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The Risk Perception Paradox—Implications for Governance and Communication of Natural Hazards

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This article reviews the main insights from selected literature on risk perception, particularly in connection with natural hazards. It includes numerous case studies on perception and social behavior dealing with floods, droughts, earthquakes, volcano eruptions, wild fires, and landslides. The review reveals that personal experience of a natural hazard and trust—or lack of trust—in authorities and experts have the most substantial impact on risk perception. Cultural and individual factors such as media coverage, age, gender, education, income, social status, and others do not play such an important role but act as mediators or amplifiers of the main causal connections between experience, trust, perception, and preparedness to take protective actions. When analyzing the factors of experience and trust on risk perception and on the likeliness of individuals to take preparedness action, the review found that a risk perception paradox exists in that it is assumed that high risk perception will lead to personal preparedness and, in the next step, to risk mitigation behavior. However, this is not necessarily true. In fact, the opposite can occur if individuals with high risk perception still choose not to personally prepare themselves in the face of a natural hazard. Therefore, based on the results of the review, this article offers three explanations suggesting why this paradox might occur. These findings have implications for future risk governance and communication as well as for the willingness of individuals to invest in risk preparedness or risk mitigation actions.

KEY WORDS: Literature review; natural hazards; risk perception

1. INTRODUCTION

Within the social sciences the term risk perception has a long tradition.(1) The term denotes the process of collecting, selecting, and interpreting signals about uncertain impacts of events, activities, or technologies.(1–3) These signals can refer to direct experience (e.g., witnessing a flood) or indirect experience (e.g., information from others, such as reading about a natural disaster in the newspaper). Yet risks cannot be "perceived" in the sense of being taken up by the human senses, as are images of real phenomena. Mental models and other psychological mechanisms that individuals use to judge risks (such as cognitive heuristics and risk images) are internalized through social and cultural learning and constantly moderated (reinforced, modified, amplified, or attenuated) by media reports, peer influences, and other communication processes.(4) Perceptions may differ depending on the type of risk, the risk context, the personality of the individual, and the social context. Various factors such as knowledge, experience, values, attitudes, and emotions influence the thinking and judgment of individuals about the seriousness and acceptability of risks. Perceptions also play a major role for

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motivating individuals to take action to avoid, mitigate, adapt to, or even ignore risks. However, the connection between risk perception, willingness to act, and risk preparedness is still not clear.

The main focus of this article lies on the discussion of results from an interdisciplinary review of previous studies about risk perception and behavioral response regarding natural hazards. It has been argued that individuals with low risk perception are less likely to respond to warnings and undertake preparedness measures than individuals with a high risk perception.[5,6] But is this really the case? Although much previous research has been conducted in the field of risk perception, our review suggests some intervening factors that influence the relationship between risk perceptions and preparedness actions. Therefore, our task is to summarize the findings on the base of the available data and highlight the implications of risk perception for risk governance and communication.

2. METHOD

This review includes papers from a broad range of disciplines focusing on a range of natural hazards. Parts of this meta-study have already been published in the report "Risk Perception and Natural Hazards" for the European Framework 7 CapHaz-Net project.[3] The purpose of the CapHaz-Net project (Social capacity building of natural hazards: Toward more resilient societies) was to highlight opportunities to enhance the capacities of European societies to prepare for, cope with, and recover from the negative impacts of a "natural" hazard. The work package 3 report (risk perception) reviewed approximately 30 European studies on floods, heat-related hazards, and alpine hazards (flash floods, avalanches, and debris floods). The purpose of the review was to define those social factors that are most relevant for risk perception of natural hazards. For the purpose of this study we expanded our review to a broader range of natural hazards: earthquakes, storms, fires, volcanic eruptions, and tsunamis. In this new study, we went beyond the findings of the CapHaz-Net report to gain an understanding of how the two factors of experience and trust affect risk perception and preparedness actions as well as how this affects risk governance.

The selection criteria of the CapHaz-Net project included articles and European case studies that were produced after 2000 (to limit the number of results received) and focused on natural hazards and risk perception. The methods used for obtaining papers for the review conducted within the CapHaz-Net project was iterative and pragmatic (i.e., reading the most important journals from different disciplines, checking the reference list of the interesting articles, asking colleagues for their studies and pending publications, and inviting 30 experts in the field of natural hazards to a workshop on risk perception in 2010 to discuss the database). For this study, however, an additional literature review was conducted to find more information about the connection between risk perception and willingness/preparedness to take action in the face of future potential natural hazards (see Table I).

The following databases were compared: www.scholar.google.com,http://www.sciencedirect.com/science, http://worldwidescience.org/, http://www.mendeley.com/research-papers/, and Thomson Reuters (formerly ISI) Web of Knowledge. We looked for the following combination of keywords: different natural hazards ("natural hazard," "natural risk," "flood," "avalanche," "earthquake," "storm," "fire," "volcanic," "volcano," "tsunami") were combined with "risk perception" (1st search), "risk management" (2nd search), "risk governance" (3rd search), "participation"(4th search), "responsibility" (5th search), "behavior" (6th search), "preparedness" (7th search), and "willingness to act (8th search). We received thousands of hits from each database in regards to all searches (an exception was "risk governance" because it is a fairly new concept), even though we limited the search by only taking into account literature published after 2000. We assumed that most of the relevant literature on risk perception of natural hazards before 2000 (e.g., Slovic[1] or Quarantelli[7]) was already covered in several papers (e.g., Plapp and Werner,[8] Renn,[9] Sjöberg,[10] Siegrist and Cvetkowitch,[11] Terpstra *et al.*,[12] Lindell and Perry[13]). We screened the reference lists of these papers, however, in order not to exclude important findings from previous work.

