



Examining associations between citizens' beliefs and attitudes about uncertainty and their earthquake risk judgments, preparedness intentions, and mitigation policy support in Japan and the United States



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ABSTRACT

Although hazards are inherently uncertain, research on citizens' judgments of risk, hazard preparedness, and support for mitigation policies has rarely accounted for citizens' beliefs about the uncertainty of fields estimating hazard risk or in science as providing accurate, unbiased knowledge, nor citizens' need to achieve quick, certain answers. Parallel online surveys of residents of earthquake-prone areas of Japan and the United States revealed that belief in scientific positivism increased policy support in both countries (as did need for closure among Americans), and belief in seismological uncertainty reduced judged earthquake risk in Japan, with small effect sizes. Preparedness was unaffected by these predictors. Associations of other factors (quake experience; trust in experts; demographics) with dependent variables were consistent with other studies, and Japanese-American differences were small on dependent variables and in most predictors. Motivation (i.e., high involvement with the topic, relevance of the fictional earthquake rupture forecast in a quasi-experiment embedded in the survey, and judged ability to use its information) strongly affected judged risk, preparedness and policy support. Low-motivation Japanese and high-motivation Americans exhibited associations most similar to overall findings for their nations. Implications of these findings for hazards research and risk communication are discussed.

1. Introduction

Understanding public beliefs about, and potential reactions to, earthquake risk estimates can support full and frank communication to minimize citizens' over- or under-reaction in their own judgments of risk, preparedness behavior, and support for earthquake mitigation policy. This paper reports modest associations between these dependent variables and uncertainty-relevant beliefs (uncertainty in seismology, scientific positivism) or personal attributes (need for closure) based on parallel surveys of Japanese and American samples.

2. Background

2.1. Examining potential uncertainty predictors of public earthquake responses

Seismologists have worked for decades on improving earthquake rupture forecasts, which provide an estimated probability for a given magnitude event in a locality over a given time period [1–3]. Ideally, such forecasts would inform lay judgments of major earthquake risk,

and thus foster appropriate levels of preparedness and support for mitigation policy. This result would be enhanced if laypeople understood the limits of scientific understanding without seeing seismology as too uncertain for a useful guide to earthquake risk. If laypeople instead insisted that true science is and must be absolutely certain, view seismology as falling short on this criterion, or demand certainty in their own lives, seismic risk estimates might be ignored or misinterpreted. The aim here is to probe whether and how such beliefs and personal attributes might affect public judgments of local earthquake risk, preparedness intentions, and mitigation policy support.

Earthquake risk for current purposes is the estimated probability (e.g., 20%) that a M 8 earthquake would occur in the locality in a given period (e.g., 30 years). Seismological estimates of this sort are subject to varied sources of technical uncertainty [4], but the focus here is rather potential *perceptions* of uncertainty in general among *public* observers of these forecasts. For example, people might be disturbed or complacent about cues of uncertainties in seismic risk estimates (e.g., if they wrongly interpret the probability attribute in forecasts as indicating uncertainty), either because they see science in general or seismology in particular as certain, or due to personal aversion to uncertainty and

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ambiguity. Our aim was to probe whether lay people see seismology as a discipline offering certainty (seismological uncertainty), and whether this belief—plus belief that science yields objective truth (scientific positivism), or a tendency to demand certainty in one's life (need for closure)—are associated with lay judgments of earthquake risk, preparedness or mitigation policy support. By contrast, most research on public response to expert uncertainty regarding hazards has concerned experts providing ranges of risk estimates [5–9], and some research has probed whether the lay observer expresses personal uncertainty about an issue [10]. While the effect of the three uncertainty predictors is the main focus of this paper, a secondary goal was assessing whether these relationships differed between Japanese and Americans living in earthquake-prone areas.

2.2. Factors in earthquake responses

Although the aim here was not to test existing models of judged risk, preparedness, or mitigation policy support, inclusion of selected measures from such models allowed for testing whether the hypothesized uncertainty predictors added significantly, much less substantively, to conventional approaches. The measures selected here included earthquake experience, trust in seismic experts, and demographic variables, as earthquake perception research has found that they are associated with judged risk, preparedness, and support for earthquake mitigation policy. This evidence is strongest for earthquake experience, judged risk and preparedness; the sign and magnitude of associations for trust and demographics can vary widely, and policy support has been much less studied [11–20].

