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ORIGINAL RESEARCH REPORT

Can We Apply the Psychology of Risk Perception to Increase Earthquake Preparation?

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Can we encourage people to prepare for a natural disaster by altering the way that scientific information about risk is presented? In assessing the risk posed by a particular hazard, people tend to be guided more strongly by their emotional reactions than by logical or statistical analysis; human beings are driven to protect themselves from risks that that they have actually experienced, that are easy to envision, or that are linked to vivid, concrete images. Thus, even if people recognize that earthquakes pose an important threat, they may be unmotivated to take action to prepare for this abstract risk in the absence of direct personal experience. Harnessing past research and theorizing, we developed a novel intervention to transform scientific information into vivid, emotionally evocative imagery. In a pre-registered study, 411 participants were shown publicly available statistics or a vivid, scientifically-grounded image of what a local school would look like after a major earthquake. When invited to sign a petition to make schools safer, 77.3% participants agreed after looking at the image compared to 68% who agreed after looking at statistics. These findings suggest that using vivid images to communicate scientific information can be an effective strategy for motivating people to support risk mitigation initiatives.

Keywords: earthquakes; risk perception; analytic and experiential systems; dual processing theory; risk as feelings; affect heuristic; judgment and decision-making; applied social psychology

When asked how much damage would be expected from a major earthquake on the Cascadia fault in the Pacific Northwest, the director of the Federal Emergency Management Agency in this area responded, "Our operating assumption is that everything west of Interstate 5 will be toast" (Schulz, 2015). The Cascadia subduction zone reaches from California to Vancouver Island, and a rupture on the Northern end of this zone would wreak havoc on the West coast of Canada. Yet, residents remain severely underprepared for such a disaster. Thus, the overarching objective of the present research was to harness existing research and theory on the psychology of risk perception to motivate people to prepare for a major earthquake.

The lack of perceived urgency to prepare for earthquakes can be understood in light of psychological research on risk perception (e.g., Loewenstein, Weber, Hsee, & Welch, 2001; Slovic, Finucane, Peters, & MacGregor, 2004; Slovic & Peters, 2006). Building on other dual-processing theories of cognition (e.g., Epstein, 1994; Kahneman & Frederick, 2002), Slovic and colleagues (2004) proposed that risk perception depends on two distinct mental systems: the analytic system and the experiential system. The analytic system evaluates risk in a slow, effortful, logical manner, relying on abstract, quantitative information such as probability estimates. In contrast, the experiential system evaluates risk rapidly and intuitively, relying on gut feelings, past experiences, and vivid imagery. While the analytic system is vital for navigating our complex modern world, the experiential system is more evolutionarily ancient, and seems to play a more potent role in driving human behaviour. As Slovic et al. (2004) put it, the experiential system "remains the most natural and most common way to respond to risk" (p. 311).

Although the analytic system enables human beings to comprehend abstract, hypothetical hazards that they have never personally encountered, the experiential system is relatively insensitive to these forms of risk. Instead, the experiential system is sensitive to hazards that people have actually experienced or can vividly imagine. Consistent with Slovic et al.'s (2004) theoretical analysis, recent research suggest that people are much more likely to express concerns about natural disasters such as floods

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if they have actually experienced these dramatic events in the past (e.g., Miceli, Sotgiu, & Settanni, 2008). Thus, although our analytic systems enable us to understand on an intellectual level that earthquakes pose a significant risk, it may be difficult for our experiential systems to generate the kind of concern that would motivate us to adequately prepare. As Siegrist and Gutscher (2008) put it, "The challenge of risk communication lies not so much in providing rational information but in adequately addressing the experiential system. A big question remains: Can there be a substitute for direct, personal experience?" (p. 777).

