

Storms, Fires, and Bombs: Analyzing the Impact of Warning Message and Receiver Characteristics on Risk Perception in Different Hazards

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In crisis communication, warning messages are key to prevent or mitigate damage by informing the public about impending risks and hazards. The present study explored the influence of hazard type, trait anxiety, and warning message on different components of risk perception. A survey examined 614 German participants (18–96 years, $M = 31.64$, 63.0% female) using a pre–post comparison. Participants were randomly allocated to one of five hazards (severe weather, act of violence, breakdown of emergency number, discovery of a World War II bomb, or major fire) for which they received a warning message. Four components of risk perception (perceived severity, anticipatory worry, anticipated emotions, and perceived likelihood) were measured before and after the receipt. Also, trait anxiety was assessed. Analyses of covariance of risk perception were calculated, examining the effect of warning message, trait anxiety, and hazard type while controlling for age, gender, and previous hazard experience. Results showed main effects of hazard type and trait anxiety on every component of risk perception, except for perceived likelihood. The receipt of a warning message led to a significant decrease in anticipated negative emotions. However, changes across components of risk perception, as well as hazards, were inconsistent, as perceived severity decreased while perceived likelihood and anticipatory worry increased. In addition, three interactional effects were found (perceived severity \times hazard type, perceived severity \times trait anxiety, and anticipated emotions \times hazard type). The findings point toward differences in the processing of warning messages yet underline the importance of hazard type, as well as characteristics of the recipient.

KEY WORDS: Crisis communication; hazard type; risk perception; trait anxiety; warning message

1. INTRODUCTION

Hazards, crises, and disasters are and will be part of our lives, either in the form of man-made or natural incidents. In 2018, natural disasters alone—such as floods, storms, or wildfires—caused over 131 billion dollars of economic losses and more than 11,800

deaths globally (CRED, 2019). In the occurrence of such hazards, warning messages can help prevent or mitigate various forms of damages by communicating risks, giving information, and recommending protective actions. Due to advancing technological development, they can be received quickly and by a growing audience, for example, via cellular broadcast-based warning systems (Gutteling, Terpstra, & Kerstholt, 2018) or smartphone apps (Rahn, Tomczyk, & Schmidt, 2020; Reuter, Kaufhold, Spielhofer, & Hahne, 2017). This makes it all the more important to understand which processes and changes warning messages initiate in their recipients.

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There are seminal theoretical frameworks linking warning messages to processes within the receiver. Two well-established models are the protective action decision model (PADM) (Lindell & Perry, 2003, 2012), and the communication-human information processing (C-HIP) model (Conzola & Wogalter, 2001; Wogalter, 2006). The PADM is focusing on human responses towards impending hazards. Within a multistage model, predecisional processes, core perceptions, decision-making processes, and behavioral responses of those at risk are integrated. The predecisional processes are initiated by several cues and factors, such as environmental cues, warnings, and characteristics of the receiver. Considering the PADM, warning messages depict one possible way to start multistage processes, with risk perception playing a central role in the adoption of protective behavior (Lindell, Arlikatti, & Huang, 2019; Strahan, Whittaker, & Handmer, 2019). The C-HIP model rather refers to the processing of warning information, as the model includes aspects of warning source and channel, and describes several substages of information processing within the receiver of a warning message, such as attention switch and maintenance, comprehension, beliefs and attitudes, and motivation to comply. Regarding the C-HIP model, warning messages are a means to inform about risk, thus making risk perception an important part of information processing. Mayhorn and McLaughlin (2014) use parts of both models to explain how people react to warning messages, namely attributes of the hazard, the warning message, and the receiver. The present study aims to investigate the impact of these three areas on risk perception.

1.1. Components of Risk Perception

Risk perception is an extensively researched construct in safety science, resulting in a large body of research that addresses perceived risk by the public in connection with specific hazards and behaviors (Wachinger, Renn, Begg, & Kuhlicke, 2013). In its original sense, risk perception is defined as the subjective judgment a person makes by characterizing and evaluating a hazard (Knuth, Kehl, Hulse, & Schmidt, 2014; Slovic, 1987). It is commonly operationalized as the perceived likelihood of a potential outcome or being affected by a threat. Contrary to this rather cognitive conceptualization of risk perception, affective components, as well, can be considered part of this construct. These include, for instance, feelings towards a hazard or disaster, such as

fear, anger, or sadness (Sheeran, Harris, & Epton, 2014).

