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The more involved in lead-zinc mining risk the less frightened: A psychological typhoon eye perspective



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ABSTRACT

In China, the current situation is that people under *indirect* threat from unprotected lead-zinc mining tends to oppose it, whereas people under *direct* threat are likely to 'sail close to the wind'. To understand this puzzle-like phenomenon, we surveyed 220 residents in a lead-zinc mining area located in Fenghuang County of China. We found that: 1) The degree of risk perception of villagers living around the mining site correlated inversely with their degree of involvement in mining risk. We refer to this as the "involvement" version of the psychological typhoon eye effect. 2) Perceived benefit and perceived harm provided a satisfactory explanation for this "involvement" version of the psychological typhoon eye effect. 3) Risk perception was negatively related to support for the relevant policy which we viewed as constituting a sort of voting behavior. The results may have implications for better understanding how benefited individuals respond to environmental health risks.

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1. Introduction

According to the U.S. Geological Survey 2013 (USGS, 2013), China is the world's largest producer of lead and zinc, accounting for nearly half of the global lead mine production (about 2.6 million tons in 2012) and more than a third of the global zinc mine production (about 4.6 million tons in 2012). Lead-zinc mining and smelting activities are, however, some of the primary sources of heavy metals pollution (Horvath & Gruiz, 1996; Tong, Schirnding, & Prapamontol, 2000). Lead exposure, which can cause increased blood-lead levels and affect many tissues and systems in the body, was responsible for about 143,000 deaths and 0.6% of the global burden of disease in 2004 and can seriously endanger human health (WHO, 2004, 2009). Where, then, should health and governmental policy makers place their concerns with respect to these issues?

The current situation is that the portion of the population (e.g., policy makers or public bodies) that is under *indirect* threat from

unprotected lead-zinc mining opposes it, whereas the portion of the population (e.g., lead-zinc mine owners and mine workers) that is under *direct* threat continues to participate in dangerous mining practices. Such a puzzle-like phenomenon has been so robust that local villagers tend to continue to practice unprotected mining regardless of any legal prohibitions (Y. Li, Wang, Yang, & Li, 2005). For example, the situation in the Dabaoshan heavy metal mining areas has frustrated the public at large because local private mining still exists, even after being shut down by the government several times from 1993 to 2005. Such unprotected mining has caused at least 250 deaths from cancer in the last 20 years (M. Wang et al., 2011). This continued private mining by local individuals can be seen as an evidence of being likely to 'sail close to the wind' with respect to environmental issues. The problem raised in this study is how to understand such a puzzle-like phenomenon from the perspective of risk perception and risk analysis.

The existing risk perception literature has provided some insights into this puzzle. Wise (2009) described a compelling example of the disjuncture between fear and danger: Londoners who were subjected to German bombings regularly during the Blitz in World War II eventually grew blasé, while those in the suburbs became more fearful. Guedeney and Mendel (1973) reported that, in a local attitude survey about a nuclear power station in France,

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anxiety was lower among those living closer to the nuclear reactor. Maderthaner, Guttman, Swaton, and Otway (1978) also found that people living far from a nuclear research reactor perceived it to be riskier than the nearer residents. Tilt (2006) reported that, although industrial workers labored on a daily basis under highly polluted conditions, they provided risk ratings that were well below those of farmers and commercial/service sector workers who were far from the polluting sources.

All these findings could then be captured under the umbrella of what is referred to here as the psychological typhoon eye effect: The closer to the center of a disaster area, the lower the level of concern felt by residents about safety and health (Li, Rao, et al., 2009; Li, Liu, et al., 2009). Contrary to conventional wisdom and to the ripple effect (Kasperson et al., 1988), that the impact of an unfortunate event decays gradually as ripples spread outward from a center, the psychological typhoon eye effect was observed one month after the 2008 Wenchuan Earthquake, where the post-earthquake concern of a convenience sample of 2262 adults was at its lowest level in the most severely devastated areas.

As noted and reviewed by Bonanno, Brewin, Kaniasty, and La Greca (2010), the research on reactions to the Wenchuan earthquake in Sichuan China 2008 is not the sole evidence for this effect. In fact, this phenomenon can be demonstrated in many contexts. In the context of terrorist attacks, a post-9/11 study of New York City public school children showed that children from the schools nearest to Ground Zero had significantly less psychopathology than children from more remote schools (Hoven et al., 2005). In the context of Severe Acute Respiratory Syndrome (SARS), it was reported that the level of exposure to SARS was not a primary determinant of experienced anxiety; nearness to the center of the epidemic was negatively related to anxiety levels (Xie, Stone, Zheng, & Zhang, 2011). Also in the context of earthquake, it was reported that a village closer to the epicenter of the earthquake (0.5 km) that occurred in 1998 in northern Hebei province, China, had considerably fewer cases of PTSD than one that was further away (10 km) from the epicenter (X. Wang et al., 2000). A similar study by J. Xie, Xie, and Gan (2011) showed that the perceived risk of experiencing an aftershock by residents of devastated cities (e.g., Hanwang, Panzhuhua) was lower than the perceived risk of aftershocks in the devastated area by people in a non-devastated city (e.g., Beijing). All these studies assessed the relationship between a disaster and a social cognitive reaction as a function of geometric distance. As Harada (2011) pointed out in a special issue on "Cognitive Studies in the Real World" in *Psychologia*, "The results are especially insightful for Japanese readers after the Great East Japan Earthquake of 2011." (Harada, 2011).