Meanwhile, researchers in earthquake engineering have made substantial progress in modelling how specific buildings would respond in an earthquake (e.g., Mahsuli & Haukaas, 2013). However, these models are abstract and highly technical; from a psychological perspective, these models are valuable for processing risk through the analytic system, but are essentially meaningless to the experiential system. By integrating these recent advances in seismic engineering with advances in the psychology of risk perception, it may be possible to more effectively convey the risk posed by earthquakes—thereby bridging the gap between the analytic and experiential systems. Specifically, we hypothesized that people's motivation to prepare for earthquakes could be increased by showing them vivid, emotionally evocative images of what real buildings would like after an earthquake, based on the best available science. Building on Slovic et al.'s (2004) theorizing, we predicted that showing people vivid post-quake images of a local public building would have a stronger impact compared to showing them the kind of abstract quantitative information that is typically provided in public bulletins about the risk of earthquakes. Theoretically, seeing these images should arouse feelings of worry, thereby motivating people to prepare for earthquakes. Indeed, recent research suggest that the effort people devote to preparing for natural disasters is predicted better by their feelings of worry than by their estimates of how likely the natural disaster is to occur (Miceli et al., 2008). In the domain of public health, a recent randomized controlled trial with smokers demonstrated that people who were exposed to graphic images (e.g., diseased lungs) felt worse about smoking and were more motivated to quit than people who saw standard messages typically provided on cigarette packages (e.g., "Cigarettes are addictive"; Evans et al., 2015). This suggest that altering the way information about risk is communicated—by providing vivid images about possible outcomes—can be a powerful tool for promoting behaviour change. To the best of our knowledge, however, this strategy has not been used or tested in the realm of natural disasters such as earthquakes.

Of course, it is well known that arousing fear can potentially backfire—undermining motivation—if one feels that there is no way to reduce the danger (e.g., Witte, 1992). People can prepare for earthquakes by taking individual action (e.g., purchasing an earthquake safety kit) and community action (e.g., seismic upgrades for older buildings). Thus, we included brief measures of how much people felt that they and their community could prepare for an earthquake, and hypothesized that exposure to images would be most effective at motivating people to prepare when they believe that preparing can make a real difference. In a similar vein, people may be more inclined to prepare for risks that seem more probable (e.g., Murphy, Cody, Frank, Glik, & Ang, 2009). Thus, we expected any intervention for increasing earthquake preparedness—including our own—to be more effective for people who think that an earthquake will happen in the near future.

The Present Research

Applying existing research and theory on risk perception, we developed a novel intervention to test whether people would be more motivated to prepare for earthquakes after viewing a scientifically-grounded image of what a real local building would look like following an earthquake. To examine this question, we formed an interdisciplinary team of seismic engineers, social psychologists, and a professional visualization artist. Because our team was based in Vancouver, we created photorealistic images of what an actual school in Vancouver would look like after a major earthquake. We focused our investigation on schools because children spend a substantial portion of their time in these buildings, many of which cannot withstand an earthquake. In British Columbia alone, more than 100 public schools are still waiting to receive seismic upgrades despite the government's efforts to make schools safer (Government of British Columbia, 2018). This problem extends to numerous other areas as well; for example, the superintendent of schools in Seaside—a city located in Oregon—lamented that only one of the four schools under his jurisdiction would be "relatively" safe in an earthquake (Schulz, 2015). Thus, there is a pressing need for seismic upgrades to minimize risks to schools in the Pacific Northwest.

We also chose to focus on schools because forecasting how a building will respond in an earthquake requires detailed building plans, which we were able to acquire from the Vancouver School Board to conduct this research. Using building plans for a high-risk school (which remained open in Vancouver at the time), the seismic engineers on our team provided detailed information about how the school building would respond in an earthquake. The visualization artist then created a photorealistic image of the school post-quake, which was checked by the seismic engineers, and further modified by the artist based on their feedback. Through this process, we created a vivid, scientifically sound representation of how the school would look after an earthquake.

Method

Overview

All participants were informed that some public schools in Vancouver are at high-risk in case of an earthquake and then randomly assigned to view the image created by our team or publicly available information about the risks that earthquakes posed to schools. We expected that participants who saw the image would be more motivated to prepare for earthquakes (compared to people who saw only the publicly available information).

Participants

Given the novelty of this research, we did not use effect size estimates to determine our sample size. Instead, we estimated the maximum sample we could collect, based on our available resources, and pre-registered a target sample size of 400 participants on the Open Science Framework (OSF; http://tinyurl.com/y2cyr57b). Participants were required to be fluent in reading English, to have grown up or be living in the greater Vancouver area (also known as the Lower Mainland), and to not have personally attended or have children attending the school depicted in the image. Based on these pre-registered exclusion criteria, we excluded and replaced 13 participants who did not live in the Lower Mainland, 5 who did not seem fluent in reading English, and 4 who had children who attended the school depicted in the image. To ensure that we would meet our target sample size, we slightly oversampled, resulting in a final sample of 411 participants who met our criteria.

