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# The Role of Emotions in Risk Communication

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We present two experiments investigating the role of emotions concerning technological and natural hazards. In the first experiment, technological hazards aroused stronger emotions, and were considered to be riskier than natural hazards. No differences were found between the texts versus audio presentations. However, the presence of pictures aroused stronger emotions and increased the perceived risk. Emotions play a mediating role between hazard types and perceived risk, as well as between pictures and perceived risk. The second experiment adopted real-world materials from webpages and TV. Emotions again play a mediating role between pictorial information and risk perception. Moreover, specific emotions were found to be associated with different types of action tendencies. For example, loss-based emotions (e.g., fear, regret) tend to lead to prevention strategies, whereas ethical emotions (e.g., anger) lead to aggressive behavior. We also find that loss-based emotions in the technical hazard scenario trigger more coping strategies (from prevention to retaliation) than in the natural hazard scenario.

**KEY WORDS:** Action tendencies; cultural differences; emotions; environmental risk; risk communication; risk perception; sensory channels

## 1. INTRODUCTION

When reading reports about natural disasters like earthquakes, we may change our prior opinion on the likelihood and severity of earthquakes. At the same time, we may feel threatened, worried, and sad. Some people may further consider helping the victims whereas others may prefer not to think about it at all. By contrast, our emotional reactions and action tendencies can be very different when manmade hazards are involved. For example, if we read a report about a gas explosion accident, we may feel angry. Instead of helping, we may want to blame the one who is responsible.

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In addition to the causes of the disaster, the way in which we receive the information can also influence our judgment, emotions, and action tendencies. For example, watching the news from the TV may induce stronger emotions than listening to the same news from the radio.

Effective risk communication is crucial to cooperative risk management and the resolution of controversial risk-related issues. The role of emotions was largely ignored in the practice of risk communication until researchers started to demonstrate the underlying mental structures of risk in the public's mind.(1,2) Risk is not only about cool-headed judgment on the magnitudes and probabilities of potential losses, as typically managed by experts, but also related to a variety of strong emotions, such as fear and anger. Emotions interact with risk judgments as well as actions.(3) Without understanding the role of emotions in risk communication, we can hardly achieve effective risk communication.



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In this article, we present two experiments that examine how emotions can be affected by the causes of hazards and presentation modes. We found that the aroused emotion is indeed an important mediator between pictorial information and risk perception, and between hazard types and risk perception. In the first experiment we found that, compared to natural hazards, technological hazards aroused stronger emotions, which led to a higher level of perceived risk in nearly all dimensions (e.g., severity, probability of occurrence, dread). No differences in perceived risk were found between the presentations of audio or text materials. However, when pictures were added to both types of materials, stronger emotions were induced, leading to higher perceived risk. Similar results were obtained in the second experiment, where real-life materials from the Internet and TV were used.

The rest of this article is organized as follows. First we review related literature. Then we report the methodologies and main results of the two experiments. Finally, we discuss the implications of our results and potential future research.

### 1.1. Cognition and Emotions in Risk Perception

Since the pioneer work of a psychometric model by Fischhoff *et al.*,[4] researchers have recognized the important role of emotions in risk perceptions. In the psychometric paradigm, risk can be characterized by two factors, "unknown" and "dread," with the latter reflecting the typical emotion when facing risks. Later models, like "risk-as-feeling"[3] and the affect heuristics,[5] are also based on the idea that emotions are an indispensable input to risk appraisal.

The studies on emotions have evolved from a philosophical conjecture to an empirical approach, especially with the advancement of modern experimental methods in psychology and neuroscience. Although the precise definition of emotions is still under debate, here we refer to emotions as a variety of mental and physiological states experienced by individuals. Judgment and decision making are often influenced by emotions. Neural scientists find that the orbitofrontal cortex in our brain plays an important role in controlling emotional influences. When an emotion is judged as relevant, then it incorporates the emotional stimuli into judgments and decision making. When an emotion is judged as irrelevant, it inhibits its influence.[6]

Although emotions can serve as cues to improve judgments and decisions, some emotions can create so-called mental noises, which interfere with a person's ability to engage in rational judgments, bias the information inquiry and processing, and hence produce barriers to effective risk communication.[7] For example, in a classical study by Johnson and Tversky,[8] the negative mood induced by a story about a fatal stabbing can increase the perceived risk of unrelated risk (e.g., natural disasters) as much as related risk (e.g., homicide). A recent comprehensive review by Waters[9] concludes that an positive affect leads to more optimistic likelihood estimates, whereas a negative affect leads to more pessimistic likelihood estimates, except for anger, which correlates with more optimistic likelihood estimates.

Emotions can be categorized in many ways, based on valence, intensity, duration, or other criteria. Although fear and worry are among the most common emotional reactions to risk events, people also exhibit other types of emotions, especially anger.[10] Böhm and Pfister[11] classify emotions into ethical and loss-based emotions. Ethical emotions involve anger, outrage, or guilt that are directed to some particular agents, whereas loss-based emotions are fear, worry, and sadness that are induced from the anticipated negative consequences or the harms that have been done already. Böhm and Pfister[12] extend the previous study and show that environmental risks are evaluated on two pathways: consequences and moral considerations. In our first experiment, we focused on the intensities of the insecurity feeling.[13] In the second experiment, we measure a broader range of emotions by using the scales from Böhm and Pfister[11] to gain insights into the underlying dimensions of emotions, as well as the relationship between emotions and action tendencies.

### 1.2. Hazard Types (Technological vs. Natural)

Environmental risks can be categorized as natural disasters versus technological hazards.[1,11,12,14] Natural disasters, such as earthquakes and tornados, involve virtually no human factors. The technological hazards, however, are typically caused by the misuse of human-made technologies or other accidents. Examples are air pollution and gas explosion. As stated by Slovic,[2] every technological advance will take the risk that it can lead to negative consequences.

People perceive natural disasters and technological hazards in different ways. The most notable differences between natural and technological hazards lie in the perception of controllability and blameworthiness. People tend to view natural disasters as an act of God and as inevitable. Technological hazards, in comparison, are thought to be more controllable because most of them are caused by individual or collective actions of human beings.[14,15] Even when people can hardly convince themselves to do anything substantial at their personal level, when it comes to technological hazards like air pollution, they still believe in the capability of the society as a whole to handle such issues.[16]

As a result, responsibilities of risk management largely depend on the different types of hazards.[17] Different causes of hazards can induce specific emotions. Technological risks usually elicit more anger than natural disasters because people or agencies can be blamed. By contrast, natural catastrophes may elicit more sympathy for the suffered victims. In this study, we empirically test the differences in aroused emotions and perceived risk dimensions regarding natural and technological hazards.