Many of the entries that we were able to retrieve were identical with the list of references that we had found in the previous searches undertaken during the CapHaz-Net project. However, there were several newer publications that we added as well as publications about natural hazards beyond floods. At the same time, the search did not reveal several studies that we had previously found in the risk perception study of the CapHaz-Net project. This indicated that the initial iterative and pragmatic method of obtaining relevant literature used in the CapHaz-Net

project produced a more extensive list about flood risks. So we combined the two lists for the review in this article.

Because the combined list accounted for more than 350 entries, we applied selection criteria for reducing the number of studies for the review. First, we placed most emphasis on the Web of Knowledge database for two reasons: this database is based on the impact factor and therefore includes mainly peer-reviewed articles (in contrast to Google Scholar), and it is not limited to journals and books of certain publishing houses (as Science Direct or Mendeley) or of certain disciplines. The next selection criterion was content: we selected all articles that linked risk perception to individual willingness/preparedness actions. As the reviewed publications show a large difference in their methods (quantitative or qualitative approaches), in numbers of participants, and in the choice of the research questions, only publications that provided empirical evidence for relationships between perception and behavior were taken into account for the review. The third and last criterion was geographic focus. Because the preconditions for case studies in Europe and in countries outside Europe are highly affected by the large differences in severity and scope of natural hazards, we decided to place our main focus on Europe. We added some literature on international studies beyond Europe if basic concepts or theories were addressed or if the literature included comparisons with European experiences. The non-European studies were not part of the direct review summarized in Table I.

The studies that remained after the selection (listed in the bibliography here) include authors from different research disciplines (psychology, social science, natural science, or philosophy). They also include many different perspectives and apply a variety of frequently used but not well-defined terms such as preparedness. Often, they do not refer to "risk perception" but to related mental constructs such as "risk awareness," "willingness to act," "preparedness," "social action," or "behavior." Several papers reviewed do not explicitly distinguish between willingness to act and preparedness but instead tend to focus on one or the other. However, from the case studies reviewed, it can be inferred that willingness to act is seen as an intention, whereas preparedness is considered partly as a physical action and partly as an individual's perception of preparedness (e.g., Njome *et al.*[14]). We tried to distinguish between the two different meanings of preparedness by differentiating between behavioral intention and protective action. When we use the term risk preparedness in this article, we refer to the behavior of individuals, who, based on their risk perceptions and other motivations, undertake special measures to mitigate or avoid the respective risk.

3. RESULTS

3.1. Overview of Results

This section presents the results of the literature review with a special focus on risk perception and natural hazards (Table I). The selected studies were screened for the main factors responsible for determining risk perception and ordered into four categories (risk factors, informational factors, personal factors, and context factors).

Risk factors (factors associated to the scientific characteristics of the risk): perceived likelihood of an event and perceived or experienced frequency of hazardous events. These factors do not play a very important role in the risk perception of natural hazards.[15] The likelihood of a disaster is barely taken into account when making judgments about perceived risk levels.[16] The perceived magnitude of a disaster is also of little importance for people's risk perception.[17] This is surprising because catastrophic potential is a rather strong predictor for risk perception in the field of technological risks.[1,9]

Informational factors: source and level of information, media coverage, involvement of experts in risk management. These factors are linked to indirect experience because individuals without direct experience of a hazard event need to base their risk understanding on external information. The information provided by mass media, for example, does have an effect on risk perception but only if the respondents lack direct experience.[18] Trust is also important here in terms of the trustworthiness of individuals providing the information.[15]

Personal factors, such as age, gender, educational level, profession, personal knowledge, personal disaster experience, trust in authorities, trust in experts, confidence in different risk reduction measures, involvement in cleaning up after a disaster, feelings associated with previously experienced floods, world views, degree of control, and religiousness. Some studies have found that age and gender have an influence on risk perception,[19,20,21,22] others saw no or little influence.[8,18,23,24] There is no consistent understanding of the importance of these factors and they seem to be mediated by other intervening factors (e.g., education: Karanci *et al.*[19]). Among the few external factors that seem to have

impact on risk perception of natural hazards was direct experience, which has been proven to exert a strong effect on risk perception.[8,15,16,18,25,26,27,28,29] Furthermore, trust in authorities and confidence in protective measures were also found to influence risk perceptions.[14,15,27,30]

Contextual factors: economic factors, vulnerability indices, home ownership, family status, country, area of living, closeness to the waterfront, size of community, age of the youngest child. These factors are usually investigated in conjunction with personal factors. The strength of the effects of contextual factors related to risk perception seems to depend on the nature of the combination of contextual variables with specific personal factors. For example, Kellens *et al*.[20] found that home ownership is not a strong predictor for risk perception, but Burningham *et al*.,[23] who focused on risk awareness, did find home ownership to be important. The mediating effect here seemed to be prior experience with damage. This proposition is also suggested by Grothmann and Reusswig,[26] who investigated private efforts for taking precautionary measures for damage prevention regarding flood risks. They also found home ownership to be an important factor when people felt vulnerable to risks. This is confirmed by Harries and Penning- Rowsell,[31] who demonstrated that individuals with flood experience took more preparedness actions than other without such experiences. Finally, communities with prior flood experience were "more likely to regard themselves as better prepared for another such event than communities that have not had experience of any major flood."[29]

On the basis of the reviewed studies, direct experience of a natural hazard even appears to be one of the most important factors. Of minor but still significant importance are media coverage (which we see as a form of indirect experience) and home ownership, which acts as a promoter for concern when either personal experience or perceived vulnerability is given. The following section discusses first the influence of experience and then turns to a second important variable: trust.