To maximize our sample size and the generalizability of our findings, we recruited both students and community members. The final sample consisted of 203 students (who received partial course credit) and 208 community members recruited from a science museum in Vancouver, B.C., who received a chance to win a membership to the museum (see **Table 1** for demographics). To ensure that the issue of earthquakes would be familiar and relevant, we only recruited University of British Columbia students who had grown up in the greater Vancouver area and community members who were currently living in this region. In addition, because our study contained two distinct samples, we pre-registered the following analysis plan: If the samples differed on any outcome variable, we would control for sample in analyzing that outcome. If the effect of condition (images vs. statistics) differed between the samples on any outcome variable, we would analyze each sample separately for that outcome variable. Otherwise, we planned to combine across samples to maximize the power to detect effects.

Table 1: Demographics.

	Undergraduate Sample	**Community Sample**
Age		
Under 19	16.7%	2.4%
19–24	78.3%	6.3%
25–30	3.4%	12%
31–35	0.5%	25%
36–40	1%	22.1%
41–45	–	19.7%
46–50	–	5.3%
51 and above	–	7.2%
Gender		
Female	79.3%	56.3%
Male	20.7%	43.3%
Number of Children		
None	100%	21.3%
1	–	32.4%
2	–	34.8%
3 or more	–	10.1%
Prefer not to say	–	1.4%

Procedure

To recruit our community sample, research assistants approached visitors at a local science museum. Before inviting them to complete our study, we asked whether they were living in the Lower Mainland and fluent in reading English. In some cases, participants asked research assistants for help in reading the materials, indicating that they were not fluent in reading in English; we made a note of these participants and excluded them from analysis.

To recruit our undergraduate sample, we listed our study on the University of British Columbia's participant pool. The listing was only visible to students who had grown up in the Lower Mainland (identified using a prescreening survey). We assumed that students would be fluent in reading English because they were attending a university with English as its primary language of instruction.

After agreeing to be in our study, participants received an iPad that presented them with a consent form. Upon giving consent, they read that some public schools in Vancouver are considered to be at high-risk in case of an earthquake, and that the B.C. government intends to upgrade or replace these schools over the next 15 years. Then, participants were randomly assigned to see either an image of a local school after an earthquake or publicly available information about the risk to local schools.

In the images condition, participants were first shown a photograph (on the iPad) of an elementary school in Vancouver that had yet to receive seismic upgrades. For ethical reasons, we asked them if they would be comfortable seeing an image of what this school would look like after an earthquake (only one participant did not feel comfortable seeing this image and was therefore excused). Then, participants saw a poster board (24″ × 18″) displaying a photorealistic image of what the school would look like after an earthquake (see **Figure 1**).

Meanwhile, the remaining participants saw information about the risk to public schools that was available on the official website of the BC government in May 2017. This information was shown on a poster board (24″ × 18″) and provided statistics regarding the number of schools facing various levels of risk in case of an earthquake (see **Table 2**). This "business-as-usual" material is typical of the kind of quantitative information that the public is given about the risk of earthquakes. As shorthand, we refer to this as the "statistics" condition. To keep research assistants blind to condition, the images and statistics poster boards were kept face down in a separate room, and the iPad instructed participants which poster board to flip over.

After participants viewed the poster board, they completed our survey on the iPad privately. To ensure that research assistants were blind to the participants' responses, research assistants stood away from participants

Figure 1: Post-Quake School Image Shown in the Images Condition.

Table 2: Statistical Information Shown in the Statistics Condition.

Rating	Definition	Number of schools in Vancouver in each category
High 1 (H1)	Most vulnerable structure; at highest risk of widespread damage or structural failure; not reparable after event. Structural and non-structural seismic upgrades required.	20
High 2 (H2)	Vulnerable structure; at high risk of widespread damage or structural failure; likely not reparable after event. Structural and non-structural seismic upgrades required.	2
High 3 (H3)	Isolated failure to building elements such as walls are expected; building likely not reparable after event. Structural and non-structural seismic upgrades required.	16

Note: This information was based on the most recent publicly available information from the B.C. government website.