### 1.3. Emotions and Information Presentation

The public media (e.g., TV, newspapers, magazines, radio, and the Internet) has a powerful influence on people's opinions about risks. Information can be communicated through various sensory channels. For example, radio only involves auditory channels, while TV involves both auditory and visual channels.

Two most frequently used sensory channels or modalities in risk communication are vision (e.g., text or pictures) and audition (e.g., speech). Although reading and listening activate different parts of the brain,[18] this does not imply that one way is better than the other. For example, Onyeka and Martin-Hirsch[19] found that information delivered through educational brochures and verbal counseling achieved the same desired effects in helping women with their knowledge about the risk of getting cervical disease. However, sensory channels in that study can be confounded with the information content and other environmental cues.

Imagery processing of information affects both emotions and likelihood assessment. The more vivid the message and the more stressful the situation, more intensive emotions may arouse, ranging from fear to anger.[3,20,21] Carroll[22] found that the perceived likelihood of an event can be increased by simply instructing participants to visualize that event. Visual information, especially pictures, is a well-established strategy to elicit imagery.[23,24] Hence we predict presenting pictures can facilitate imagery thinking and induce more intense emotions as well as higher perceived risk.

### 1.4. Emotions as Mediators

Although it is known that hazard types and presentation modes can influence risk perception and emotions, the underlying processes need further investigation. Previous research in consumer behavior suggests that emotional states can be mediators between the store environment and purchasing behavior,[25] and between advertising content and attitudes towards the brand.[26]

The mediating role of emotions from stimuli and responses can be understood by looking at the findings from neuroscience. There are direct neural projections from the sensory thalamus (which performs crude signal-processing) to the amygdala (which is widely believed to play a critical role in the processing of affective stimuli) that are not channeled through the neocortex (which involves higher functions, such as conscious thought).[27] Thus, we propose that a stimulus, such as the presence of pictures, can arouse emotion before the conscious judgment of risk, and the aroused emotion in turn may serve as information for the later judgment. The information of hazard types, on the other hand, is more consciously processed. Thus we expect that the mediating role of emotions is weaker between hazard types and perceived risks. Our findings are consistent with this conjecture, i.e., we found that emotions play a partial mediating role between hazard types and risk perception, but serve as a full mediator between pictorial information and risk perception.

### 1.5. Emotions and Action Tendencies

Some theories suggest that actions are actually expressive behavior of emotions. Withdrawal action, for example, is an expressive behavior of fear, which has a protective function from an evolutionary point of view.[28] More recent neuropsychological studies offered strong evidence that without emotional experience, no decisions can be formed, even with completely normal cognitive abilities.[21]

Specific emotions lead to specific actions. According to Lazarus,[29] an angry person is more likely to attack, whereas a fearful person may favor avoidance or escape. Cryder *et al.*[30] found that sadness tends to increase spending when the self-focus is high. Böhm and Pfister[11] suggested that action tendencies are also determined by the perceived causation of environmental risk, as well as emotions. They found that aggression was strongest when a single human agent caused the disaster. Aggression was also found to be correlated with ethical emotions, such as anger.

Although our results are mostly consistent with Lazarus[29] and Böhm and Pfister,[11] we also found that the same emotion may trigger different action tendencies, depending on the types of the hazards and the sociocultural conditions. We found that negative emotions (e.g., fear) can lead to aggressive behavior in technological hazards, but not in a natural disaster. Moreover, the reactions to negative emotions in technological disasters are more complicated. They range from passive action (e.g., escaping) to very aggressive action (e.g., attacking the responsible agents).

### 1.6. Cross-Cultural Differences

Whether emotions are universal or culture specific is an interesting research question. Part of our research design followed the work of Böhm and Pfister[11] but with a Chinese sample, which allows a cross-cultural comparison with their German sample. Our factor analysis replicated their four-factor structure underlying emotions. The action tendencies we found, however, were slightly different from theirs, in that political actions were lacking in our sample. This is not difficult to understand given the different sociopolitical systems between the two countries. It supports the converging position in emotion literature, which states that emotions are universal but some societies may differ in how they express specific emotions.

### 1.7. Expected Findings

To summarize based on the above discussion, we expect that technological hazards would arouse stronger emotions than natural hazards. Technological hazards would be perceived as more severe but also more controllable than natural hazards. Emotions serve as mediators between stimulus (e.g., hazard types, images, etc.) and perceived risk. We also expect to observe cultural differences in action tendencies, but not in the underlying structure of emotional responses to a particular type of hazard.

## 2. EXPERIMENT 1

### 2.1. Method

#### *2.1.1. Design and Procedure*

This experiment adopted a mixed $2 \times 2 \times 2$ design. The three independent variables were (1) hazard type (natural vs. technological, within-subject); (2) sensory channel (audio vs. written text, within-subject); and (3) image condition (with pictures vs. without pictures, between-subject). The dependent variables were induced emotional arousal and perceived risk. The degree of understanding of the materials from two sensory channels served as the control variable.

For risk appraisal tasks, we selected two technological hazards (water contamination and air pollution) and two natural hazards (earthquake and landslide). The selection of these four cases was based on three reasons: (1) all cases are from real life; (2) the affected areas are similar; and (3) all are involuntary risks. The exercise material was about desertification.

Each material included three paragraphs: the general description of the problem, the severity of the problem, and the causes of the problem. The length of each paragraph was limited within a range of $275 \pm 15$ Chinese characters. The audio materials had one version of male voice and one of female voice with medium speed (1 min 5 s $\pm$ 5 s).

We recruited five independent raters to choose pictures that matched best among several sets of pictures, and make assessments on the vividness of the pictures. The two most representative pictures were selected to be included in the information materials. The Appendix presents the English version of the information materials that were translated from the original Chinese texts.

Each participant was assigned randomly to one of the two image conditions (with vs. without pictures). Then he or she was asked to assess four hazards sequentially. One technological and one natural hazard were described in written texts, whereas the other technological and one natural hazard were presented with audio materials. All cases were combined either with or without pictures, depending on the image conditions. The order of presentation was counterbalanced. The experiment took about 30 minutes.

#### *2.1.2. Measurement of Variables*

We chose five frequently used psychometric dimensions that are suitable for the comparison between technological and natural hazards.[7] These dimensions are:

(1) Overall risk level (1 = extremely low; 6 = extremely high);

(2) Severity of consequences (1 = not serious at all; 6 = extremely serious);
(3) Possibility of occurrence (1 = very low; 6 = very high);
(4) Controllability (1 = very easy to control; 6 = very difficult to control);
(5) Dread (1 = not dreadful at all; 6 = extremely dreadful).