Additionally, Li et al. (2010) conducted two sequential surveys of 5216 residents in non-devastated and devastated areas in September–October 2008 and April–May 2009. They observed two variations in the psychological typhoon eye effect and dubbed these variations as "guanxi" (关系) versions of the psychological typhoon eye: the closer the relationship between a respondent and victims who had suffered either *physical* or *economic* damage, the less the concern about safety and health felt by a respondent. These "guanxi" (relational) versions provide additional evidence to suggest that the degree of an individual's concern about safety and health did not grow with an increase in the devastation level as common sense had expected.

According to previous studies, risks can be categorized as human-caused risk (anthropogenic risk) vs. nature-caused risk (non-anthropogenic risk) due to differences in the source of the harm (Siegrist & Sütterlin, 2014; Xie, Wang, Zhang, Li, & Yu, 2011) and also can be categorized as chronic risk vs. acute risk due to differences in the rates of diffusion (Chakraborty, 2001; Chakraborty, Collins, Grineski, Montgomery, & Hernandez, 2014).

The psychological typhoon eye effect was previously found and reported in acute nature-caused risk, acute human-caused risk, and chronic human-caused risk (see Table 1 for details). Given that the activities of lead-zinc mining and smelting are the primary sources of heavy metals pollution in Feng village and that the mining risks were constant and subtle, we categorized the risk investigated in the current study as chronic human-caused risk. Compared with acute risks (see the upper row in Table 1), such as the German bombing of London and earthquakes, lead-zinc mining risks are experienced more indirectly and more slowly.

Getting back to the discrepancy between outsiders' and insiders' reactions to lead-zinc mining risk, the reader will note that their risk perception and attitude seems likely to form another "guanxi" (关系) variation of the psychological typhoon eye effect. That is, those who are least involved in lead-zinc mining seem to reveal the greatest concern about mining safety and health, whereas those who are most involved in lead-zinc mining seem to reveal the least concern about personal safety and health. Therefore, the first aim of the present study was to empirically test this speculation: The degree of risk perception was expected to be inversely correlated with the degree of involvement in mining risk within an area.

Despite the fact that similar, interesting findings have appeared in many studies, the mechanism of the psychological typhoon eye effect is unclear. Attempts have been made to identify possible/alternative explanations. For instance, the psychological immunization theory assumes that resistance to adverse life events is naturally acquired through repeated exposure (Henderson, Montgomery, & Williams, 1972). Residents in devastated quake areas are presumed to be provided with an increased psychological immunity to the severe disaster by their natural exposure to hazardous stimuli. Some previous researchers (e.g. Li, Rao, et al., 2009; Maderthaner et al., 1978) viewed the psychological immunization theory as a possible explanation and mentioned it in their discussion. To test whether the psychological immunization theory could account for the psychological typhoon eye effect, Li et al. (2010) asked respondents to indicate the extent and frequency of their personal exposure to the earthquake damage, using a six-point scale (from "not at all" to "extremely strong" for the extent and from "never" to "always" for the frequency). The covariance analysis in Li et al.'s (2010) study revealed that the psychological typhoon eye effect was independent of the extent of exposure to hazardous stimuli. This result suggested that the psychological immunization theory is insufficient to account for the psychological typhoon eye effect. The residents did not receive increased psychological immunity to the severe disaster by personal exposure to hazardous stimuli. Before we can accept the conclusion that the residents had not received such increased psychological immunity, however, the distinctions between exposure to hazardous stimuli and people's subjective perceptions of the same stimulus (Brewer & Hallman, 2006; Howarth, 1988) should be taken into account.

Another possible explanation suggested by Maderthaner et al. (1978) and Li, Rao, et al. (2009) might be Festinger's theory of cognitive dissonance, which is defined as an uncomfortable psychological state in which two opposing cognitions, which ultimately need to be reconciled, are experienced (Festinger, 1962). As remarked in a blog by Gray (2010), the devastation of an area creates a sense of danger, yet an individual may have no choice but to remain close by, counter to their survival instinct. To reconcile these conflicting beliefs, the individual may unconsciously lower their self-assessed risk to justify remaining in the area. However, the cognitive dissonance account has not yet been directly tested, mainly because it is difficult to manipulate the levels of cognitive dissonance in a field study. Because the level of cognitive dissonance cannot be measured and manipulated in the center of the lead-zinc mining risk area, we decided not to test the cognitive

Table 1

A classification of risk and cases in which evidences of the psychological typhoon eye effect have been reported.

		Source of harm	
		Human-caused risks	Nature-caused risks
Rates of Diffusion	Acute risks	German bombings of London (Wise, 2009) 9/11 terrorist attacks (Hoven et al., 2005)	Earthquake (Li et al., 2010; Li, Rao, et al., 2009; Li, Liu, et al., 2009; Wang et al., 2000; Xie, Xie, & Gan, 2011) SARS (Xie, Stone, Zheng, & Zhang, 2011)
	Chronic risks	Nuclear power station (Guedeny & Mendel, 1973; Maderthauer et al., 1978) Industrial pollution (Tilt, 2006)	Biological invasion enters a new ecosystem without human intervention (the psychological typhoon eye effect has not been reported yet)

Note. Acute risks are non-routine and accidental hazards. Chronic risks are gradual hazards (Chakraborty, 2001; Chakraborty et al., 2014). Human-caused risks are caused by human activities and human-made technologies; Nature-caused risks are caused by naturally occurring events (Siegrist & Sütterlin, 2014; X. F. Xie et al., 2011).

dissonance account in the present study.