3.2. Risk Perception and Experience

For clarity we have divided experience into two components: direct experience and indirect experience. Direct experience is internal (e.g., experiencing a hazard event with one's own eyes), whereas indirect experience is external (e.g., media and education). The following sections provide a summary of two types of experience and their effects on risk perception.

3.2.1. Direct Experience

Direct experience can have a positive effect on risk perception.[8,15,16,18,25–27] This could reinforce precautionary behavior. But it also might have a negative affect (low severity and seldom experienced events can produce a false sense of security/misjudgment of ability to cope). Some examples show this influence of direct experience in more detail: personal exposure to the natural event (e.g., a flood) can offer an illustration of the threat and demonstrates the potential for future risk. Hence, experience of a natural hazard leads to a higher risk perception in most cases. For example, risk perception was positively correlated with personal memories of having experienced damage in an earlier flood in Italy.[16] Ruin *et al*.[5] confirm this finding: individuals without direct flood experience tend to underestimate danger, whereas individuals with direct flood experience tend to overestimate danger. This has also been documented in studies about landslides: victims who experienced large personal damages from landslides perceived a higher occurrence rate of these hazards, saw them as being more life threatening, and had a greater sense of dread than those with less experience.[32] Hazard experience also heightened risk perception of volcanic eruptions.[33]

However, there are also examples of the opposite effect: individuals who had previous experience with a hazard event and who did not experience personal damages are more likely to believe that a future event will unlikely affect them and, therefore, their risk perception decreases.[34–39] Mileti and O'Brien[37] describe the residents' reasoning in the following way: "If in the past the event did not hit me negatively, I will escape also negative consequences of future events."[37] This shows that it is less the experience "in itself," but rather the severity of the personal consequences experienced in past events that shapes the respondents' perceptions.

3.2.2. Spatial Differences

Spatial associations are also important for risk perception. It could be demonstrated that perception of a flood threat depends on the place of residence,[40] even within the flood prone area;[41] for comparison in Asia, see Hung *et al*.[6] People seem

to have a stronger perception of risk through the geographical distribution of flood risks than time distribution (probability).[41] Two studies in France showed that flood experience of the individuals turned out to be the strongest factor for risk perception, which was directly related to the location of residents in areas prone to muddy floods.[15] Ruin *et al*.[5] classified maps of road sections prone to floods by classifying the participants' observations as "over-" or "underestimation" with respect to the calculated danger: risk perception was high when impacts were observed close to the place of residence.

3.2.3. Indirect Experience

Indirect experience includes education, media, and hazard witnesses.[39,42,43] Several authors have collected factors correlated with hearing risk warnings, understanding warnings, and believing warnings. Exposure to a variety of different media (printed, broadcast, digital, etc.) correlates with subjective recollection of hearing warnings. The quality of the media also played a role in understanding and believing warnings. Information provided through mass media shapes risk perception to some degree: *"The media proved to be an important and popular channel of information about the development and aftermath of local extreme phenomena. This source came well ahead of other formal sources of information, including schools and information campaigns."*[29] If persons report that they have had personal experience with hazards media coverage does not play a major role.[18] However, media reports about an expected flood can stimulate individuals to recall the previous experience of a flood event.[25] Moreover, indirect experience can play an important role for recalling previous personal experience or previously stored indirect experience.[44] Risk perception and risk awareness reach high levels directly after a flood event, but soon fade away over time. It seems to be essential to help people recall the experience of the flood if one wants to motivate them to take protective actions against a new flood.[25] This "window of opportunity" can be used in risk education and risk communication.

3.3. Risk Perception and Trust

In addition to personal experience, the second most important factors for risk perception of natural hazards according to our review are trust in scientific experts and authorities and confidence in protective measures.[14,15,27,30] Trust is employed by individuals to manage personal risk through externalized faith: as a result of an increasingly complex world, individuals are not able to inform themselves about all threats that they face. Therefore, they are forced to trust in authorities and experts. Trust is used as a shortcut to reduce the necessity of making rational judgments based on knowledge by selecting trustworthy experts whose opinion can be considered as accurate.[11] This can result in a reduction of the uncertainty, but, due to the fundamental affective dimension of trust (which involves items like honesty, integrity, goodwill, or lack of particular interests), individuals may feel more at risk if their trust in experts is lacking or damaged.[45] Therefore, we see that trust has an important effect on an individual's risk perception.

However, trust seems to have two contrasting side effects. People in areas unprotected by dikes tend to underestimate risks under most circumstances.[46] This is even more so when people have high trust in management performance, for example, in the case of flood protection, in structural protection such as dikes and dams. Trust here lessens the perception of flood likelihood and magnitude and, therefore, reduces willingness and preparedness actions.[27] Whitmarsh[47] found similar results on climate change versus flood perception and behavioral response. Furthermore, Bichard and Kazmierczak[48] found that most people believe that authorities are mainly responsible for flood protection and thus obliged to alleviate residents from the burden of taking protection for themselves. In addition, experience has an impact on trust. The experience of trust forming relationships is an important step toward willingness to act and preparedness for natural hazards. An individual's decision to act is determined by how he or she interprets the given information based on previous experiences.[33]

Therefore, we can see that both direct and indirect experience, as well as trust, can affect an individual's expectations about potential outcomes (Table I). In addition, positive or negative feelings associated with personal flood experience were found to have different effects on trust, risk perception, and preparedness intention: negative feelings associated with previous experience decrease trust in official flood protection measures and increase risk perceptions; positive feelings increase trust in authorities and decrease risk perception.[27]