We chose the Feelings of Insecurity Checklist by Gutteling[13] to measure the emotion arousal of individuals. The subjects stated whether the hazards made them feel *tense*, *nervous*, *restless*, or *fearful*, or whether they were "*terror-struck*" on a 6-point scale (1 = definitely not; 6 = definitely yes). Demographic information such as age, gender, and educational achievement were also collected.

#### 2.1.3. Manipulation Check

Two questions were added into each task for the manipulation check:

(1) How well do you understand the information presented just now (1 = do not understand at all; 6 = fully understand)?
(2) What do you think are the causes of this environmental problem (technological or natural)?

The purpose of the first control question is to exclude the possible impacts caused by a lack of understanding, so that materials presented in audio and written forms can reach the same process level. The second question examines the participants' perception of the causes of the environmental problems in order to ensure a consistency between their perception and our manipulations.

#### 2.1.4. Participants

In total, 210 subjects participated in the experiment in Peking University, China. Most of them were university students. The data that do not fulfill our requirements in control questions were excluded, resulting in 187 subjects in the final analysis, among which 99 were males. The average age was 22.7 years ($SD = 3.6$). The experiment took about 30–40 min. The participants received a gift worth eight RMB as their reward.

### 2.2. Results and Discussion

#### 2.2.1. Consistency and Manipulation Check

Reliability of the emotional scale from the Feelings of Insecurity Checklist was good for both types of hazards, with alpha = 0.86 for technological hazards and alpha = 0.88 for natural hazards. We used the average score of all emotion scales under each condition as the new variable for the measurement of emotion arousal.

No significant difference was found for the degree of understanding across different presentation modes (with vs. without pictures, audio vs. written texts) and different hazard types. Five participants were excluded because the manipulation check revealed that their perceived causation was different from the one we require for our manipulation.

#### 2.2.2. Risk Perception and Emotion Arousal for Different Hazard Types

Table I demonstrates significant differences between technological and natural hazards in risk perception and emotion arousal for several repeated measures. Gender was controlled as a covariate variable. Technological hazards were perceived as more severe, more likely, and more dreadful, but more controllable than natural hazards. Technological hazards also aroused stronger emotions.

#### 2.2.3. Comparisons of Presentation Conditions

Since the five risk attributes were found to be highly correlated with the overall perceived risk, we only discuss the relation between the overall level of perceived risk and other variables in the rest of this article. Table II displays the impacts of presentation conditions on perceived risk and emotion arousal. Whenever the materials included pictures, participants stated a higher level of perceived risk and stronger emotion arousal. Whether the information was presented through written text or audio had no significant impact on the overall risk perception, but the audio condition did induce higher emotion arousal. A further analysis revealed a significant interaction between the sensory channel and gender ($F(1,184) = 8.71$, $p < 0.01$, partial $\eta^2 = 0.05$ ). Different sensory channels had no impact on the emotion arousal for males ($F(1,97) = 2.07$, $p = 0.15$, partial $\eta^2 = 0.02$), whereas the emotion arousal for females was higher ($F(1,86) = 7.88$, $p < 0.01$, partial $\eta^2 = 0.08$) under the audio condition (mean = 3.46, SE =

**Table I.** Differences of Risk Perception Between Technological and Natural Hazards

| | Technological Hazards | | | Natural Hazards | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 95% Confidence Interval | | | 95% Confidence Interval | | | |
| | Mean (SE) | Lower | Upper | Mean (SE) | Lower | Upper | $F$ (1,184) | Partial $\eta^2$ |
| Overall risk | 4.84 (0.05) | 4.74 | 4.95 | 4.37 (0.06) | 4.25 | 4.49 | 34.98** | 0.16 |
| Severity | 4.79 (0.05) | 4.69 | 4.89 | 4.62 (0.05) | 4.52 | 4.71 | 5.95* | 0.03 |
| Controllability | 3.73 (0.06) | 3.62 | 3.85 | 4.43 (0.05) | 4.32 | 4.53 | 11.58** | 0.06 |
| Possibility | 4.64 (0.06) | 4.52 | 4.75 | 3.49 (0.07) | 3.36 | 3.62 | 51.31** | 0.22 |
| Dread | 4.62 (0.06) | 4.50 | 4.75 | 3.54 (0.07) | 3.40 | 3.68 | 52.79** | 0.22 |
| Emotion arousal | 3.36 (0.08) | 3.20 | 3.51 | 2.97 (0.07) | 2.84 | 3.10 | 6.98** | 0.04 |

*Note:* $^*p < 0.05$; $^{**}p < 0.01$.

**Table II.** Difference of Perceived Risk and Emotional Arousal Between Presentations

| | With Pictures | | | Without Pictures | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 95% Confidence Interval | | | 95% Confidence Interval | | | |
| | Mean (SE) | Lower | Upper | Mean (SE) | Lower | Upper | $F$ (1,184) | Partial $\eta^2$ |
| Overall risk | 4.71 (0.07) | 4.58 | 4.84 | 4.50 (0.06) | 4.38 | 4.63 | 4.98* | 0.03 |
| Emotion arousal | 3.31 (0.09) | 3.15 | 3.48 | 3.01 (0.08) | 2.85 | 3.18 | 6.34* | 0.03 |

| | Audio | | | Text | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 95% Confidence Interval | | | 95% Confidence Interval | | | |
| | Mean (SE) | Lower | Upper | Mean (SE) | Lower | Upper | $F$ (1,184) | Partial $\eta^2$ |
| Overall risk | 4.62 (0.06) | 4.51 | 4.74 | 4.59 (0.05) | 4.49 | 4.69 | 0.01 | 0.00 |
| Emotion arousal | 3.18 (0.06) | 3.06 | 3.30 | 3.15 (0.07) | 3.08 | 3.28 | 6.69* | 0.04 |

*Note:* $^*p < 0.05$; $^{**}p < 0.01$.

0.09) as compared to the text condition (mean = 3.29, SE = 0.09). However, the sensory channels have no significant impacts on the overall perceived risk levels for both genders. There are no significant two- and threefold interactions among hazard types, sensory channels, and image conditions.

### 2.2.4. *Emotions as a Partial Mediator Between Hazard Types and Risk Perception*

Previous analysis revealed significant effects of both hazard types and imagery conditions on the emotion arousal and perceived risk. In this section, we further examine whether hazard types have impacts on risk perception through emotions as a mediator. In the next section, we study the mediating role of emotions between pictures and risk perception.