Alternatively, a so called “perceived benefit” account has been proposed by several investigators. X. Wang et al. (2000) proposed a possible explanation of why the villagers closer to the epicenter had a considerably lower level of PTSD. They proposed that this was because the closer village was allotted considerably greater immediate disaster relief and subsequent reconstruction support because they had been assessed by government relief authorities as having suffered greater damage. These resources in turn appeared to have helped buffer members of the village from developing chronic PTSD reactions (Wang et al., 2000). Tilt’s (2006) study on risk perception from industrial pollution proposed that the reason the risk rating provided by industrial workers was lower than that provided by farmers and commercial/service sector workers was that the industrial workers could earn more monthly income than the others could. The perceived benefit account is also consistent with the health belief model (Janz & Becker, 1984) and protection motivation theory (Floyd, Prentice–Dunn, & Rogers, 2000; Rogers, Cacioppo, & Petty, 1983), which were originally proposed to predict behavior in the context of personal health threats. Janz and Becker (1984) found that a kind of cost-benefit analysis occurred wherein an individual weighs the healthy action’s effectiveness against perceptions that it may be unpleasant or time-consuming. The severity and vulnerability assessments are reduced by perceived intrinsic and extrinsic rewards from the unhealthy behavior (Rogers et al., 1983). Bockarjova and Steg (2014) first applied protection motivation theory to slow-onset environmental risk and found that higher perceived rewards associated with a conventional vehicle negatively affected adoption of electric vehicles. Because the perceived benefit account is reasonable but lacks abundant empirical evidence in environmental studies, the second aim of the present study was to empirically test whether the perceived benefit account can explain an involvement version, that is, that involvement in risky mining decreases risk perception, of the psychological typhoon eye effect. If the perceived benefit account is correct, we should observe a negative relationship between the perceived benefit and risk perception. Because risk perception can be taken to be a function of perceived benefit and perceived harm (Holtgrave & Weber, 1993), we further hypothesized that both perceived benefit and perceived harm might be correlated with risk perception by the villagers.

In the real world, several media have reported, but not studied, cases in which panic behavior as well as a sort of “voting” behavior (rather than the concerns about safety and health surveyed in the above studies) grow with a decrease in the devastation level in a manner similar to what the psychological typhoon eye effect expected or described. As an example of panic behavior, when the Fukushima incident happened after the Tohoku Earthquake on March 11, 2011, it was not the nearby Japanese but the Chinese who lived far away from Fukushima who engaged in panic buying of salt, causing supermarkets in some major cities to run out (Setiogi, 2011). Likewise, drug stores in Russia and British Columbia,

Canada (but not Japan), reported shortages of iodine pills, in spite of health officials insisting that potassium iodide is not an anti-radiation drug (Chen, Shen, Ye, Chen, & Kerr, 2013). A very relevant case was reported in a news article entitled “A survey showed that opponents of Jiangmen nuclear fuel project were not local residents but entrepreneurs from neighboring cities” (调查称江门反核者多非当地普通群众 周边城市企业家成急先锋) (Observer, 2013). According to this report, the Jiangmen nuclear fuel project in China, which was valued at 40 billion CNY, was forced to be cancelled because of fierce opposition, not from residents of the central area (i.e., Jiangmen) but from residents of peripheral areas (that is, those are about 50–100 km distance from Jiangmen; such as Zhongshan, Guangzhou and Foshan). This project met the same fate as paraxylene (PX) producing projects in China. Since 2007, the PX projects planned in Xiamen, Dalian, and Kunming were shut down because of public fears about possible environmental pollution. This sort of policy “voting” behavior is not isolated to Chinese. The German government (rather than the Japanese government) was compelled to reevaluate nuclear power and, in a spectacular policy U-turn, made a decision to terminate nuclear power in Germany by 2022 because of opposition and demonstrations by German voters (Opinion polls show that 80% of Germans no longer accept nuclear power.) (Batsford, 2013). Nevertheless, whether these media reports were accurate is unclear due to a lack of scientific evidence.

Because voting is a very important tool for expressing a person’s preference for a candidate’s policy in democratic societies (Asim, 2012; Blais, Gidengil, & Neviite, 2004), we decided not only to investigate the inverse impact of involvement in mining risk on the degree of risk perception but also to investigate the impact of risk perception on the tendency for a type of voting behavior-support for a relevant policy. Therefore, the third aim of the present study was to test the hypothesis that risk perception is correlated with support for a relevant policy. Because we explored the antecedents and consequences of risk perception at the same time in the former hypotheses, this third hypothesis implied that risk perception has a mediating role between perceived benefit/harm and support for a relevant policy.

In summary, the goal of the current study was to investigate 1) whether an “involvement” version of the psychological typhoon eye effect exists in a lead-zinc mining area; 2) whether perceived benefit and perceived harm can explain the “involvement” version of the psychological typhoon eye effect; and 3) whether risk perception has an impact on support for a relevant policy. Integrating prior theoretical efforts and research, this study presents a research model linking the main variables in Fig. 1.