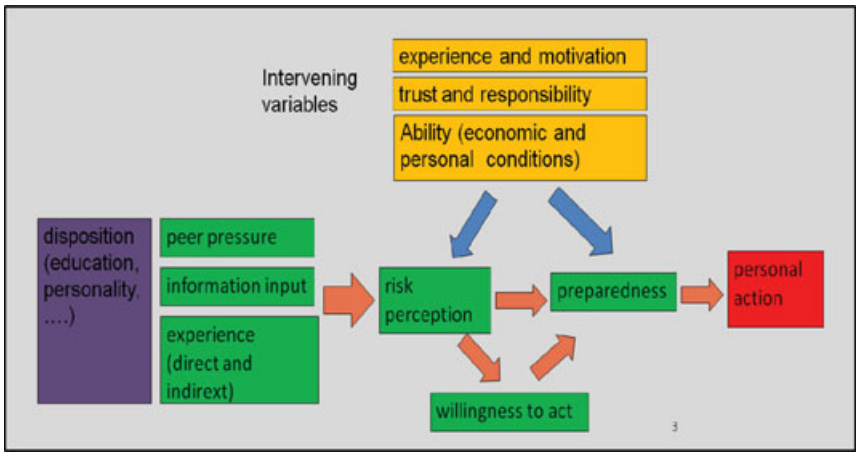

Fig. 1. Visualization of the "hazard to action-chain."

3.4. The Risk Perception Paradox

The reviewed studies show the complex relationship between risk perception and social responses: some studies assume that individuals with low risk perception are less likely to respond to warnings and undertake preparedness measures than individuals with a high risk perception.[5,6] However, this is not always the case. Many studies provide evidence that even though individuals have experience and high risk perception, they seldom take appropriate preparedness actions.[18,19,34,49] Haynes *et al.*[50] argue in the same direction: "it is now understood that there is not necessarily a direct link between awareness, perceived risk and desired (by risk managers) preparations or behavioral responses."[50] Miceli *et al.*[16] noted that "most empirical evidence suggests that the link between these two variables [risk perception and preparedness actions] is quite weak or even null."[16] Different authors have recently revised models of the link between risk perception and its input factors on the one hand and preparedness actions on the other hand.[13,51] On the basis of these findings we have developed the following more simple heuristic as one way of allowing for a discussion of implications. There are three possible reasons that might be responsible for the weak relationship between risk perception and personal actions (Fig. 1). These three reasons are related to the intervening variables: (1) experience and motivation, (2) trust and responsibility, and (3) personal ability (economic and personal conditions).

- Reason 1: Individuals understand the risk but choose to accept it due to the fact that the perceived benefits of living close to the river appear to outweigh the potential negative impacts.[6,52]
- Reason 2: Individuals understand the risk but do not realize any agency for their own actions; the responsibility for action is transferred to someone else.[27]
- Reason 3: Individuals understand the risk but have little resources to affect the situation.[14]

The first possible reason for the risk paradox is linked to the expectations of people living or staying in hazardous areas despite the risk. There are three possibilities why individuals might perceive that benefits outweigh the potential negative impacts. The following three examples expand on these notions: individuals are aware that a specific natural hazard is likely to occur and will have serious personal consequences, but they have other risks (which may be perceived as more serious) to worry about (e.g., social, economic, and security-associated issues were mentioned).[53] Moreover, the need to secure daily livelihoods is mentally more salient than risk perception of natural hazards.[54] Individuals with and without hazard experience can judge the threat of a future natural hazard to their livelihood as low and that, therefore, the benefits (e.g., fertile land for agriculture or the beauty of the landscape) outweigh the disadvantages.[6,52] A study about floods and volcanic hazards found that if individuals expect worse living conditions after evacuation, or if they are afraid that they cannot protect their property when evacuating their homes, they will stay in a risky area as long as possible.[55] Moreover, the conditions of evacuation prevent individuals from evacuating even when faced with a major natural catastrophe: during volcanic eruptions individuals did not want to evacuate

Table I. Systematic Review of European Studies (Post-2000) on Risk Perception of Natural Hazards and Disaster Preparedness

Reference	Natural Hazard	Country	Concrete Example	Factors Explored	Outcome Investigated
Armas and Avram[21]	Flooding	Romania	Danube delta floods	Age, gender, religiousness, years of formal education, income, type of support expected, professional activism, ownership status, also the different items of flood perception are tested as factors	Perception of flood risks measured on a scale of 30 different items (connected with personal feelings, fear, trust, perceived own vulnerability): these variables are also tested against each other
Armas[22]	Seismic risks	Romania	Bucharest earthquakes: 1944, 1977, 1986, 1990 (Danube delta), landslides	Social vulnerability (normalized composed index of two samples: poverty ratio and demographic vulnerability ratio, depending on age, gender, and education level)	Perception of a seismic risk
Baan and Klijn[58]	Flooding	Netherlands		Perceived fairness in risk-benefit distribution, familiarity with the risk, reason for exposure to risk, seriousness of the effect, degree of control and preparedness	Perception of flood risks compared to others (smoking, nuclear plant, bee sting, road traffic)
Barberi *et al*.[53]	Volcanic hazards	Italy		Age, gender, educational level, amount of information given, confidence in evacuation plan and in the government	Risk perception, perception of their own vulnerability, preparedness, trust in authorities
Bichard and Kazmiercza[48]	Climate change risks, especially floods	England and Wales		Awareness of flood climate change, awareness of flood risk, attribution of responsibility for action, age, social grade	Preparedness of home owners to make changes to their homes (flood protection measures and energy saving measures)
Biernacki *et al*.[29]	Flooding, landslides, storms	Poland		Place of residence, previous experience, source of information, size of the community (settlement hierarchy and socioeconomic structure), degree of establishment of the community	Risk perception, degree of preparedness of the local community
Bird *et al*.[60]	Volcanic risks	Iceland	Early warning system around Katla volcano	Hazard knowledge, risk perception, adoption of personal preparedness measures	Differences between tourists and tourism employees
Botzen *et al*.[46]	Floods	Netherlands		Socioeconomic factors, geographical characteristics, personal experience with flooding, knowledge of flood threat, individual risk attitude	Flood risk perception (risk beliefs)
Brilly and Polic[41]	Flooding	Slovenia	Floods in Celje: 1990 and 1998	Experience with floods, geographical areas, perceived probability of floods occurring	Flood risk perception: perceived threat (visualized on self-drawn maps), and concerns related to floods