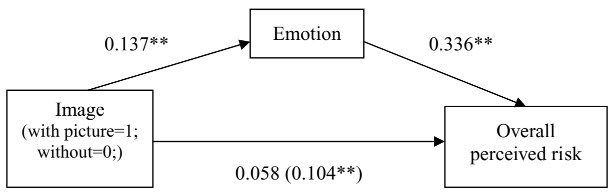
As the hazard type was a within-subject independent variable, the mediating role of emotion arousal between hazard type and overall perceived risk was tested and interpreted based on the procedures proposed by Judd *et al.*[31] First, as reported in Table I, technological hazards lead to stronger emotion arousal and higher overall perceived risk than natural hazards. Second, emotion arousal was a significant predictor of perceived overall risk in both technological hazards ($\beta = 0.411$, $t(185) = 6.128$, $p < 0.01$) and natural hazards ($\beta = 0.260$, $t(185) = 3.669$, $p < 0.01$). Third, when the overall difference of perceived risk between two hazard types was regressed on the sum and difference of emotion arousals of two hazard types, only the difference of emotion arousal presented a significant predictor ($\beta = 0.437$, $t(184) = 6.547$, $p < 0.01$) whereas the sum of the emotion

**Table III.** Mediational Analysis of Emotion Between Pictures and Perceived Risk

| Independent Variables | Model 1 Emotion Arousal Standardized $\beta$ | Model 2 Perceived Overall Risk Standardized $\beta$ | Model 3 Perceived Overall Risk Standardized $\beta$ |
|---|---|---|---|
| Image (with pictures = 1) | 0.137** | – | 0.058 |
| Emotion arousal | – | 0.104** | 0.336** |
| $R^2$ | 0.019 | 0.011 | 0.121 |
| Adjusted $R^2$ | 0.017 | 0.010 | 0.119 |
| $F$ | 14.20** | 8.16** | 51.44** |
| $df$ | 1 | 1 | 2 |

Dependent Variables: Models 1–3.

*Note:* *$p < 0.05$; **$p < 0.01$.




*Note:* The numbers in the figure are standardized beta.
*$p < 0.05$; ** $p < 0.01$.

**Fig. 1.** Emotion as a mediator between image condition and risk perception.

arousal did not. These results suggest that emotions serve as a mediator of the difference of perceived risk between hazard types. After the sum of emotion arousal was centered, the intercept of the regression model was significant ($\beta = 0.319$, $t(184) = 4.481$, $p < 0.01$), indicating the residual treatment difference over and above mediation, and hence showing a partial mediation effect. Therefore, we have evidence that technological hazards are perceived as riskier partially due to higher emotion arousal.

#### 2.2.5. *Emotions as a Mediator Between Image Processing and Risk Perception*

Table III shows three regression models for the test of the mediation effect based on the procedure recommended by Baron and Kenny.[32] In the first model, the with-picture treatment increases emotional arousal significantly. In the second model, higher emotional arousal correlates with higher perceived risk. In the third model, when both image and emotion are entered into the regression, the effect of image is not significant any more. Only emotion is significant, which indicates a full mediation effect of emotion between image and risk perception (also see Fig. 1). The direct effect of image condition is 0.114, and the indirect effect is 0.046 (Sobel $z = 2.03$, $p < 0.05$).

Altogether the first experiment tested the mediating role of emotions between hazard causation and perceived risk, as well as between pictorial information and perceived risk. The measured emotions here, however, only focused on insecure feelings. In the second experiment, we use more realistic information materials to investigate richer dimensions of emotions, and we also study the relationship between specific emotions and action tendencies.

## 3. EXPERIMENT 2

### 3.1. Method

#### 3.1.1. *Design and Procedure*

In this experiment, we examine the effects of different media on the perception of one catastrophic event. A mixed 2×2 design was used to test the impacts of two factors: (1) hazard type (technological vs. natural, within-subject) and (2) information media (webpage vs. TV, between-subject). Gas explosion was chosen for the technological risk and landslide for the natural hazard.

We selected real-life media coverage (i.e., TV and on-line reports) on two catastrophic events: the landslide caused by flood in Yunnan Province on July 20, 2004, and the gas explosion in a coal mine in Shanxi Province on November 28, 2004.

Materials from TV news with a broadcasting time of 4 min 20 s and 4 min 3 s were excerpted from CCTV's Morning News and Evening News. In the report of landslide, a heavy rainfall was mentioned, but the causes were not specified, whereas in the case of gas explosion, it was reported that the causes are under investigation.

For each event, three webpages were selected from relevant reports on www.sina.com for the participants' reference. Both TV news and webpages were delivered within the three days in the aftermath of the events. They covered information about the current situation, casualties, and emergent rescue measures taken by the government. Because sina.com's information source was www.xinhua.com (each of these webpages was labeled with its source), consistency between on-line reports and TV news could be guaranteed. The participants were not allowed to click the links embedded in each webpage in order to ensure that the information they acquired was the same. Participants were allowed to spend around 4 min browsing the page in order to guarantee that they spent the same time on the Internet materials and the TV news.

Due to the limitation of choosing real-life reports as material, only one of the three webpages of reporting on the gas explosion contained pictures, while the other two were presented in written texts only. In case of the landslide event, all webpages were in written text without pictures.

#### *3.1.2. Measurement of Variables*

Participants rated the intensity of each of the 18 specific emotions developed by Böhm and Pfister:[11] anger, pride, indignation, relief, fear, trouble, regret, envy, worry, sadness, contempt, guilt, fury, outrage, hope, helplessness, admiration, sympathy. The question was: "When you think of this situation, how intensely do you feel . . .?" The rating scale ranged from 1 (not at all) to 6 (very strongly).

We also measured the action tendencies using the scales developed by Böhm and Pfister.[11] Participants were asked to rate each of the 31 behaviors showing how strongly they felt inclined to perform it.

The overall risk perception was measured using a 6-point scale (1 = very low risk; 6 = very high risk) as in the first study. Participants were further asked to assess the level of expertise and credibility of media sources (i.e., TV and webpage) on a 5-point scale.

#### *3.1.3. Manipulation Check*

As in Experiment 1, two questions were asked for each task for the manipulation check:

1. How well do you understand the information presented just now (1 = do not understand at all; 6 = fully understand)?
2. What do you think are the causes of the problem (technological or natural)?

The purpose of controlling the degree of understanding was to ensure that TV news and Internet materials could reach the same level of information processing. It allows us to exclude the potential effect caused by a lack of understanding, so that the difference between TV news and Internet materials are comparable.