2. Methods

2.1. Data collection and sample

The lead-zinc mine area we investigated is located in the “Feng” administrative village (pseudonym for a village) of western Hunan

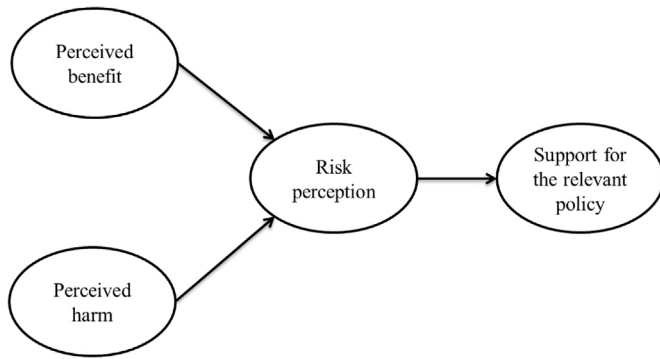


Fig. 1. Hypothesized structural equation model. Ovals indicate latent factors.

Province, China. The administrative village consists of four historical villages with 346 local families, lodged within steep hills and roughly 40 km from the nearest county town. Mining activities in the area go back to the Qing Dynasty (1644–1912). Since 1994, the local villagers have had governmental permission to exploit the mines. At the time of an earlier survey, the state-owned or collective-owned mine enterprises had already officially been closed down to protect the environment (Lora-Wainwright, 2013). However, many private mines still operate in the village. The geographical distribution of the villages and mines are shown in Fig. 2, which clearly shows that the lead-zinc mines and villages are mixed within this area. Environmental geography studies found that the concentrations of lead (Pb) in the soil were much higher than Level 2 of the National Environmental Quality Standard for Soils in China (GB15618-1995), i.e., the level suitable for the soil of arable land, and that the lead levels in the blood of local residents and crops were above national safety levels in the “Feng” administrative villages. (Ji, Li, Yang, Sun, & Wang, 2009; Wang, Lu, Chen, Zheng, & Liu, 1994).

For our current study, one adult was randomly chosen from each household to complete a questionnaire. A stratified random sampling method, in which the sample was stratified by gender and age, was used. A total of 220 local villagers were randomly selected. An extensive face-to-face interview covering a number of issues, including some items that were unrelated to the current study (e.g. items about economic geography and epidemiology), was conducted to gather information from each participant in their homes by trained interviewers. The demographic information for the sample is listed in Table 2. It should be noted that the mine owners

coded in the present study are still engaged in mining work.

2.2. Questionnaire

The questionnaire was designed to measure four constructs, which focused on mining situations, and the contents of each item are shown in Table 3. We utilized the psychometric paradigm (Fischhoff, Slovic, Lichtenstein, Read, & Combs, 1978; Slovic, 1987) as a research framework to measure risk perception about a lead-zinc mine. Three items for measuring risk perception about a lead-zinc mine were adapted from previous studies (Fischhoff et al., 1978; Xie, Stone, Zheng, & Zhang, 2011). The respondents were asked if they thought the pollution caused by the lead-zinc mine was serious, dreadful, and uncontrollable. For the measurement of the other constructs, new items related to lead-zinc mining were formulated according to the actual situation and interviews in the “Feng” village. To prepare for the benefit and harm measures, we interviewed 12 local villagers, three medical geographers who had previously carried out heavy metal pollution research in Feng village, and two staff members from the local Center for Disease Control (CDC). The questionnaire we developed was based on the first-hand information they provided. Four items were used to measure perceived benefit and eight items were used to measure perceived harm (see Table 3). Items were recoded so that higher values expressed a better perception of lead-zinc mining and lower values expressed a worse perception of lead-zinc mining. Another variable was “support for the relevant policy”, which was intended to measure the villagers’ voting intention. The items for measuring the support for a relevant policy were adapted from a study by Tanaka (2004). Our study obtained this information by asking questions about whether the participants or other villagers favored lead-zinc mining in the village. The questions were answered on a 5-point scale (see Table 3).

To determine their level of involvement in mining activities, the respondents were asked to classify their identity into one of four categories (1 = “villager not involved in mining”; 2 = “family member of mine owner/worker”; 3 = “mine worker”; and 4 = “mine owner”). “Mine owner” referred to people who owned the mine but were still engaged in mining work. “Mine worker” referred to people who physically enter and work in a mine owner’s private mine. “Family member of mine owner/worker” referred to the immediate families of a mine owner/worker. “Villager not involved in mining” referred to those who had never worked in any mine nor had family members who had ever worked in one.

Xiangxi Tujia & Miao Autonomous Prefecture

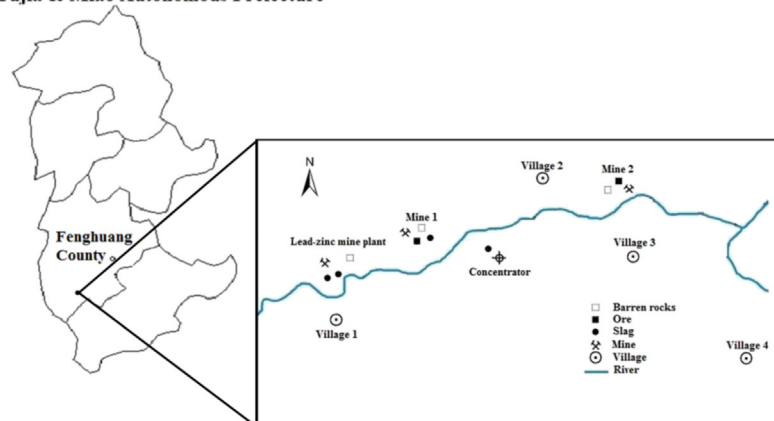


Fig. 2. Geographical distribution map of the villages and mines investigated.