There are several theoretical frameworks that focus on cognitive and affective components of perceived risk and related (protective) behaviors or attitudes: The extended parallel process model (EPPM) (Popova, 2012; Witte, 1994) covers cognitive appraisals of threat and efficacy appraisals as influential factors on the likelihood of protective action. Affective appraisals, such as fear towards a threat, can lead to fear control, which in turn can result in maladaptive behaviors. The affect heuristic (Finucane, Alhakami, Slovic, & Johnson, 2000; Slovic & Peters, 2006; Slovic, Finucane, Peters, & MacGregor, 2007) describes an affect driven experiential system. Especially in high-pressure situations, an automatic, intuitive information processing is initiated by feelings or affective perceptions towards a threat, enabling a fast adoption of protective behaviors. In contrary to the experiential system, the analytic system is based on a slower way of processing information, for example, by weighing different aspects of a threat and required protective measures.

Cognitive *and* affective components of risk perception are relevant to the adoption of protective behaviors, as evidenced by a meta-analysis regarding health behaviors (Sheeran et al., 2014): Heightening and combining cognitive and affective components of perceived risk (called risk appraisals) increase the intention to act and health-related behaviors itself. Similar associations have been reported in crises and warning associated research, however, risk perception is often operationalized via single components rather than as a multidimensional construct (Leppin & Aro, 2009; Sheeran et al., 2014; Wilson, Zwickle, & Walpole, 2019), making a multifaceted approach a research desideratum. Therefore, as with Sheeran et al. (2014), perceived risk is measured in the present study with different components, namely risk perception and perceived severity as cognitive components and anticipated emotions and anticipatory worry as affective components.

1.2. Warning Message

Warning messages provide information to the public about threats and hazards, as well as recommendations for actions (Mayhorn & McLaughlin, 2014; Mileti & Peek, 2000). Their main objective is to galvanize the public, ideally towards protective behavior. In the case of a hazard, warning messages can help those at risk to take action faster (Markwart

et al., 2019), which in turn can prevent or minimize damage. Important attributes to understand warning messages are their source, channel, style, timelines, and content (Kuligowski & Dootson, 2019; Mayhorn & McLaughlin, 2014). Looking at the content, Kuligowski and Dootson (2019) summarize the five W's of a warning message: Who provides the message? When are they recommended or needed? Where does the hazard take place? Why do people need to take action? And what actions are recommended? To use this information properly when issuing warning messages, it must be adapted to the type of impending hazard (Drabek, 1999; Sorensen, 2000).

1.3. Hazard Type

Various taxonomies classify hazards and disasters, for example, by making a distinction between natural (e.g., floods, storms, droughts), biological (e.g., crop fungal diseases), man-made (e.g., terroristic attacks, war), or technological hazards (e.g., nuclear accidents) (Kuipers & Welsh, 2017; Mileti, 1999; Perry, 2007; Tierney, Lindell, & Perry, 2001). Yet, the majority of empirical research in this field focuses on a specific hazard or event type and does not target a taxonomic or even comparative approach. This single-sided view on different hazard types impedes a comparative examination of overlapping factors like risk perception. Thus, only a few studies exist that contrast hazards in terms of risk perception: Ho, Shaw, Lin, and Chiu (2008) investigated risk perception in connection with two different disaster types, namely landslides and floods. They found that, next to gender and previous experience, the type of disaster has an influence on risk perception. Landslides were associated with a higher life threat than floods, while floods had a higher impact on the associated financial loss. The authors conclude that characteristics of the hazard itself must also be taken into account when risk needs to be communicated. Heilbrun, Wolbransky, Shah, and Kelly (2010) compared three different kinds of hazards (natural disaster, violent crime, and terrorism) via vignettes and systematically varied threat imminence, risk level, and hazard type. Under the high-risk level condition, they found differences in risk perception and the intention to act between the three hazards. For example, in the event of a natural disaster participants were more likely to change their daily activities, relocate, or secure their homes. Based on these preliminary findings, a comparison of different hazard types seems reasonable

to understand the role of hazard type in the process of risk and crisis communication.