as they completed the survey (thereby minimizing demand characteristics). The iPad first asked participants to report how much dread, anxiety, nervousness, and worry they felt while thinking about a major earthquake happening in Vancouver within the next ten years ($\alpha = .94$). We averaged participants' responses to create a measure of their feelings of worry (our expected mediator); these emotion words were taken from the anxiety-subscale from the Discrete Emotions Questionnaire (Harmon-Jones, Bastian, & Harmon-Jones, 2016). Then, they completed a 3-item self-report measure of their intentions to prepare for an earthquake ($\alpha = .85$), adapted from a previous measure of intentions to prepare for floods (Terpstra, 2011), and a 3-item self-report measure of their support for city-level action to reduce earthquake risk ($\alpha = .76$; adapted from Flynn, Slovic, Mertz, & Carlisle, 1999). After participants completed these self-report measures, we obtained a behavioral measure by offering them the opportunity to add their names to an existing petition to fast-track upgrades for high-risk schools in B.C.

Then, participants completed single-item measures of our moderator variables. They were asked to rate whether they personally could do anything to lessen the effects from earthquakes (capturing personal efficacy) and whether the city could do anything to lessen the effects, capturing community efficacy (Flynn et al., 1999). They also rated how likely it was for an earthquake to occur in Vancouver within the next ten years from a scale of 1 (*Extremely Unlikely*) to 5 (*Extremely Likely*).

Finally, all participants were shown a photograph of the school featured in the images condition and rated how familiar they were with the school prior to participating in our study. This question enabled us to exclude any participants who had previously attended or had children attending the school depicted in the photograph. Participants then provided their demographics. For details and scale reliabilities for all measures, see **Table 3**.

Pre-registered Hypotheses

We predicted that participants in the images (vs. statistics) condition would report greater personal intentions to prepare for an earthquake, express higher levels of support for city action, and be more likely to sign a petition to fast-track upgrades for high-risk schools in B.C. In addition, we expected these effects to be explained by feelings of worry. Although our key analyses focused on the main effect of condition, we additionally predicted that the effects of viewing images (vs. statistics) might be moderated by feelings of efficacy or the perceived likelihood of an earthquake. In line with current best practices in psychological research, we pre-registered all of our materials, hypotheses, and planned analyses on the OSF at http://tinyurl.com/y2cyr57b.

Table 3: List of Measures.

Measure	Coefficient α (overall)	Items	Response Options	Source
Feelings of Worry	.94	Dread Anxiety Nervous Worry	1 – Not at all 2 – Slightly 3 – Somewhat 4 – Moderately 5 – Quite a bit 6 – Very much 7 – An extreme amount	Harmon-Jones et al. (2016)
Personal Intentions to Prepare	.85	To what extent are you interested in information about earthquake preparedness? To what extent do you intend to search for information about earthquake preparedness? To what extent do you intend to prepare for an earthquake?	1 – Not at all 2 – Hardly 3 – Somewhat 4 – Quite 5 – Very	Terpstra (2011)
Support for City Action	.76	Mandatory strengthening of existing government buildings, even if this means an increase in taxes. Better public earthquake information programs, even if this means an increase in taxes. Better community emergency preparedness, even if this means an increase in taxes.	1 – Strongly oppose 2 – Somewhat oppose 3 – Somewhat support 4 – Strongly support	Flynn et al. (1999)
Petition	–	Would you like to add your name to the following petition for fast-tracking seismic upgrades for high risk schools in British Columbia?	0 – No 1 – Yes	–
Personal Efficacy	–	If an earthquake is going to harm me it will, and there isn't much I can do about it; what will be, will be.	1 – Strongly agree 2 – Somewhat agree 3 – Somewhat disagree 4 – Strongly disagree	Flynn et al. (1999)
Community Efficacy	–	If an earthquake is going to occur, there is not much my city or community can do to lessen its effects.	1 – Strongly agree 2 – Somewhat agree 3 – Somewhat disagree 4 – Strongly disagree	Flynn et al. (1999)
Likelihood Estimate	–	How likely do you think it is for a major earthquake to occur in Vancouver within the next 10 years?	1 – Extremely unlikely 2 – Unlikely 3 – Neutral 4 – Likely 5 – Extremely likely	–
Familiarity with School	–	Before today, how familiar were you with the school pictured below?	1 – No familiarity 2 – Looks familiar but I am not sure why 3 – Looks familiar because I have passed by it 4 – Looks familiar because I have been inside it 5 – Looks familiar because I or my child/children have attended it	–