Table 2
Demographic data in the surveys (N = 220).

		Percentage (%)		Percentage (%)	
Gender	Male	42.3	Education Level	Illiterate	27.3
	Female	57.7		Primary school	43.2
Age	Under 30	8.2	Involvement Level	Junior school	29.5
	30–39	12.7		Mine owner	15.9
	40–49	25.5		Mine worker	52.7
	50–59	20.0		family member of mine owner/worker	12.3
	Over 60	33.6		Villager not involved in mining	19.1

Table 3
Indicator variables used for testing the causal model.

Risk perception
How would you describe the damage to your village caused by mining? (severity) 1 = Very small; 2 = relatively small; 3 = not sure; 4 = relatively big; 5 = very big
How would you describe your concern about the damage to your family caused by mining? (Dread) 1 = not worried at all; 2 = not worried; 3 = not sure; 4 = worried; 5 = very worried
How would you describe the possibility that you and your family could avoid the negative effects caused by pollution? (Control) 1 = completely impossible; 2 = impossible; 3 = not sure; 4 = possible; 5 = definitely possible
Perceived benefit
To what extent the mining has an effect on your family income? 1 = substantially reduced; 2 = reduced; 3 = unchanging; 4 = increased; 5 = substantially increased
To what extent the mining has an effect on your village's fiscal revenue? 1 = substantially reduced; 2 = reduced; 3 = unchanging; 4 = increased; 5 = substantially increased
To what extent the mining has provided your family with opportunities to make money? 1 = substantially reduced; 2 = reduced; 3 = unchanging; 4 = increased; 5 = substantially increased
To what extent the mining has provided your village with opportunities to make money? 1 = substantially reduced; 2 = reduced; 3 = unchanging; 4 = increased; 5 = substantially increased
Perceived harm
Mining has made the yields of your village's crops (reverse scoring): 1 = substantially reduced; 2 = reduced; 3 = unchanged; 4 = increased; 5 = substantially increased
Mining has made the quality of your village's crops (reverse scoring): 1 = substantially reduced; 2 = reduced; 3 = unchanged; 4 = increased; 5 = substantially increased
Mining has made the quality of your village's fields: 1 = much better; 2 = better; 3 = unchanged; 4 = worse; 5 = much worse
Mining has made the quality of your village's air: 1 = much better; 2 = better; 3 = unchanged; 4 = worse; 5 = much worse
Mining has made the quality of your village's drinking water: 1 = much better; 2 = better; 3 = unchanged; 4 = worse; 5 = much worse
Mining has made the villagers' health status: 1 = much better; 2 = better; 3 = unchanged; 4 = worse; 5 = much worse
Mining has made your families' health status: 1 = much better; 2 = better; 3 = unchanged; 4 = worse; 5 = much worse
How would you describe the area of the land occupied by tailings and waste mine in your village: 1 = none; 2 = small; 3 = not sure; 4 = large; 5 = very large
Support for the relevant policy
Do you favor or oppose accepting a lead-zinc mine in your village? 1 = strongly oppose; 2 = somewhat oppose; 3 = neutral; 4 = somewhat favor; 5 = strongly favor
Do other villagers who are similar to you favor or oppose accepting a lead-zinc mine in your village? 1 = strongly oppose; 2 = somewhat oppose; 3 = neutral; 4 = somewhat favor; 5 = strongly favor

3. Results

Prior to testing the main hypotheses, the study conducted a number of preliminary analyses to ensure the validity and reliability of the data. First, by using AMOS 18, a confirmatory factor analysis was conducted to evaluate the discriminant validity of risk perception, perceived benefit, perceived harm, and support for the relevant policy. One-factor and four-factor models were performed to test which model provided the best fit for the data (Anderson & Gerbing, 1988). The hypothesized four-factor model yielded a better

fit than the single-factor model (see Table 4) with a change in the chi-square of 275.98 ($\Delta df = 10$, $p < 0.001$). Second, all variables in the study had an acceptable Cronbach's α value greater than 0.6 and were considered reliable (Hair, Anderson, Tatham, & Black, 1998). Descriptive statistics, correlations, and reliability for all study variables are shown in Table 5. These results indicate that the scales of the variables possessed adequate reliability and validity for use in the hypotheses tests.

After statistically controlling for gender, age, and education, the villagers' ratings of their risk perception differed significantly

Table 4
Fit indices for the factor structure.

Model	χ^2	<i>df</i>	χ^2/df	$\Delta\chi^2$	Δdf	GFI	IFI	CFI	RMSEA
Model 1: One-factor	501.56	119	4.22			0.76	0.64	0.64	0.12 (0.11–0.13)
Model 2: Four-factor	225.58	129	1.75	275.98	10	0.90	0.92	0.91	0.06 (0.05–0.07)

Table 5
Descriptive statistics, correlations for all study variables and reliabilities.