#### *3.1.4. Participants*

A total of 300 university students from Beijing, China participated in the second experiment. Improperly answered responses and missing values (which did not meet the requirements of AMOS) were deleted, leaving 271 participants as the final sample for analysis. There were 147 males and 124 females. The average age was 23 years old ($SD = 3.3$).

### 3.2. Results and Discussion

#### *3.2.1. Difference in Risk Perception Between Different Information Media*

Using an independent-sample *t*-test, we compared the differences in risk perception between different media (TV vs. website) for both the gas explosion and the landslide. Table IV shows that for the case of the landslide, participants perceived higher risk when watching TV than when reading texts (without pictures) from the website, whereas no difference was found between watching TV and reading texts (with pictures) from the website for the case of the gas explosion. It seems that the difference was caused by the presence of vivid images (either from TV or pictures from the Internet). There was no difference in the self-reported understanding levels under the two media conditions for both hazards. Hence on average, the difference of perceived risk should not be attributed to different levels of understanding.

#### *3.2.2. Factor Analysis of Emotions*

A significant result was obtained when the 18 emotional adjectives were subject to the Barlett test of sphericity ($\chi^2 = 1256.51$, $p < 0.001$), allowing the use of factor analysis. Factor analysis with VARIMAX rotation and iteration was applied. Based on the scree plots, the four-factor solution was found to be more appropriate after double-loaded items had

**Table IV.** The Effects of Webpage and TV on Risk Perception

| | Perceived Risk | | | | |
|---|---|---|---|---|---|
| | Web M(*SD*) | TV M(*SD*) | *t* | *df* | *p* |
| Gas explosion | 4.87 (0.92) (text with pictures) | 4.84 (.85) | 2.45 | 268 | 0.807 |
| Landslide | 4.45 (0.77) (text without pictures) | 4.69 (.82) | −2.56 | 269 | 0.011 |

*Note:* $^{*}p < 0.05$; $^{**}p < 0.01$.

**Table V.** Factor Analysis on Emotions

| Factor | Emotions | Landslide | Gas Explosion |
|---|---|---|---|
| 1. Ethical | Fury | 0.876 | 0.899 |
| | Indignation | 0.851 | 0.862 |
| | Anger | 0.672 | 0.848 |
| | Contempt | 0.641 | – |
| Explained variance | | 18.1% | 18.7% |
| 2. Loss-based prospective | Helplessness | 0.682 | 0.838 |
| | Fear | 0.759 | 0.795 |
| | Worry | 0.827 | 0.616 |
| | Trouble | 0.566 | 0.569 |
| | Guilt | – | 0.672 |
| Explained variance | | 16.3% | 19.3% |
| 3. Positive | Pride | 0.764 | 0.833 |
| | Envy | 0.760 | 0.830 |
| | Admiration | 0.608 | 0.663 |
| | Relief | 0.534 | – |
| Explained variance | | 13.7% | 13.7% |
| 4. Loss-based retrospective | Sympathy | 0.823 | 0.738 |
| | Regret | 0.748 | 0.730 |
| | Hope | 0.489 | 0.665 |
| Explained variance | | 10.9% | 12.6% |
| Cumulative explained variance | | 59.0% | 64.3% |

been crossed out. Table V shows the factor loadings for both hazards. We obtained similar results as reported by Böhm and Pfister.[11] Thus we use the same labeling for the factors to make them more comparable. In the case of landslide, the four factors were: (1) *Ethical emotions*: intense emotional reactions, such as fury, indignation, anger, and contempt, directed to the responsible agents after catastrophic events; (2) *Loss-based prospective emotions*: mainly the disturbed emotions, such as fear, worry, helpless and troubled feelings experienced by individuals after the events; (3) *Positive valence*: pride, admiration, envy, and relief, usually brought by the effective rescue measures from the relevant agencies; (4) *Loss-based retrospective emotions*: sympathy, regret, and hope, mainly describing the emotions induced by the experience of victims. These four factors explained 18.1%, 16.3%, 13.7%, and 10.9% of the total variance, respectively.

In the case of the gas explosion, we identified a similar four-factor structure of emotions. These factors contained essentially the same items except for three specific emotions (contempt, guilt, and relief). The four factors account for 18.7%, 19.3%, 13.7%, and 12.6% of the total variance, respectively. See Table V.

### 3.2.3 *Loss-Based Retrospective Emotions as a Mediator Between Media Condition and Risk Perception*

Similar to the first study, we analyzed whether emotion, especially the *loss-based retrospective* emotion factor,[1] is a mediator between media modes and risk perception. The procedure recommended by Baron and Kenny[32] was applied to test the mediation effects. As shown in Table VI, for the landslide case, both the media condition and *loss-based retrospective* emotions were significantly correlated with perceived risk (Model 1 and Model 2), but after the emotion variable was entered into the regression together with the media condition, the latter was no longer significant (Model 3). The direct effect of media modes was 0.106, while the indirect effect was 0.034 (Sobel $z = 2.13$, $p < 0.05$). This indicates a significant mediation effect of emotions in the relation between media modes and perceived overall risk, i.e., information media influences risk perception through emotions. Fig. 2 is a graphical representation of this result. Note that for the case of landslide, the two media conditions were webpage without pictures versus TV, which is equivalent to written text without pictures versus audio with pictures in the first experiment. Therefore, the result was consistent with Experiment 1.

For the case of gas explosion, the media condition had no significant impacts on the perceived risk. This was also consistent with Experiment 1 because

[1] All four factors of emotions were correlated significantly with the perceived risks. The retrospective loss-based emotion factor has the highest correlation with perceived risk among the four emotion factors.

**Table VI.** Mediational Analysis for Loss-Based Retrospective Emotions (Landslide Scenario)

| | Dependent Variables | | |
|---|---|---|---|
| Independent Variables | Model 1<br>Retrospective Loss-Based Emotions<br>Standardized $\beta$ | Model 2<br>Overall Risk Perception<br>Standardized $\beta$ | Model 3<br>Overall Risk Perception<br>Standardized $\beta$ |
| Media condition (TV = 1; website = 0) | 0.165** | 0.141* | 0.106 |
| Loss-based retrospective emotions | – | – | 0.208** |
| $R^2$ | 0.027 | 0.020 | 0.062 |
| Adjusted $R^2$ | 0.023 | 0.016 | 0.055 |
| *F* | 7.487** | 5.418* | 8.808** |
| *df* | 1 | 1 | 2 |

*Note:* $^*p < 0.05$; $^{**}p < 0.01$.