1.4. Receiver

Characteristics and prior experiences of a person influence the perception of their environment, and thus the perception of warning messages and risk. Similarly, how people respond to a warning message is not always the same. Among others, reactions depend on several individual factors (Drabek, 1999; Figner & Weber, 2011; Mayhorn & McLaughlin, 2014). In terms of sociodemographic variables, the role of age and gender on risk perception is often examined. With regard to gender, some studies show that men perceive lower risks than women (Figner & Weber, 2011; Flynn, Slovic, & Mertz, 1994; Ho et al., 2008; Savage, 1993), while women are more likely to believe in disaster warning messages (Turner, Nigg, & Paz, 1986). Other authors found no gender differences for people living in rather hazardous neighborhoods (Greenberg & Schneider, 1995), non-white men and women (Flynn et al., 1994), or inhabitants of gender-equal countries (Olofsson & Rashid, 2011). Higher age was found to be associated with an increased perception of risk in terms of natural disasters, but this relationship was inconsistent when other types of hazards were considered (Kellens, Zaalberg, Neutens, Vanneuville, & Maeyer, 2011; Savage, 1993). Overall, the body of research regarding sociodemographic variables is rich but inconsistent.

Next to sociodemographic variables, personality traits, such as trait anxiety, may influence the perception of risk (Butler & Mathews, 1987; Chauvin, Hermand, & Mullet, 2007). High trait-anxiety is often associated with a higher perception or even overestimation of risk (Maner & Schmidt, 2006). But in terms of preparatory behavior, anxious individuals may be less likely to prepare themselves (McNeill, Dunlop, Skinner, & Morrison, 2016; Mishra & Suar, 2012; Notebaert, Clarke, & MacLeod, 2016). Possible reasons for this could be that anxious individuals tend to accept risk less, avoid information about possible protective actions (Paton, 2003), or use avoidance- and emotion-oriented coping strategies (Mishra & Suar, 2012). Wirtz, Rohrbeck, and Burns (2019) specifically focused on the relationship between trait-anxiety and preparedness behavior concerning terror threat. They found one direct and two indirect pathways between these two constructs: The effect of anxiety on preparedness was

positively mediated through vulnerability and negatively mediated through self-efficacy. Also, there was a negative independent effect of anxiety on preparedness. Thus, the relationship between these two constructs is a rather complex one, involving multiple pathways.

In addition to individual characteristics, another considerable factor is whether a person has had previous experience with a hazard. Studies examining previous experience found that earlier experience leads to a higher risk perception (Ho et al., 2008; Olofsson & Rashid, 2011). But here, too, the findings are inconsistent, as other studies found opposite trends (Scolobig, Marchi, & Borga, 2012; Wachinger et al., 2013). And again, the majority of studies focuses on singular or specific hazards, for instance, risk perception and previous experience regarding earthquakes only (Kung & Chen, 2012).

1.5. Research Aims

As already implied by Mayhorn and McLaughlin (2014) and previous research (Lindell & Perry, 2012; Wogalter, 2006), there are a several factors that play a role in warning associated processes. These include characteristics of the hazard itself, the warning message, but also characteristics and processes on the receiver's side. Looking at risk perception, to our knowledge, there are few studies that examine cognitive *and* affective components of risk perception over time in connection with warning messages for different hazard types. Given these research gaps, the present study aims to compare five different types of hazards in terms of risk perception before and after the receipt of a warning message. In contrast to previous comparisons of hazards (e.g., Heilbrun et al., 2010), the study has higher ecological validity by using official previously issued warning messages as study materials. Also, individual factors and characteristics will be taken into account. Based on the existing findings, this study aims to answer the following research questions (RQ):

- RQ1: Do cognitive and affective components of risk perception differ between different hazard types?
- RQ2: Do receiver characteristics, such as trait anxiety, influence different components of risk perception?
- RQ3: Does the receipt of a warning message cause changes in different components risk perception? And how do interactions between trait

anxiety and hazard type affect changes in risk perception?

2. METHOD

The present study was approved by the Ethics Committee of the University Medicine Greifswald (BB 169/18).

2.1. Sample

The sample was collected during a period of eight months from May to December 2019. The survey ended before the COVID-19 pandemic reached Germany at the end of 2019, thereby preventing any effects on the collected data. Participants were recruited via flyer advertising and internet forum posts. They were asked to take part in a survey about hazard warning messages. As compensation of expense, participants were offered 5 Euros or a voucher of the same value. Data collection occurred to be online (questionnaire via hyperlink) or offline (via paper-pencil questionnaire) and took on average 20.51 minutes (M) ($SD = 56.90$).