Results

Sample Effects

The community sample reported greater personal intentions to prepare for an earthquake (*M* = 3.57, *SD* = 0.89) compared to the undergraduate sample (*M* = 3.29, *SD* = 0.76), $F(1,407) = 12.52$, $p < .001$, $\eta_p^2 = .03$. The community sample also expressed more support for city action (*M* = 3.38, *SD* = 0.61) compared to the undergraduate sample (*M* = 3.26, *SD* = 0.51), $F(1, 407) = 4.97$, $p = .03$, $\eta_p^2 = .01$. The community and undergraduate sample did not differ in whether they signed a petition to support school upgrades, *B* = –0.21, *p* = .49. We did not find any significant interactions: the effect of our manipulation did not vary with sample for any of our dependent variables (*p*s > .50; for these results, see Text S1). In line with our pre-registration, we combined our two samples when signing a petition was the main outcome, but included sample as a covariate when personal intentions to prepare and support for city actions were the main outcomes.

Pre-registered Hypotheses

Key outcomes

Consistent with our hypothesis, participants were more likely to sign the petition to fast-track seismic upgrades after being shown images rather than statistics, $\chi^2(1, N = 410) = 4.48$, $p = .03$, $\varphi = .11$. Overall, 77.3% of participants agreed to sign the petition in the images condition, compared to 68% of participants who agreed in the statistics condition. In contrast, we did not find any differences between the images condition and the statistics condition on personal intentions to prepare for an earthquake or support for city action (see **Table 4** for means and standard deviations).

Table 4: Raw Means and Standard Deviations on Self-Report Outcomes.

	Statistics Condition	Images Condition	*p*	η_p^2
	Mean (SD)	Mean (SD)		
Personal Intentions to Prepare	3.37 (0.83)	3.49 (0.84)	.14	.005
Support for City Action	3.30 (0.53)	3.33 (0.60)	.54	.001

Mediation

The effect of images on feelings of worry varied by sample, $F(1,407) = 7.95$, $p = .005$, $\eta_p^2 = .02$. Therefore, mediation analyses were conducted for each sample independently. Within the undergraduate sample, participants who were shown a vivid image reported greater feelings of worry (*M* = 4.29, *SD* = 1.50) compared to those who were shown statistics (*M* = 3.58, *SD* = 1.43), *b* = .71, *p* < .001, *d* = 0.48. Feelings of worry did not, however, reliably predict signing the petition, precluding mediation (see **Table 5**). Within the community sample, there was no significant difference in feelings of worry between participants who were shown images (*M* = 3.53, *SD* = 1.66) and those who were shown statistics (*M* = 3.69, *SD* = 1.64), *b* = –0.16, *p* = .48, *d* = 0.10, precluding mediation.

Moderation

The effect of images on support for city action was moderated by the extent to which participants believed their city could effectively lessen the impact of earthquakes, $F(1,406) = 5.29$, $p = .02$. To probe this significant interaction, we examined mean differences in support for city action between our two conditions (images vs. statistics) at different levels of perceived community efficacy. Relatively speaking, participants were more likely to exhibit support for city action after seeing images (vs. statistics) if they believed that their community could effectively lessen the harm from earthquakes (see **Table 6**). We did not find any evidence of moderation for any of our remaining analyses (see **Table 7**).

Exploratory Analyses

At a reviewer's request, we examined whether viewing images (vs. statistics) had an effect on people's beliefs about how likely it is for an earthquake to occur in Vancouver. To start, we examined whether our samples differed in their estimates. Undergraduate students thought an earthquake was more likely to occur in the next 10 years (*M* = 3.59, *SD* = 0.87) compared to community members (*M* = 3.39, *SD* = 0.94), $t(408) = -2.30$, $p = .02$. Thus, we conducted our analysis with sample entered as a covariate. Participants who viewed images did not think that an earthquake was more likely to occur compared to those who viewed statistics, $F(1, 407) = 0.09$, $p = .77$. This held when we analyzed the two samples independently (*p*s > .17).

Table 5: Mediation Analyses for Undergraduate Sample.