	Mean	SD	r					
			1	2	3	4	5	
1. Risk perception	3.55	0.92	0.68					
2. Involvement	2.35	0.96	0.19*	–				
3. Perceived benefit	3.73	0.43	–0.29**	–0.26**	0.78			
4. Perceived harm	3.65	0.45	0.66**	0.19*	–0.20**	0.75		
5. Support for the relevant policy	3.02	1.01	–0.38**	–0.19*	0.32**	–0.40**	0.77	

Note. $N = 220$. Alpha coefficient reliabilities appear in diagonal; * $p < 0.05$; ** $p < 0.001$.

depending on their involvement ($F(3, 213) = 3.04, p < 0.05$, and $\eta^2 = 0.04$, by ANCOVA). The scores for their risk perception (see Fig. 3) from highest to lowest were: villager not involved in mining, family member of mine owner/worker, mine worker, and mine owner. Fisher's least significant difference (LSD) post hoc test further revealed that the 'villager not involved in mining' group reported the highest risk perception, significantly higher than the ratings given by mine owners and mine worker ($ps < 0.05$). No significant difference was observed between the rated risk perceptions of the latter two groups ($p > 0.05$). The rated risk perception of the 'family members of mine owner/worker' group was the second highest, but, similarly, no significant difference was found between their rated risk perceptions and those of the other three groups ($ps > 0.05$). These results showed that the risk perception of villagers living around the mine significantly increased with a decrease in their involvement in mining risk. The hypothesized "involvement" version of the psychological typhoon eye effect was thus observed in the present study.

The hypothesized model (see Fig. 1) was tested using the structural equation model (SEM) with AMOS 18 and examined with the following goodness-of-fit indices: chi-square (χ^2), χ^2/df , goodness-of-fit index (GFI), comparative fit index (CFI), Tucker–Lewis Index (TLI), and root-mean-square error of approximation (RMSEA). There is a limitation to the chi-square test in that the χ^2 is highly sensitive to sample size, especially if the number of participants is greater than 200. An alternate statistic examines the ratio of χ^2 to the df for the model (Hoe, 2008; Joreskog & Sorbom, 1986). Kline (1998) suggested that a χ^2/df ratio of 3 or less is a reasonably good indicator of model fit. The GFI, CFI, and TLI should be greater than 0.90 to indicate an acceptable model fit. A value of 0.08 or less for RMSEA would suggest a close fit of the model in relation to the degrees of freedom.

Following Anderson and Gerbing (1988) recommendations, the absolute fit of the hypothesized model was assessed using a nested

models comparison. A model is said to be nested within another model when the set of freely estimated parameters of the first model is a subset of those estimated in the second model (Anderson & Gerbing, 1988). First, the hypothesized model was estimated to determine whether it fit the data. The model provided an acceptable fit (see Table 6) to the data. Although the χ^2 was significant, the χ^2/df ratio was less than 3. All of the standardized path coefficients for the hypothesized model yielded significant coefficients ($ps < 0.001$) in the appropriate direction. In accordance with recommendations from methodological experts (Anderson & Gerbing, 1988), we tested an alternative model to compare with the hypothesized model. Because previous studies (Siegrist, Earle, & Gutscher, 2003; Tanaka, 2004) found that perceived benefit and perceived harm (Bower & Miller, 1960; Holtgrave & Weber, 1993) had an impact on behavioral tendencies such as support for the relevant policy, we estimated an alternative model to test whether the addition of paths from perceived benefit to support for the relevant policy and from perceived harm to support for the relevant policy would result in a significant improvement over the hypothesized model. If the addition of the paths significantly improved the model fit, this would indicate that the paths should be included in the model. The result showed that the standardized path estimate from perceived benefit to support for the relevant policy was significant, but from perceived harm to support for the relevant policy was not significant ($\beta = 0.11, p > 0.05$), so this insignificant path was deleted from further analyses. Thus, the alternative model was a better fit to the data (see Table 6). Similar to the result from the hypothesized model, although the χ^2 was significant, the χ^2/df ratio was also less than 3 in the alternative model.

Since the models were nested, the difference in χ^2 between the two models could be used to assess the improvement in the fit of the new model. Compared with the hypothesized model, the model fit of the alternative model improved significantly ($\chi^2(1) = 11.42, p < 0.005$). As a result, we proceeded with further analyses using the alternative model. The path estimates for the final model are depicted in Fig. 4. Perceived benefit ($\beta = -0.19, p < 0.01$) and perceived harm ($\beta = 0.87, p < 0.001$) significantly predicted risk perception. The path coefficient of perceived harm on risk perception was higher than that of perceived benefit on risk perception, implying that perceived harm seems to play a greater role in predicting risk perception than perceived benefit. Moreover, risk perception ($\beta = -0.42, p < 0.001$) and perceived benefit ($\beta = 0.29, p < 0.001$) significantly predicted support for the relevant policy.