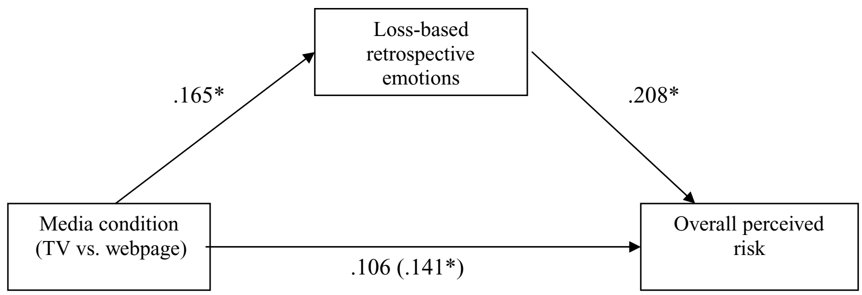



**Fig. 2.** Mediation analysis for loss-based retrospective emotions (landslide scenario).

in this case both media conditions involved pictures, namely, webpage with pictures versus TV, so that the main difference between the two conditions was only written texts versus audio, which had no significant effect on risk perception in Experiment 1. Hence, in this case we do not discuss the mediating role of emotions because at least one of the conditions of mediation relationships was not satisfied.

### *3.2.4. Expertise and Credibility of Media Sources*

In addition to presentation modalities (e.g., written text vs. audio/video), the difference between webpage and TV in actual risk communication also lies in the credibility and expertise of each media source as perceived by the public.[33] In the second experiment, participants also made assessment of the expertise and credibility of the media sources. For both hazards, TV was rated as having more expertise and being more credible (Table VII). As we expected, the judgments of expertise and credibility were correlated with the perceived risk. The correlation of expertise and perceived risk was 0.21 for the gas explosion ($p < 0.01$) and 0.12 for the landslide ($p < 0.01$). The correlation of credibility and perceived risk was 0.21 for the gas explosion ($p < 0.01$) and 0.17 for the landslide ($p < 0.01$).

### *3.2.5. Factor Analysis of Action Tendencies*

The Bartlett test of sphericity ($\chi^2 = 2862.30$, $p < 0.001$) was significant for the 31 action scales,

**Table VII.** Difference in Expertise and Credibility of Webpage and TV

| | Gas Explosion | | | | Landslide | | | |
|---|---|---|---|---|---|---|---|---|
| | Web | TV | *t* | *df* | Web | TV | *t* | *df* |
| Expertise | 3.96<br>(0.98) | 4.27<br>(1.09) | −2.48* | 268 | 3.93<br>(0.84) | 4.21<br>(0.95) | −2.54* | 269 |
| Credibility | 4.60<br>(0.87) | 4.85<br>(0.90) | −2.33** | 268 | 4.37<br>(0.89) | 4.94<br>(0.87) | −5.39** | 268 |

*Note:* $^*p < 0.05$; $^{**}p < 0.01$.

**Table VIII.** Factor Analysis on Action Tendencies

| Factor | Emotions | Landslide | Gas Explosion |
|---|---|---|---|
| 1. Help /prevention | I would do something so that potential harmful consequences may be prevented or at least mitigated | 0.835 | 0.814 |
| | I would personally help those afflicted | 0.829 | 0.811 |
| | I would do something to improve the situation | 0.797 | 0.851 |
| | I would try to help to reduce or limit damage | 0.735 | 0.811 |
| | I would personally participate in actions to improve the situation | 0.730 | 0.726 |
| | I would try to comfort those afflicted | 0.726 | 0.677 |
| | I would try to employ preventive measures | 0.715 | 0.697 |
| | I would do anything to stop what is going on | 0.636 | 0.647 |
| | I would personally initiate actions to improve the situation | 0.609 | 0.640 |
| | I would donate to an environmental or relief organization that takes action against the situation | 0.605 | 0.631 |
| Explained variance | | 22.8% | 22.4% |
| 2. Aggression /retaliation | I feel like yelling at the one who is responsible | 0.829 | 0.761 |
| | I feel like taking vengeance | 0.829 | 0.768 |
| | I feel ready to spit in the face of the one who is responsible | 0.777 | 0.773 |
| | I would like to sue the one who is responsible | 0.746 | 0.764 |
| | I feel like hitting the one who is responsible | 0.746 | 0.729 |
| | I would try to coerce the one responsible into rehabilitating for what happened | 0.674 | 0.728 |
| Explained variance | | 15.3% | 14.5% |
| 3. Escape /avoidance | I wish that I could undo everything that happened | 0.768 | 0.778 |
| | I would like to forget everything as soon as possible | 0.755 | 0.788 |
| | I would like not to know anything about it | 0.728 | 0.689 |
| | I would try to get as far away as possible | 0.711 | 0.786 |
| | I would not know what to do | 0.610 | 0.589 |
| | I feel like running away | 0.543 | 0.528 |
| Explained variance | | 11.1% | 12.7% |
| 4. Self-focus | I feel like slapping myself in the face | – | 0.738 |
| | I feel like patting myself on my shoulder | – | 0.711 |
| Explained variance | | | 7.2% |
| Cumulative explained variance | | 49.2% | 56.8% |

allowing the use of factor analysis. Factor analysis with VARIMAX rotation and iteration was applied. For the landslide scenario, based on the scree plots, the three-factor solution was found to be more appropriate after double-loaded items had been crossed out. Table VIII shows the factor loadings. The three factors were: (1) *Help/prevention*: 10 items, describing the willingness to participate in rescue actions after the catastrophe; (2) *Aggression/retaliation*: six items, describing the tendency of revenge actions towards the responsible agents after the events; (3) *Escape/avoidance*: six items, describing the willingness to keep distance from the catastrophe. All three factors accounted for 49.2% of the total variance (22.8%, 15.3%, and 11.1% for each factor).

The same principal component analysis was also conducted for the case of the gas explosion. In addition to the three factors as in the case of landslide, we obtained one more factor, namely, *self-focus*, which describes the self-comforting or self-punishment behavior after the events to reduce the stress. The four factors explained 56.8% of the total variance. The variance explained by *help/prevention, aggression/retaliation, escape/avoidance,* and *self-focus* were 22.4%, 14.5%, 12.7%, and 7.2%, respectively (Table VIII).

The factors we have found were also reported by Böhm and Pfister,[11] except the political action tendencies that were not found in our sample. Furthermore, self-focused behavior tendencies only appeared in the gas explosion scenario, but not in the landslide scenario. It shows that action tendencies differ across different sociocultural conditions and across different types of hazards.