				Indirect Effect	
Outcome	**Path b**	**Path c**	**Path c'**	**a*b**	**95% CI**
Personal Intentions to Prepare	0.22	0.18	0.02	0.16	[0.06, 0.27]
Support for City Action	0.07	0.05	–0.01	0.05	[0.01, 0.10]
Petition[a]	0.09	0.35	0.29	0.06	[–0.09, 0.24]

Note: The effect of images on feelings of worry (path a) is significant, *b* = .71, p < .001. Path b represents the effect of worry on each outcome. Path c represents the total effect of images on each outcome. Path c' represents the effect of images on each outcome, controlling for feelings of worry. Confidence intervals were estimated using 5000 Monte Carlo simulations. All analyses were performed using Hayes' (2018) PROCESS macro for SPSS.

[a] All regression coefficients (including 95% CI) are expressed in log-odds metric.

Table 6: Mean Difference on Support for City Action at Different Levels of Community Efficacy.

Community Efficacy	Mean Difference	95% CI	SE	*t*	*df*	*p*
Strongly Agree (1)	–0.358	[–0.70, –0.02]	.174	–2.059	406	.040
Agree (2)	–0.194	[–0.41, 0.02]	.108	–1.791	406	.074
Disagree (3)	–0.031	[–0.15, 0.09]	.059	–0.521	406	.603
Strongly Disagree (4)	0.133	[–0.01, 0.28]	.072	1.841	406	.066

Note: The first column represents possible responses to the following question: "If an earthquake is going to occur, there is not much my city or community can do to lessen its effects." Participants who strongly agreed with the statement scored the lowest on community efficacy (and vice versa).

[a] Represents the difference in means between the images condition and the statistics condition. Positive values indicate greater support for city action in the images condition.

Table 7: Pre-registered Moderation Analyses.

Outcome	Moderator	*B*[a]	95% CI	SE	*p*
Personal Intentions to Prepare[b]	Personal Efficacy	0.05	[–0.15, 0.24]	0.10	.62
	Perceived Likelihood	0.02	[–0.16, 0.19]	0.09	.86
Support for City Action[b]	Community Efficacy	0.16	[0.02, 0.30]	0.07	.02
	Perceived Likelihood	–0.02	[–0.14, 0.10]	0.06	.76
Petition[c]	Perceived Likelihood	–0.35	[–0.84, 0.15]	0.25	.17

Note: All analyses were performed using Hayes' (2018) PROCESS macro for SPSS.

[a] Regression coefficient associated with the interaction term.

[b] In line with our pre-registration, analyses were performed with sample entered as a covariate.

[c] Regression coefficient (including 95% CI) expressed in log-odds metric.

Discussion

The present research provides the first evidence that creating scientifically-grounded images of what public buildings would look like after an earthquake may represent an effective strategy for motivating people to support risk mitigation initiatives. Compared to participants who saw publicly available statistics, those who saw a photorealistic post-quake image of an actual Vancouver public school were more likely to sign a real petition to support seismic upgrades for schools. Interestingly, seeing this image (vs. statistics) did not alter participants' self-reported intentions to prepare for earthquakes or their support for city action. This suggests that seeing the image may have had a relatively narrow effect, increasing participants' willingness to take immediate action to support an initiative that was directly relevant to the problem highlighted in the image (i.e., schools in need of seismic upgrades).

What is the practical significance of getting 77.3% participants in the images condition to sign the petition versus 68% in the statistics condition (a difference of 9.3%)? To tackle this question, we compared the effect of our intervention to other variables that should be related to whether people agree to sign a petition to seismically upgrade schools, including whether they believed an earthquake was likely to occur and whether they had children. Across our student and community samples, 79.9% of participants who thought an earthquake was "likely" to occur signed the petition, compared to 68% who chose the neutral midpoint of the scale (a difference of 11.9%). Within the community sample, 81.3% of parents signed the petition compared to 55.8% of adults without children (a difference of 25.5%). This suggests that the effect of our intervention on getting people to sign a petition to make schools safer is roughly comparable to the effect of believing an earthquake is likely to occur but much smaller than the effect of having children.