The standardized total effects on support for the relevant policy were further calculated. It is necessary to consider not only direct effects but also indirect effects when evaluating the influence of each factor on support for the relevant policy. The strength of the influence of each factor on support for the relevant policy from the viewpoint of the standardized total effects produced by both direct and indirect effects was -0.42 for risk perception, 0.37 for perceived benefit, and -0.37 for perceived harm. Risk perception was, therefore, the most important factor in the support for the

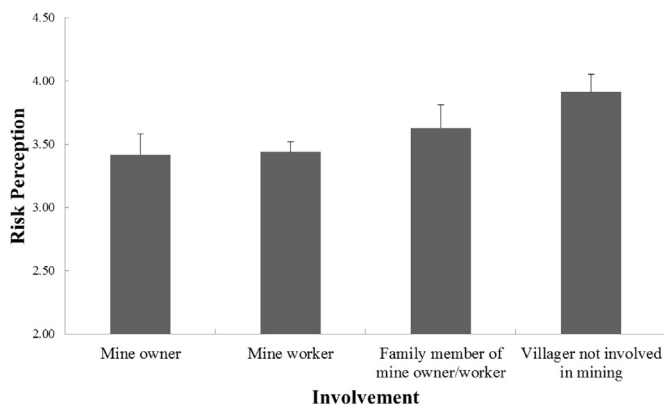


Fig. 3. Mean of risk perception. Bar heights indicate mean values. Error bars indicate standard error.

Table 6
Fit indices and model comparisons.

Model	χ^2	df	χ^2/df	$\Delta\chi^2$	Δdf	GFI	CFI	TLI	RMSEA
The hypothesized model	210.31	116	1.81			0.90	0.91	0.90	0.06 (0.05–0.07)
The alternative model	198.89	115	1.73	11.42	1	0.90	0.92	0.91	0.06 (0.04–0.07)

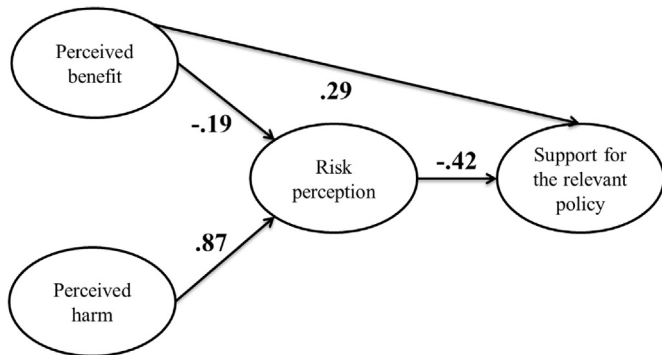


Fig. 4. The final structural equation model. Ovals indicate latent factors. All coefficients are significant ($p < 0.01$).

lead-zinc mining preferred policy.

4. Discussion

The risk perception of the villagers living around the mining site differed significantly depending on their involvement. The score of the risk perception from highest to lowest was: villager not involved in mining, family member of mine owner/worker, mine worker, and mine owner. We dubbed it the “involvement” version of the psychological typhoon eye effect in the lead-zinc mining area. That is, the more involved in lead-zinc mining the villagers were, the less they were concerned about the pollution risk from lead-zinc mining. This finding extends our understanding of the psychological typhoon eye effect. Unlike the fundamental effect, where the concern about safety and health was a function of *geometric* distance, the concern about safety and health reported in the present variation is a function of *involvement* distance, even though the geometric distance remained constant. In this type of case, in which the geometric distance remained unchanged (see map in Fig. 2), the cognitive dissonance account is unlikely to work and cannot be tested because of a lack of “objective dissonance”. This is because all our participants shared the same degree of cognitive dissonance – there is a pollution risk from lead-zinc mining and they continue to live nearby and, therefore, would be expected to want to restore consistency or consonance. However, it could be argued that dissonance is a subjectively experienced phenomenon. In this sense, differences in psychological distance caused by involvement might lead to subjectively experienced cognitive dissonance. Future studies are needed to test whether subjectively experienced cognitive dissonance could account for the psychological typhoon eye effect.

The observed “involvement” version of the psychological typhoon eye effect, together with other previously reported variations in the psychological typhoon eye effect, are important to consider in planning mental health interventions (Bartels & VanRooyen, 2012) and important for policy makers when deciding how to best battle public health risks, because it enables researchers and policy makers to better understand the psychology of those who have suffered through a natural disaster (Gray, 2010). An awareness of the discrepancy between people who were

involved more and those who were involved less in mining may enhance decisions in situations in which there are environmental health threats and may also enrich our understanding of how people can become resilient to different kinds of threats. The psychological typhoon eye effect has previously been detected and reported in three categories of risk (see Table 1, acute human-caused risk, acute nature-caused risk, and chronic human-caused risk). Although researchers have found the psychological typhoon eye effect in its original version in chronic human-caused risks, such as nuclear power stations, a variation termed the “involvement” version was first explored within this category of risk. It is worth exploring whether other variations of the psychological typhoon eye effect can be applied in this risk category. Furthermore, to the best of our knowledge, the psychological typhoon eye effect has not been reported in chronic nature-caused risk (see the bottom left cell of Table 1). It would be interesting to explore in future studies whether the psychological typhoon eye effect exists in chronic nature-caused risk.

Our results provided evidence to support our conjecture that perceived benefit and perceived harm can explain the “involvement” version of the psychological typhoon eye effect. Our observed finding that the more benefit from private mining the villagers perceived, the lower the risk they perceived supported the so-called “perceived benefit” account proposed by several investigators (Tilt, 2006; X. Wang et al., 2000). In addition, we found that perceived harm correlated positively with risk perception. The finding that the path coefficient of perceived harm on risk perception was higher than that of perceived benefit suggested that perceived harm had a greater influence. Such a finding was intuitively expected, since previous studies had shown that perceived harm was a strong explanatory factor for risk perception (Holtgrave & Weber, 1993).