(*Continued*)

Table I. (*Continued*)

Reference	Natural Hazard	Country	Concrete Example	Factors Explored	Outcome Investigated
Burningham *et al*.[23]	Floods	United Kingdom	Flood events of 1998 and 2000	People's recognition that their property is in an area that is potentially at risk of flooding, flood experience, length of time in residence, age, gender	Flood risk awareness
De Groot[76]	River floods	France, Germany, Netherlands		Human/nature relationship (mastery over nature, stewardship of nature, partnership of nature, participation in nature), respondent's sense of place, safety perception, background variables (age, educational level, experience of flooding, possibility of flooding)	Adherence to two different flood risk management styles: "room for river" and "dike reinforcement"
Felgentreff[25]	Flooding	Germany	1998 Odra flood	Experience of a flood event, media reports of a second flood event	Perception of flood risk after a flood event
Grothmann and Reusswig[26]	Flooding	Germany	2002 Elbe flood	Perception of flood risk experience, perceived risk of future floods, perceived reliability of public flood protection, perceived efficacy and costs of protective behavior, perceived ability to perform these actions, nonprotective responses (like fatalism, denial, wishful thinking)	Private efforts for taking precautionary measures for damage prevention
Heijmans[55]	Floods, volcanic hazards			Experience with natural hazards, credibility of the warning source, kind of preparedness, coping measures	Risk perception (floods, volcanic), vulnerability
Heitz *et al*.[15]	Mud flood	France	Alsace	Knowledge factors: location within the catchment, trust in information	Risk perception of individual stakeholders
Jóhannesdóttir and Gísladóttir[49]	Volcanic hazard	Iceland	Southern Iceland	Age, experience of an eruption, region, vulnerability	Risk perception
Kaiser and Witzki[40]	Storm floods	Germany		Country (north sea region): Belgium, United Kingdom, Denmark, the Netherlands, Germany	Risk perception, risk awareness, willingness to act
Karanci *et al*.[19]	Earthquakes, floods, landslides	Turkey		Sociodemographic factors (gender, education,), locus of control, previous disaster experience, anxiety, being a participant in a training program	Disaster-related cognitions (disaster expectation, worry about future disasters, loss estimations, beliefs in the possibility of mitigation and preparedness), actual preparedness behaviors

(*Continued*)

Table I. (*Continued*)

Reference	Natural Hazard	Country	Concrete Example	Factors Explored	Outcome Investigated
Kellens *et al*.[20]	Floods, storm surge	Belgium		Actual flood estimates, location, age, gender, home ownership, permanent residence, education, children living at home, storm surge experience, experience with previous flood hazards, different locations within the house (sea view, ground floor, cellar)	Risk perception
Krasovskaia[79]	Flooding	Norway	1995 flood	Public versus expert panel (decisionmakers), "river affinity," nationality	(a) Perception of risk for life and health (b) of economic and environmental loss
Miceli *et al*.[16]	Landslides, flooding	Italy	1998: 150 landslides in Avellino and Salerno, Campania	Age, gender, level of education, experience of damage, level of feeling informed, participation level, closeness to the waterfront, adoption of protective behavior	(1) Perception of flood risks: (a) based on likelihood estimates and (b) based on feelings of worry; (2) Adoption of protective behavior
Pagneux[80]	Ice-jam floods	Iceland		Experience of the past flooding events in town	Knowledge, awareness, risk estimation, worries
Plapp and Werner[8]	Flooding, windstorm, earthquake	Germany	Inn, Rhine, Donau	Perceived personal risk, fear evoked by the risk, familiarity of hazard, likelihood of fatal consequences, frequency of hazardous events, age, educational level, gender, world views	General flood risk perception, general windstorm perception, general earthquake perception, personal risk perception
Plattner *et al*.[81]	Different natural hazards			Perception affecting factors: effective individual risk, voluntariness of risk taking, individual options to reduce risk, knowledge and experience with risk source, endangerment (likelihood to die, fear evoked), subjective damage rating, subjective flood recurrence frequency	Personal risk perception
Raajmakers *et al*.[82]	Sea level rise	Spain	Ebro Delta	Stakeholder groups of the Ebro-Delta: the rice farmers association, the water distribution cooperative, the salt manufacturer, the tourism industry, local and regional authorities, and park managers	Flood risk perception, characterized by the notions of awareness, worry, and preparedness
Ruin *et al*.[5]	Flash floods, storms	France	Southern France	Danger in road sections (GIS variables and cognitive maps), age, profession, family status, area of living, flood experience	Risk perception of individual drivers

(*Continued*)

Table I. (*Continued*)