More broadly, our finding that viewing images increased participants' willingness to take a simple, immediate action (e.g., signing a petition) is consistent with recent research on the potent but short-lived impact of visual imagery on behavior. For example, a vivid image of a Syrian child named Aylan Kurdi lying face down on a Turkish beach spurred a massive increase in donations to a Swedish Red Cross fund to help refugees—but donations returned to baseline levels within 6 weeks of the photo's publication (Slovic, Västfjäll, Erlandsson, & Gregory, 2017). This suggests that vivid images may create only a brief window of opportunity in which people are motivated to take action. Thus, it may be most effective to pair vivid images with immediate and relevant opportunities such as signing a petition or donating to a cause. To make these benefits more long lasting, it may be worthwhile to offer people the opportunity to make an immediate commitment to a more extended form of action, such as signing up to receive a bi-annual shipment of earthquake kit supplies or to make monthly donations to a cause. Indeed, immediately following the publication of Aylan Kurdi's photograph, the number of people signing up to make monthly donations to the Swedish Red Cross increased ten-fold, and almost none of these new donors opted out in the subsequent six months.

As well as providing opportunities to take immediate action, policymakers may be well-advised to create scientifically-grounded images of buildings that are tailored to the specific behavior they are trying to promote. For example, if residents need to be persuaded to accept temporary school closures to enable seismic upgrades, then providing post-quake images of the relevant schools might be a productive strategy in building support for this initiative. In contrast, to encourage homeowners to pay for seismic upgrades to their own living spaces, it could be more effective to enable them to see what a typical house in their neighborhood would look like after an earthquake. Of course, given the effect sizes we observed, creating relevant images is unlikely to provide a magic bullet in promoting risk mitigation behavior. Instead, using images should be viewed as one additional approach that can be harnessed as part of a multi-faceted strategy for encouraging people to prepare for earthquakes. This approach may also be valuable for other natural disasters, particularly those that occur rarely and that people may have never experienced directly. It would also be interesting to examine whether people are more likely to share images (vs. dry statistical information) on social media; in the real world, the effectiveness of imagery might be greatly magnified if people are inclined to share it.

We formulated our hypotheses using a dual-processing theory of risk perception (Slovic et al., 2004), but other dual-processing theories such as the Elaboration Likelihood Model (ELM; Petty & Cacioppo, 1986) can also be used to interpret our findings. According to ELM, attitudes change through one of two routes: the central route and the peripheral route. When people evaluate information using the central route, they carefully deliberate its strengths and weaknesses (akin to the analytic system). In contrast, when people use the peripheral route, they rely on mental shortcuts such as how the information makes them feel (akin to the experiential system). In general, people use the peripheral route unless they have the motivation and resources to evaluate a piece of information. Thus, our image may have been more effective in part because it could be readily processed via the peripheral route, whereas the statistics might have only been persuasive if people processed this information via the central route. Although our study was not designed to test this distinction, future research could draw on the ELM to examine whether our intervention makes less of a difference for people who are motivated and able to use the central (vs. peripheral) route to process statistical information.

Although we showed participants either publicly available statistics or a vivid image, another approach would be to present people with both types of information together. In an exploratory study that we conducted, however, presenting both types of information was marginally less effective than presenting the image alone (materials and data for this preliminary study are available at http://tinyurl.com/y2sp3ono). This tentative finding is consistent with past research, which suggests that providing quantitative information can induce a deliberative mindset, making people less responsive to emotionally evocative information (Small, Loewenstein, & Slovic, 2007). Another possible approach would be to show people a post-quake image of a school that had been seismically upgraded along with a school that had not been upgraded. Yet, when we tested this approach in another exploratory study, we found no evidence that providing two images was more effective than providing a single image of the school that had not been upgraded (for materials and data, see http://tinyurl.com/y34qvwyw). In both of our exploratory studies, we showed participants the post-quake images on iPads, which produced somewhat weak and inconsistent effects. In our main pre-registered study reported here, we increased the strength of our manipulation by presenting the image on a large poster board. We would speculate that a campaign designed to share post-disaster images with the public would be more effective if the images were placed on billboards rather than, say, texting them to people to view on their smartphone screens.

A potential downside of creating post-disaster images is that viewing these pictures could arouse intense feelings of worry, plausibly leading people to be paralyzed by fear rather than to be motivated to take action. Surprisingly though, seeing the post-quake image (vs. statistics) only increased feelings of worry in our student sample, but not our community sample. Seeing the image may not have generated intense feelings of worry in part because we excluded participants for whom the image was most directly self-relevant—those who had children attending the school shown in the image. We would expect that showing people a post-disaster image that was highly relevant to them (e.g., of their own neighborhood) would produce more dramatic effects. It is also worth noting that our sample reported relatively high levels of personal and community efficacy for dealing with earthquakes. Showing images of the aftereffects of a potential disaster might be more likely to backfire for people who feel incapable of preparing for the disaster.