### 3.2.6. *Emotions and Action Tendencies*

Böhm and Pfister[11] suggested that different emotions induce different types of action. We

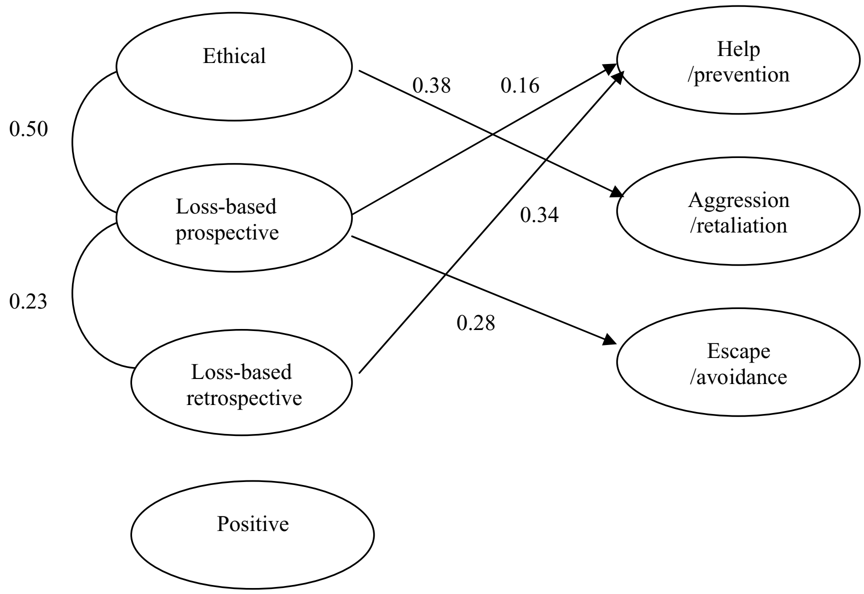



**Fig. 3.** Emotion and action tendency (landslide scenario).

*Note:* CMIN = 1,189.78, DF = 618, $p < 0.0001$, GFI = 0.81, AGFI = 0.79, IFI = 0.87, TLI = 0.85, CFI = 0.86, RMSEA = 0.058 (with 0.053–0.063 as 90% confidence interval).

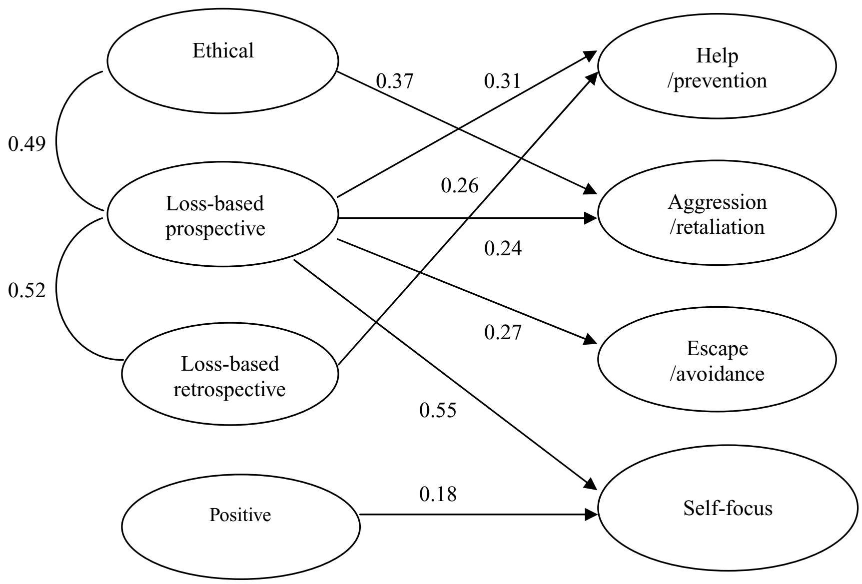



**Fig. 4.** Emotions and action tendencies (gas explosion scenario).

*Note:* CMIN = 1072.85, DF = 687, $p < 0.0001$, GFI = 0.83, AGFI = 0.81, IFI = 0.91, TLI = 0.90, CFI = 0.91, RMSEA = 0.045 (with 0.040–0.051 as 90% confidence interval).

applied structural equation modeling to study the relationship between emotions and action tendencies. Fig. 3 shows the coefficients for all significant paths for the case of the landslide, and Fig. 4 shows the result for the gas explosion scenario. Although the fit indices are not ideal according to common standards, the current models represent the best fit when comparing with the competing models. It offers us useful insights into the relationship between emotions and action tendencies. In both cases, *ethical*, *loss-based prospective*, and *loss-based retrospective* emotions were correlated, whereas *positive* emotions were not correlated with the other three types of emotions.

For both scenarios, ethical emotions were correlated with *aggression/retaliation* action tendencies, whereas *loss-based* (*prospective and retrospective*) emotions were correlated with *help/prevention* tendencies. In addition, *loss-based prospective* emotions were correlated with *escape/avoidance* action tendencies.

*Positive* emotions were correlated with *self-focused* behavior for the case of the gas explosion, whereas this relationship could not be found in the landslide scenario. On the other hand, *loss-based prospective* emotions not only triggered *help/prevention* and *escape/avoidance* action tendencies as in the case of the landslide, but also two other action tendencies, namely, *aggression/retaliation* and *self-focused* behavior. This reflects the fact that, in the case of technical hazards, people resort to more coping strategies and tend to be more aggressive when they are scared or worried about the potential losses. Note that loss-based emotions were correlated with aggressive actions in the gas explosion scenario, but not in the landslide scenario, as we expected.

## 4. GENERAL DISCUSSION

Media coverage is one of the strongest determinants of societal risk perception.[34,35] Our study offers some insights into the potential impacts of different media on public risk perception as well as reactions. It seems that vivid pictures can arouse more intense emotions, and can increase perceived risk significantly. Hence, TV coverage is more influential than other less vivid media. Moreover, people (at least in our sample) tend to consider TV as a more professional and more reliable source of information even though one can get information with the same or even higher quality from the Internet, radio, and magazines. This suggests that policymakers and risk experts should use pictures besides written text, as well as television, in order to communicate with the public.

Our study also showed that one should distinguish manmade and natural hazards in the practice of risk management. Manmade hazards tend to arouse stronger emotions, and may invite more aggressive reactions. Especially when people are afraid about the potential losses, their action tendencies are more unpredictable in the case of manmade disaster, ranging from aggression, help, escape, self-comfort, to even self-punishment. By comparison, the reaction to natural hazards tends to be less emotional and mostly concentrates on help/prevention and escape/avoidance. Policymakers should be prepared for more disruptive reactions from society towards technological or manmade catastrophes.