Reference	Natural Hazard	Country	Concrete Example	Factors Explored	Outcome Investigated
Siegrist and Gutscher[18]	Flooding	Sweden		Area (German or French-speaking area, mountain, urban, hazard area), age, gender, home ownership, past experience, involved in cleaning up after a disaster	Perceived risk, prevention behavior
Siegrist and Gutscher[61]	Flooding	Switzerland		Flooding experience: people who were affected by a severe recent flood disaster versus people not affected but living in flood-prone areas	Perception of the effects of a flood, precautionary measures
Sjöberg[10]	All natural hazards	Sweden	Different Swedish cities and regions	Tampering with nature, sex, age, age of youngest child, income, educational level, size of community,	Perception of a disaster risk (nuclear disasters), new and unknown risk, perceived dread by politicians and the public
Slinger *et al.*[76]	Flooding	Netherlands	Scheldt Estuary	Shifts in opinions of citizens, scientists, and policymakers	(a) Flood risk perception of citizens and scientists; (b) Responsiveness of scientists and policymakers to the perception of local inhabitants
Stanghellini and Collentine[75]	Water management	Italy	Alta Valsugana, Trento	Socioeconomic as well as environmental variables: use of water (domestic, agricultural, touristic), biodiversity, vulnerability of fresh water supply by wells, availability of water (identified by the participants of a public workshop)	Awareness of citizens (results collected from focus groups)
Tekeli-Yesil *et al.*[24]	Earthquake	Turkey	1999 earthquakes in Turkey	Gender, age, family status, home ownership, educational level, area location, earthquake experience (having participated in rescue and solidarity activities in previous earthquakes), knowledge about earthquakes and mitigation measures	Taking action to prepare for an earthquake
Terpstra *et al.*[12]	Floods	Netherlands		Different small scale flood risk communication program (workshops and focus groups), direct personal experience, and attitude polarization	Risk perception
Terpstra[28]	Flooding	Netherlands	Dutch coast (Rhine, Meuse, Lake Marken)	Feelings associated with previous experience of floods, trust in flood protection agencies	Perception of flood likelihood, flood preparedness intentions
Whitmarsh[47]	Flooding	United Kingdom	Floods in south England	Relevant experiences of flooding and air pollution	Knowledge, attitudes, risk perception, behavioral responses to climate change

because of the perceived high risk of dying in the evacuation camps.[50] The allegedly "irrational" behavior is due to a rational comparison of the risks of staying versus leaving. Renn[9] suggests that most individuals perceive natural hazards as cyclical phenomena. So if you endure or survive a catastrophic event you believe you will not experience another event of this kind during your lifetime (e.g., in the case of a 100-year flood).

The second possible reason for the risk paradox is linked to trust: the influence of trust has been extensively studied in the context of risk preparedness. As explained earlier, trust in flood protection, for example, lessens perceptions of flood likelihood and magnitude and, therefore, reduces intentions to prepare for floods.[27] These results from the Netherlands can be compared to the results from a flood-study in Romania, where the lack of resources and mistrust in authorities reinforces nonadaptive behavior.[14] In general, trust seems to be directly related to preparedness actions.[56,57,33] When individuals trust in structural and/or governance measures to keep them safe they are less likely to act than when they believe they have no choice but to act (e.g., no physical or governance structures for protection or little trust in the effectiveness of these structures).[6,58] It has been noted that changes in Western governance see the "rolling back" of the state, which means that individuals and communities increasingly have to take responsibility for their own preparedness,[59] but their perception of the authorities as being responsible for the well-being of the citizens has not changed accordingly.

The third possible reason for the risk paradox is linked to confusion or ignorance about the appropriate action to take as well as a lack of capacity/resources to help oneself. Therefore, it is not just a matter of raising risk perception but also of providing individuals with the physical and mental capacity to affect their own situation. Experience and trust are important in transferring/sharing knowledge between "experts" and "lay people." Siegrist and Gutscher[18] argue that the gap between risk perception and action could be due to the fact that residents "*did not know what they should do.*"[18] Njome[14] found that even though residents around the Mt. Cameroon Volcano had quite high risk perception and an accurate understanding of the potential risk of eruption, they lacked the knowledge and economic resources to take action. Bird *et al.*[60] have reported similar results from volcanic hazards in Iceland: tourists had very low hazard knowledge and did not adopt preparedness measures. In contrast, foreigners working in Iceland showed a high level of risk perception yet lacked knowledge about the warning system and emergency respond procedures. This finding is also supported by Grothmann and Reusswig,[26] who reported that even if individuals show preferences toward preparedness actions they can be stopped short by their physical capacity to take action: *"If the person chooses a protective response, he or she first forms a decision or intention to take action, labeled protection motivation. Protection motivation does not necessarily lead to actual behaviour due to actual barriers, such as a lack of resources like time, money, knowledge or social support, not expected at the time of intention forming."*[26]

4. DISCUSSION

4.1. The Role of Experience

At first sight the connection between personal experience of a natural hazard event and the perception of the risk might appear trivial (surely you are afraid of a flood when your house has been flooded before), but the results of this review show that the causal pathways are more complex than the proposition of the direct link between experience and preparedness implies. There are may intervening variables such as personal agency to act, perception of hazard cycles, time distance to previous events, and others. These complex relationships have many implications for practical risk management.

Managers will face a large variety of hazard perception patterns within a single location due to past exposure to damages (different experiences). The strength and salience of personal experience determine the time frames in which people are able to recall past experiences and motivate appropriate actions. Furthermore, the credibility and motivational power of risk communication depend largely on personal experience and trust in previous management attempts by public authorities, as well as their personal capacity to adopt preparedness actions. In addition, it is of great importance whether individuals perceive the responsibility of preparedness actions to be in their hands or the hands of the risk managers/government.