Another possible explanation for the psychological typhoon eye effect is the gap between experiencing and imagining. Previous studies showed that people overestimate the intensity of their reactions to an imagined event. Gilbert, Morewedge, Risen, and Wilson (2004) measured people’s anticipations and experiences of regret and self-blame and found that people are less susceptible to regret in real situations than they are when they imagine events. Wilson, Wheatley, Kurtz, Dunn, and Gilbert (2004) found that people predicted that losing would make them feel worse than it did and selected a higher dose of a drug (hypothetical medication) to cope with an anticipated loss than did people who actually lost. Likewise, some studies found evidence that was consistent with the idea that rare events seem to be given more weight when imagined (e.g. by reading the descriptive information) than when experienced (Hertwig & Erev, 2009; Rakow & Newell, 2010). However, a gap between experiencing and imagining is not the case in our study. The villagers under investigation all lived in the lead-zinc risk area, and the risks they perceived were not imagined but truly experienced. Future study is needed to test whether this gap between experiencing and imagining could account for the psychological typhoon eye effect.

Furthermore, some other potential factors of the effect need to be considered in the future. Researchers (Jang, 2005; Jang & Lamendola, 2006) found that the Hakka spirit seemed to cause the Hakka people to accept that what had occurred had acted as a

catalyst for future-orientated action and reduced stress after the 921 earthquake in Taiwan. These results suggested that cultural differences exist that may be important in investigating the psychological typhoon eye effect. Moreover, previous studies indicated that high levels of hazard-related anxiety could trigger avoidance and denial (Cameron & Leventhal, 2003) and thus further reduce the likelihood that people would prepare (Paton, Smith, & Johnston, 2005). In future studies, it would be interesting to distinguish between the responses to anxiety by different groups and to explore whether hazard-related anxiety can lead to the psychological typhoon eye effect.

The observed relationship between risk perception and support for the relevant policy are in accord with common-sense expectations that the more risk the villagers perceived, the less their support for the lead-zinc mining preferred policy. Nonetheless, the important thing is that risk perception was distorted in this particular situation in a way described by the psychological typhoon eye effect. The distorted risk perception consequently influenced the observed support for the relevant policy. The 'support for the relevant policy' measured in the present study is a sort of "voting" behavior. Voting plays an important role in the functioning of modern society (Elkind & Faliszewski, 2010). Policy voting is at the heart of the electoral connection between popular preferences and elite decisions (Schoen, 2008). There has been increased interest in involving the public in decisions regarding science and technology policies, such as issues concerning the management of environmental and health risks (Rowe & Frewer, 2000). Therefore, the present study on the impact of risk perception on 'support for the relevant policy' is of practical significance. The knowledge of how risk perception influences support for the relevant policy can help us to understand the cognitive process underlying policy voting, thereby provide a psychology-based theoretical foundation for facilitating people's foresight and green awareness.

One limitation of the current study is that the response rate was not recorded, although only a few eligible participants declined to participate. The primary reasons that caused participants to decline to complete the survey were the time commitment (at least 30 min) and language barriers (those who could only speak the local dialect, the Miao language). Another limitation of the current study is that some measures of risk perception were ambiguous. For example, different respondents may have had different interpretations of "negative effects caused by pollution." Future studies should include a manipulation check to ensure that the items used are not ambiguous, or future studies should develop new items that are clearer.

In conclusion, this study helps us to better understand how villagers living around the mining site perceive and respond to environmental health risks from a psychological typhoon eye perspective. The villagers' low perception of risk as well as their pro-voting in many cases can be considered to be a "distorted" action because the voters may be subject to economic temptation (such as the instant gain from mining). With this in mind, the agents of risk analysis and policymaking should be aware of the unique role that interest groups (such as mine owners) play in shaping policy choices. Apart from the involvement of an interest group, risk communication and risk management is understandable and people's responses are predictable. Once an interest group becomes involved in practicing, planning, or managing risk, the perceived risk as well as the interest-group's pro-voting becomes distorted, as revealed in the present study. Therefore, policy makers and managers involved in risk management should think twice about the desires of different interest groups before they act.

This study may also help us to develop potential intervention strategies for dealing with "distorted" action. The first strategy is to

mention the "obvious" cost of lead-mining risk. A potential intervention for people who are under direct threat (e.g., lead-zinc mine owners and mine workers) could be to manipulate the way the opportunity cost (or harm) is framed. As suggested by recent framing studies (Magen, Dweck, & Gross, 2008; Zhao et al., 2015), mentioning the "obvious" opportunity cost of alternatives may help decision makers choose in a more informed manner. That is, the explicitness of the opportunity cost in each alternative can influence the impulsive choice of the decision maker - the same option (mining activity) which is seen as a gain/reward in one frame (hidden frame) can be seen as a loss/cost in another frame (explicit frame). The second strategy could be to provide opportunities to make money from occupations other than lead-zinc mining. Considering the economic temptation (Janz & Becker, 1984), offering new options for making a living (such as planting cash crops) might reduce the attractiveness of lead-zinc mining.

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