Böhm and Pfister[11] tested a process-based model that starts from the appraisal of risks, mediated by specific emotions, and eventually elicits specific action tendencies. Some of our results were consistent with theirs, especially the four types of emotions that emerged from factor analysis. As mentioned in Section 1, although emotions seem to be universal across cultures, the action reactions to specific emotions depend on the sociocultural factors as well as the causes of the hazards. We found that people tend to exhibit self-focused behavior in case of the technological hazards (gas explosion) but not in case of natural disasters (landslide). We also found a lack of political reaction in our Chinese sample. We encourage further investigations in other Asian countries (e.g., Japan) with similar culture but less political suppression in order to disentangle the cultural and political influences.

Sjöberg[36] criticized that many studies under the psychometric paradigm had equated emotions with dread, whereas other dimensions of emotions were typically ignored. He found that even positive emotions are important to risk perception and related attitudes. In the second experiment, we measured a variety of emotions that are typical reactions in a risk event, ranging from fear and anger to sympathy and relief. All four emotion factors were significantly correlated with subjective risk perception.

The strong relationship of emotions and risk perceptions has been well documented. However, which comes first, emotion or appraisal? The causal relationship between emotions and appraisals is a difficult research question that is still under careful and painstaking investigation. Zajonc[37] proposed that emotions are independent of cognition, and can occur through *low route* without any cognitive assessment, while other researchers emphasized the role of automatic appraisal as a precedent of emotion.[38] More recently, many neuroscientists believe that emotions and cognitions cannot be separated (see Storbeck and Clore[39] for a review). Sjöberg[36] suggested a three-stage process, in which a preliminary appraisal based on peripheral attributes gives rise to emotions, which in turn help to form new and fully developed appraisals.

Our experiments showed that the hazard causations and the presence of pictures did influence emotions and risk perceptions. Given that the risk appraisals we elicited were more likely to be fully developed appraisals than automatic preliminary appraisals, we assume the direction from emotion to cognition in our mediation analysis. It seemed to support the hypothesis that hazard types and information presentations influence risk perception through the induced emotions at least partially.

Interestingly, we found that women listening to the news indeed felt more intense emotions than when reading the news. This may reflect the gender differences in auditory brains that were reported in previous studies.[40,41] However, no differences were found in risk perception between the two modalities, both for men and women. This may be explained by the fact that the brain regulation system can control the influence of emotions—it enhances the influence of emotional stimuli when more relevant and inhibits it when less relevant[6] (also see our discussion in Section 1). The underlying mechanisms need to be studied further, preferably using temporal techniques in neuroscience experiments.

In conclusion, our study highlighted the important role of emotions in risk communication. In particular, emotions can be influenced by hazard types and presentation modes, and in turn influence risk perception and actions. Such studies can help us to understand the precedents and consequences of public emotional reactions to catastrophic events.

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## APPENDIX: INFORMATION MATERIALS USED IN THE FIRST EXPERIMENT (TRANSLATED FROM CHINESE)

### Desertification (practice materials)

China is one of the countries that suffer from desertification the most. The caused annual losses exceed 540 Billion Yuan ( = $54 billion).

In the mid 1990s, soil of 1.9 million km$^2$ was eroded by wind, and 260,000 km$^2$ was eroded both by water and wind. The wind-eroded areas of soil were increasing, and the area of the devastated soil graded as "severe and above" increased by 32% from 660,000 km$^2$ to 870,000 km$^2$. Although the government has implemented prevention programs, land still keeps degrading by a rate of 3,000 km$^2$ per year.

To some extent, the phenomenon is caused by natural factors such as drought and wind, but man also plays a leading role because of his myopic exploration and utilization of land, which includes myopic enlargement of fields, over-grazing, and unplanned mining which leads to the devastation of plants.

### Water Contamination

Water contamination is a severe problem in China. Around 46.5% of rivers and over 90% of urban water are severely polluted. Hence, 1/4 of the population's drinking water does not meet the hygiene standards.

The disposal of industrial and civil waste, together with a drastic increase of unexpected pollution accidents, will cause severe contamination and damage to the ecology of fishing water, which threatens both fish and breeding industries. Water contamination has become one of the main environmental problems China faces today.

According to experts, the main pollution source of rivers is the waste disposal of the cities and industrial enterprises, making every outlet a contaminated area off-the-bank. If there are factories up along branches, the whole river will be polluted. Resources from the Department of Water indicate that annual waste disposal in China makes up to 600 million tons, and the number is increasing every year, with over 80% of waste flowing into rivers without any treatment.

### Air Pollution

Air pollution is a severe problem in China. The concentration of pollutants of some big cities by far exceeds that prescribed by international standard, making those cities the most polluted cities in the entire world.

Contaminated air will make respiration difficult once it has been inhaled, causing diseases such as malfunction of respiration organs, asthma and lung cancer, even acute and chronic poisoning or death. Furthermore, air pollution has spread far beyond some regions and has become a worldwide issue, which has great impact on global warming.

Air pollution is mainly caused by unreasonably high pollutant emission. In 2002, China discharged about 19.95 million tons of sulfur dioxide, ranking the first in the world, with about 11.65 million tons of soot, and about 10.92 million tons of industrial powder. Experts pointed out that pollutants must be cut by at least 40% if China wants to solve its environmental problem.

**Earthquake**

An earthquake measuring 6 on the Richter scale broke out in the mountainous area about 200 km west from the Iranian capital, destroying several villages. According to a local source, at least 500 people died in the earthquake, 2,000 people were wounded, and 12,000 are now homeless. The earthquake also destroyed the road connecting the epicenter and Teheran, burying over 60 cars underneath the earth. The disaster affected at least eight provinces and included two intense aftershocks.

Iranian seismographers said that the fatality was great due to two reasons: first, the building structure and materials of local houses left them more vulnerable; second, the geographic location of Iran on a multi-fault area contributed to the intensity of the earthquake.

**Landslide**

A devastating landslide broke out in the South of China on the 18th of July. The unprecedented flood damaged infrastructure such as traffic, water systems, power systems, and telecommunication. A large-scale mud-flow and a landslide that generated a volume of up to 15,000 $m^3$ occurred at 2 am on the 20th of July, hitting 69 spots in the county's 2 $km^2$ area, and destroying many villages, killing hundreds of people, leaving a dozen of them seriously wounded, some of whom were buried or washed away by the landslide.

According to an expert analysis, both the geographic situation and the lasting rainstorm combined led to the disaster. Rocks on the high steep cliff of the mountains around the county were not hard enough to resist the lasting heavy rain. Their penetrability was only good enough for the surface layer of soil to absorb water up to a saturated level, causing soil and rocks to move, thus leading to a large-scale devastating disaster.

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