The fact that personal experience of a hazard event is a strong factor in risk perception can be applied in concrete risk communication programs. Risk communication can help people to envisage the negative emotional consequences of natural disasters.[61]

The mental images of a risk may refer to former experiences of a risk event in a direct way: "visual imagery is equivalent to stimulating an actual visual experience and motor imagery is equivalent to stimulating an actual motor experience."[62] Feelings associated with hazard experience are important and can also be recalled via communication. But even if people have no direct experience with damages caused by natural hazards, they can still empathize with such experiences if stories of other people suffering through such damages are reported to them. Press coverage also contributes to a person's perception of risk, particularly if individuals lack personal experience with the risk and are unable to verify claims of risks or benefits from their own experience. In contrast to popular belief, however, there is no evidence that the media create opinions about risks or even determine risk perceptions. Studies on media effects suggest that individuals select elements from media reports and use their own frame of reference to create understanding and meaning. Most people reconfirm existing attitudes when reading or viewing media reports.[63,64,65]

Another issue to consider is the fading character of disaster experience. The Fukushima catastrophe highlights this phenomenon. Eighty years ago a tsunami occurred in the vicinity of Fukushima, which killed 3,000 people, 50 years ago a major tsunami killed 142 people, but one year ago a major tsunami warning was issued, but the actual tsunami turned out to be weak and left no serious damage.[66] People started to associate tsunamis with minor impacts and did not take the warnings about major damages caused by tsunamis seriously any more. So it was not surprising that the actual disaster in 2011 was first ignored even after dramatic warnings were issued.[66] Tsunamis are rare events; therefore, the percentage of individuals who have experienced a tsunami is low. The experience of the disaster potential of tsunamis needs to be embedded within the narratives about everyday lives of people exposed to this risk. In regard to the tsunami in Thailand in 2004, only people who had experience with tsunamis were able to recognize the warning signals. People need to understand the warnings/cognitive signals of a tsunami and know how to act effectively once a warning is issued.[67] But even if they understand the warning and its implication they still may decide to do nothing because they don't know what to do or they feel that the warning agencies have exaggerated the threat. An old fairy tale describes: if someone cries "Wolf" two times and nothing happens, nobody believes him or her the third time, even if the wolf is actually approaching. The mechanism of fading representations of threat depends on the severity of the danger and the success of authorities and other institutional actors to keep memories alive: Dow and Cutter[68] observed household strategies for hurricane risk assessment and found that individual assessment practices took the past hurricane and evacuation experiences into account. A successful evacuation plan with reports about previous hazard experiences helped inform future evacuation decisions.

Another effect related to the first reason for the risk perception paradox is the personal judgment of the risk compared to specific advantages. Gough[52] explained that inhabitants of a community in New Zealand in close proximity to active volcanoes (with low eruption rates) choose to live there because of the beauty of the area, even though they have a realistic perception of the risk. Therefore, providing these individuals with information and encouraging discussions of the risk that is relevant to them and their area might encourage a higher level of preparedness. Although a volcano is an example of a rare event, its consequences are potentially devastating and, therefore, it might be very important to ensure that individuals know what to do in the face of such an event; that they are equipped with the cognitive understanding to be able to recognize warning signals and act accordingly. From the high importance of direct experience one can follow that communication methods close to personal experience would work best. Examples could be: to experience the power of water by walking through a river, listening to lively narratives from hazard witnesses, studying historical accounts of past disasters (e.g., flood marks in medieval European cities or shrines in Japan). Media reports might not raise any propensity to take actions unless the readers can recall some kind of direct experience of a painful damage to themselves or others they know. Such an indirect experience provides a reference to one's own memories or imagination of a potential natural hazard event.

Risk perception can be amplified or attenuated by indirect experience. Two communication networks play the primary role in risk amplification: the media and personal interaction with other people.[69] Frewer *et al.*[69] found that "the media, in isolation, is unlikely to account for amplification processes described within the social amplification of risk framework." What remains is the communication via "the informal personal network." Frewer[70] argues that

amplification via the informal personal network plays a major role in the perception of genetically modified organisms (GMOs). The data "demonstrated that people's risk perception does increase and decrease in line with what might be expected upon examination of the amplification and attenuation mechanisms integral to the framework."[69] One can assume that this is also true for natural hazards: information by media is an indirect experience. It gives authorities the opportunity to use and widen the window of opportunity for risk education: risk perception and risk awareness reach higher levels after a flood event, but soon drop back to average levels. It is essential to use this "window of opportunity" after a flood event to plan and market new mitigation strategies.

Finally, risk education can be seen as an indirect experience of a hazardous event in learning environments. It has been reported that children are able to educate their parents, as shown by the example of the British girl who had learned the tsunami-warning signs in school and saved local people from the tsunami when she was in Thailand for holidays.[71] This event is one example as to how efforts spent on children's hazard preparedness education are an important way of influencing the population as a whole.[72]

4.2. The Role of Trust

Trust is an important factor of risk perception and becomes even more important if individual knowledge about the hazard is low. Siegrist and Cvetkovich,[11] working with different, mainly technological risks, were able to prove that the more individuals believed they knew enough about a risk the more they trusted in their own personal judgment and not in the advice of the authorities. This has to be kept in mind when looking for competent and transparent risk communication by authorities and experts. There seems to be a strong relationship between the uncertainty of the risk and the role of trust.[73] Paton[74] argues that trust only becomes necessary when the decisionmaker faces a situation of uncertainty. When dealing with natural hazards, decisionmakers are normally confronted with uncertainty. In this situation "trust functions to reduce the uncertainty and complexity that people encounter when faced with novel events ...."[74] Trust then becomes "a construct of considerable importance when dealing with unfamiliar, infrequent and complex environmental hazards."[74] Paton's studies of bushfires, earthquakes, volcanic eruptions, and floods show that "when dealing with infrequently occurring natural hazards, information will be evaluated in terms of peoples' generalized beliefs regarding trust in the social institutions providing information." High levels of trust can be counterproductive in regards to encouraging individual to take preparedness actions. In other words, if people trust in the protection provided by public authorities, they may not see the point in taking personal protective measures. At the same time, trust in authorities is necessary to build up a social climate in which advice from authorities will be taken into account in a crisis situation.