Because our key analyses entailed examining the main effect of our intervention, we included only single-item measures of our potential moderator variables including personal efficacy and community efficacy. Although this decision allowed us to keep the survey short, enabling community members to participate, it is important to recognize that single-item measures contain measurement error that limit our ability to detect reliable effects (e.g., Wanous & Hudy, 2001). Thus, to assess the reliability and validity of our single-item measures, we conducted a follow-up study with 55 community members from the Lower Mainland (materials and data are available at https://tinyurl.com/y3k6urx3). In this study, participants completed our single-item measures of efficacy and a longer measure of how futile it is to take individual and collective action to prepare for an earthquake (adapted from Turner, Nigg, & Pazz, 1986). As expected, our single-item measure of community efficacy correlated moderately strongly with this 4-item measure of the perceived futility of collective action ($\alpha = .80$), $r(53) = -.66$, $p < .001$; people who felt their community could lessen the effects from earthquakes also found taking collective action to be less futile. In contrast, there was a fairly weak correlation between our single-item measure of personal efficacy and a 4-item measure of the perceive futility of individual action ($\alpha = .75$), $r(53) = -.29$, $p = .03$. Thus, we may have detected that the effect of our intervention was moderated by community efficacy—but not personal efficacy—in part because the former measure may have been more reliable than the latter. This suggests that it would be worthwhile for investigations that are focused on examining the role of efficacy to use longer measures of these constructs. Most importantly, the null results we obtained for personal efficacy should not be interpreted as implying that personal efficacy does not matter (consistent with the notion that the absence of evidence does not constitute evidence of absence).

Another limitation of the current research was that we included only two conditions, comparing the effects of seeing the image created by our team versus seeing publicly available statistics about the risk of earthquakes to schools. Although we made this decision to maximize power, the design of our study does not enable us to identify which aspects of our post-disaster image made it more effective than the business-as-usual information available on the government's website. Indeed, in creating the image, we hoped to maximize the engagement of the experiential system by choosing a specific local building and vividly illustrating how it would look after an earthquake. Future research could identify which ingredients are necessary to produce the effects we observed; for example, it is possible that simply describing how the building would look after an earthquake might be sufficient. Similarly, more work is needed to establish the strength and duration of our effects. For example, future research can examine whether exposure to vivid imagery produces lasting changes in how people think about earthquakes and earthquake preparation. Nevertheless, our research provides the first evidence that scientific information about natural disasters can be effectively conveyed to the public by sharing how a specific building would look in the wake of the disaster.

Conclusion

Finucane, Peters, and Slovic (2003) characterized human decision-making as a "dance of affect and reason." A great deal of basic research has shown that affect and reason are often like dance partners who are listening to completely different sound tracks. The present research demonstrates how we might choreograph this dance more effectively: by using scientific information to build an emotionally evocative image of what a building might look like after an earthquake. Compared to an existing government strategy that uses statistics to communicate the risk that earthquakes pose to schools, our approach using vivid imagery encouraged 9.3% more people to sign a petition to support seismic upgrades. This research provides initial evidence that using vivid images to convey scientific information can be an effective part of a broader strategy for motivating people to support risk mitigation initiatives. Harnessing the psychology of risk perception to motivate people to prepare for earthquakes is of pressing importance given that scientists expect a full rupture on the Cascadia fault to produce "the worst natural disaster in the history of North America" (Schulz, 2015).

Data Accessibility Statement

Data, materials and program syntax can be found on OSF at http://tinyurl.com/y49ypb4b.

Additional File

The additional file for this article can be found as follows:

- **Text S1.** Condition by Sample Interactions. DOI: https://doi.org/10.1525/collabra.238.s1

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Competing Interests

The authors have no competing interests to declare.

Author Contributions

- Contributed to conception and design: All authors
- Contributed to acquisition of data: IL, EE, ED
- Contributed to analysis and interpretation of data: IL, PS, ED
- Drafted and/or revised the article: IL, PS, ED
- Approved the submitted version for publication: All authors

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