2.3. Uncertainty predictors

Little research has explored lay beliefs about the certainty or uncertainty of different professional or expert fields. Studies with American subjects found that laypeople see different scientific fields as varying in the certainty of their findings or forecasts—e.g., forensics as most certain and psychology as least certain, with seismology rated about as precise as nuclear physics [21], or forecasts involving physics and engineering as most certain and for economics, politics and crime as least certain [22]. For earthquake risk estimates specifically, would seismology be deemed a field relatively certain (e.g., as involving geophysics), or would traditional notions of the “more or less random” occurrence of a major quake (see [23], p. 29) undermine belief in its certainty? Assuming the public deems seismology relatively uncertain, this might affect their own beliefs about and responses to earthquake risks.

Belief in scientific positivism entails belief that science offers accurate, unbiased and value-neutral information about the world accessible to all peoples. This belief is stronger among the general public and activists than among ecological scientists and public lands managers [24,25], and has been associated with whether laypeople select “incompetence,” for example, as a good reason for why disputes occur among scientists [26]. This factor has not been applied in the hazards field before, but many people interpret experts who provide ranges of risk estimates (i.e., uncertain estimates) as being dishonest and/or incompetent [5]. Belief that science is accurate and certain may lead to expectations that seismology should be as well, adversely affecting earthquake-related beliefs and intentions if seismic risk estimates seem uncertain.

Need for closure is a personal trait, whether enduring or situation-specific, which entails desire for “an answer on a given topic, any answer ... compared to confusion and ambiguity” ([27], p. 337). It can be reflected in desire for predictability, preference for order and structure, discomfort with ambiguity, decisiveness, and close-mindedness; for example, a person with this trait wants to quickly and permanently seize upon an answer, to avoid the aversive quality of chaos, disorder and ambiguity [28]. The uncertainty of future events,

including hazard events, is likely to threaten people with high need for closure, perhaps enhancing preparedness action and hazard mitigation policy support: if I take personal action and support public action, I can be confident damages will not occur. Need for closure's impact on judged risk is less clear, as it might induce people to extreme views, such as very high or very low (denial) judgments of seismic risk. Concern about Ebola in the U.S. was positively associated with this need [29].

2.4. Cross-national comparisons

In probing the role of these beliefs and cognitive styles in hazard views, we also wanted to account for variation across societal contexts. A long tradition of cross-national contrasts has demonstrated that hazard perception processes in one country generally appear in others, and explanations that work one place tend, within varying constraints, to work elsewhere. For example, factors in earthquake preparedness intentions—less likely than behavioral measures to be biased by either cultural context or other factors (e.g., resources)—were similar in seismically-similar areas of Japan (Kyoto) and New Zealand (Napier), despite their collectivist and individualist cultures, respectively [15]. A comparison of Japanese (suburban Yokohama) and American (western San Fernando Valley, southern California) views of earthquakes found Americans reported more preparedness actions despite higher Japanese concern and higher Japanese support for raising taxes to mitigate earthquake risks; at both sites income predicted preparedness, but age was significant only in Japan [30]. Another example concerns cross-national risk perceptions and their explanations: psychometric research has found roughly similar “dread” and “knowledge” dimensions underlying hazard perceptions across nations using slightly different hazard lists and measures [31–34], and across four European countries trust and judged risk were weakly to moderately correlated [35].

Among the hypothesized predictors, comparative studies of beliefs about seismological uncertainty or scientific positivism do not appear to have been conducted. On need for closure (NFC), studies with business students found Japanese less likely than Canadian counterparts to rush to closure [36], and Americans most likely to rush to closure, Canadians less, and Japanese least [37], although these studies did not use the NFC measure applied here. Thus Japanese in this study might be expected to exhibit lower mean scores on NFC, but it is unclear whether NFC would be less associated with earthquake responses in Japan than in the U.S.

3. Methods

3.1. Seismic history of sample regions

Sample regions for this study were the Nagoya region in Japan and the San Francisco Bay area in the United States. The Nagoya region is near the subduction zone along the Nankai Trough, where the Philippine Sea plate subducts beneath the Eurasia plate at about 5 cm (cm) per year. This plate motion generates strain along the plate boundary; accumulated strain released as great earthquakes in 1498, 1605, 1707, 1854, and 1944. In the San Francisco Bay area, the San Andreas fault has the Pacific plate moving right-laterally relative to the North American plate at 5–6 cm/year. This plate motion caused the 1906 San Francisco earthquake (M 8.3) and an 1857 earthquake of about the same magnitude in southern California. Both plates have been linked with $M7$ earthquakes, such as the 1989 Loma Prieta earthquake (M 7.1) and the 2004 Kii Peninsula earthquake (M 7.4).

3.2. Samples

Online opt-in survey panels were used to recruit respondents, with panel members who were residents of the Nagoya and San Francisco Bay areas randomly invited (subject to quotas to represent the

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