4.3. Implications for Risk Governance

This section discusses actions that can be taken to address the risk perception paradox from an institutional perspective. The perception of flood events has been found to change as a result of participation processes.[75,76] Research indicates that people become more aware of floods and are more motivated to initiate protective action if they are involved in a participatory exercise. This seems mainly due to both a shift toward more trust in the authorities and the experts and a shift toward realizing personal agency to protect oneself. If people are involved in designing and testing emergency plans, they have a better idea what the authorities are able to perform and what each resident can do to improve protection and crisis management. Working together with the authorities increases trust and, at the same time, avoids the risk of creating a sense of false security that one might get by delegating all responsibility to public authorities. An interactive and iterative process of risk management where all stakeholders are involved can considerably improve risk governance and emergency preparedness. As a result of successful participation exercises, the public, public authorities, and disaster experts expressed their willingness to learn from each other. Citizens were ready to adjust their perceptions and behavior once they were confronted with reliable information on exposure, consequences, and options for protective measures.

De Groot[77] explored the relationship between public environmental ethics and river flood policies. He distinguished between two different flood risk management styles: "room for river" and "dike reinforcement." Adherence to the "room for river style" correlates with the "stewardship," whereas adherence to "dike reinforcement" is predicted by "mastery over nature." It can be assumed from these

results that the perception of nature is connected with the willingness to take certain actions. But can these views be altered by risk governance measures? One effect of participatory workshops is that citizens are less focused on technical measures but prefer policymakers to consider the full range of flood risk management measures, including stricter zoning and building flood reservoirs and polders.[76]

Participatory engagement is also an important tool for gaining or promoting trust.[33,52,56] Kates *et al.*[78] propose: "Many of the approaches that support such a broadening of risk management practices are relatively unthreatening to implement. Communities can undertake a continuing process of participatory vulnerability assessments, including consideration of possible future threats. . . ."

Participation processes in the context of natural hazard risk governance can meet several purposes:

- The public will gain knowledge and personal agency with respect to risks and protective measures.
- Authorities will gain knowledge from the "lay experts"/the public and can collect ideas for measures that are effective for the given population.
- Trust can be created so that warnings and other types of vital information will be taken seriously if issued in an emergency.

4.4. Distinction Between Natural and Technological Hazards

The reviewed results of the natural hazard literature revealed another interesting insight: the neat distinction between natural and human-induced hazards is slowly vanishing. We face a new, even more complex situation: because of climate change and new strategies to influence natural hazards, these risks are no longer seen as "natural." Rather than an act of God or Nature, floods and similar events are increasingly perceived as "human-induced." More and more people tend to believe that the extent of damage as well as the frequency of disasters are caused or at least amplified by human actions such as interventions into the climate or redirecting rivers.[13] As a result, natural hazards could face the same kind of patterns that characterize the perception of technological hazards.[38] The study by Baan *et al.*[58] documents such changes in the perception of floods, which occurred as a result of a discussion on intentionally inundating calamity polders to protect more downstream areas. If floods are associated with human actions it has major repercussions for risk governance because social institutions will be blamed not only for inadequate response and emergency measures (as in the past) but also for the severity or frequency of the disasters themselves.

The new situation of a mix of natural and human-induced hazards was highly prevalent in the Fukushima case, where an earthquake, a tsunami, and a nuclear accident occurred in a close causal sequence. It seems to be almost impossible to be prepared for such kind of multirisk exposure; therefore, it becomes even more important to gain experience (or at least knowledge) of the single risk components (earthquake, tsunamis, nuclear risks) to be able to understand the complex situation and have the knowledge to recognize what kind of action is needed. In these situations, the experience of high uncertainty is likely to cause helplessness. This feeling in turn reduces the willingness to act. In the future it will hence be necessary to pay more attention to the connection between natural and human-induced hazards and the perception of these hazards in the affected populations. Personal experience will not be readily available for constructing adequate mental models of such combined disasters because they are still emerging. They will also place additional stress on trust in public authorities because different institutions with separate mandates are normally dealing with these risks.

5. CONCLUSIONS

This review has shown the complexity of the relationship between risk perception and preparedness for actions. We found that experience of a natural hazard and trust or lack of trust in authorities and experts are the primary factors that shape individual risk perception of natural hazards in often complex causal arrangements with many intervening factors. Cultural and individual factors such as media coverage, age, gender, education, income, social status, and others do not play such an important role as primary predictors for preparedness but they can act as modifiers or amplifiers. In spite of the fact that there is a large number of empirical studies about risk perception and personal action, the relationship between perception and behavioral response relative to preparedness is still unclear and controversial. It is generally assumed that high risk perception will lead to personal protective actions. However, this depends on many contextual factors, in particular the

ability of the individual to recall past damages or, at least, to imagine the effects of a disaster. In addition, if people trust public authorities, they are more likely to take warnings seriously and act accordingly. However, such responsiveness depends on the perception of one's own agency to engage in effective protective actions and on the strength of belief that personal responsibility can be delegated to public emergency management. These issues need to be taken into account when developing communication and participative activities.

The findings of the review suggests that public participation measures are probably the most effective means to create awareness of potential disasters, to enhance trust in public authorities, and to encourage citizens to take more personal responsibility for protection and disaster preparedness. It will be a major challenge for risk management and also an important research topic for future research to understand people's responses to natural hazards as well as a combination of natural and technological hazards and to design the most appropriate measures for effective risk communication, stakeholder involvement, and emergency preparedness.

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