggest that many people do not view natural hazards as a threat to their way of life, consistent with other studies that have examined cultural worldviews of risk (Sjoberg, 2000). At the same time, the weak but directional relationships between some cultural worldviews and the perception of the risk of some types of natural hazards suggest natural hazard risk perception can be biased by sociality in Australia. These inconclusive and contrasting findings may be related to the non-universality

of the cultural theory of risk, which originated in the United States to explore the social origins of views on risk, but which has had limited success in explaining views on risk in other Western countries (Sjoberg, 1998; Xue et al., 2014) and little to no application in non-Western settings. The cultural theory of risk does not appear to fully explain who fears what and why in Australia, and future research should attempt to integrate a range of epistemological perspectives and methodologies into a local understanding of natural hazard risk perception that acknowledges diverse populations. Further, the study examined natural hazard risk perception in the general population at a time when there had been no major recent natural hazard events in the area from which the sample was drawn. Since the study was undertaken, a series of major and widespread events have occurred in this area (drought, bushfire, flood, pandemic, storm). Further research could determine if the perception of risk, and associations with sociality, have changed since these events occurred.

Understanding of what people do in the face of risk, what advice they accept and the actions they engender is increasingly part of the design and implementation of hazard specific preparation programmes (e.g., Victorian Government, 2021; Whittaker et al., 2020). Research into the segmentation of risk perception and relationships with natural hazard decision making within the general public is an important area of research because it assists emergency and other service providers, communities, and policy makers to identify the values that influence the adoption of risk treatments and protective actions. However, broader policy settings of risk reduction do not often address the socio-psychological settings within which disaster risk reduction takes place. Despite successful application of segmentation approaches such as archetypes (e.g., Strahan et al., 2019) the findings of the present study suggest that segmentation of the Australian population by cultural worldviews of risk is not a viable segmentation approach and is likely of limited utility for adoption into preparation programmes or disaster risk reduction strategy, except as part of a new and integrated heuristic that captures the complexity of potential influences on natural hazard risk perception in Australia.

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