2.2. Materials

Participants were presented warning messages that had already been used to warn the public in Germany. This means that wording, content, and sender of the messages were already defined. The warning messages were anonymized and staged into the format of a warning application for smartphones, called NINA (BBK, 2020). The app NINA is provided by the Federal Office of Civil Protection and Disaster Assistance. It is free of charge for the public and used by the German government, federal states, and local communities to provide location-based warning messages via push notifications. Hazards to which the app refers include threatening weather situations, as well as large-scale emergencies and national or local threats (Petridou, Danielsson, Olofsson, Lundgren, & Große, 2019). All warning messages are attached in the Supporting Information (Figs. S1–S5).

2.3. Design and Study Procedure

The structure of the survey is shown in Fig. 1. Participants had to state their informed consent before starting the survey. In the beginning, age and gender were assessed. Trait anxiety was measured with the state-trait-anxiety inventory (STAI-T) (Laux,

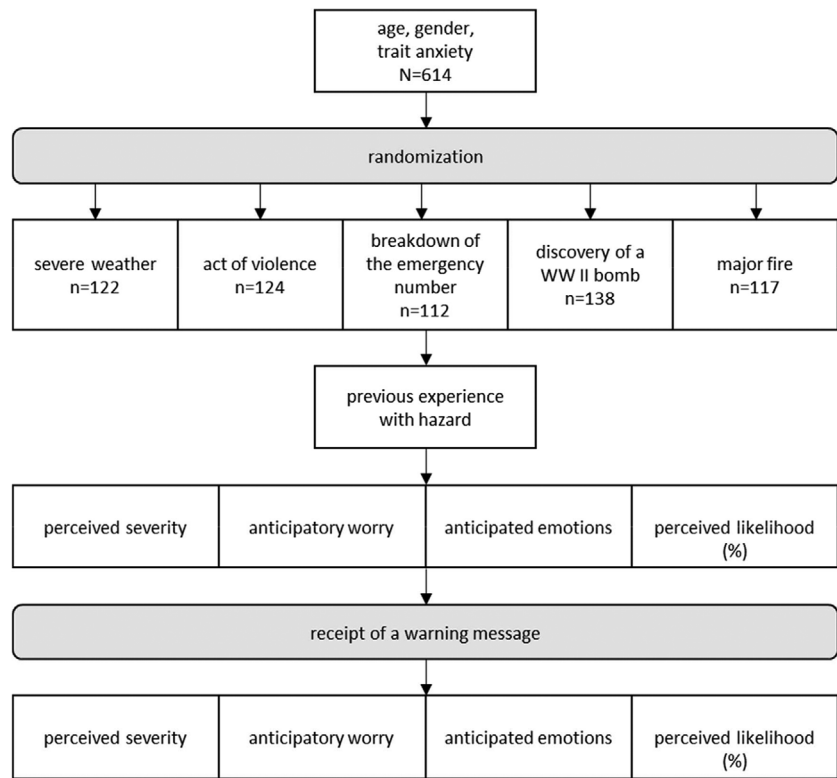


Fig 1. Study procedure.

Glanzmann, Schaffner, & Spielberger, 1981) by assessing affective states related to trait anxiety in the past two weeks. STAI-T consists of 20 items with four-point Likert scales from 1 (*almost never*) to 4 (*almost always*) and shows satisfying internal consistency (Cronbach's $\alpha = 0.92$). After that, participants were randomly allocated to one of five hazard types: (1) severe weather, (2) act of violence, (3) breakdown of emergency number, (4) discovery of a WWII bomb, or (5) major fire, for which they received a short explanation. All the following questions were related to this event. Participants were asked whether they or a person close to them (e.g., family or friends) had ever experienced the respective hazard. Personal experience was given when one of these conditions was answered with "yes." Then, risk perception was assessed via the following four components: perceived likelihood (likelihood of being affected by the hazard in the future in percentage), anticipated emotions (mean score of three items for future feelings of anxiety, tension, sadness at the occurrence of the hazard; $\alpha = 0.81$), anticipatory worry (concern of being affected by the hazard in the future) and perceived severity (severity of the consequences at the occurrence of the hazard). Ex-

cept for perceived likelihood (measured from 0 to 100% on a visual analogue scale), all components were assessed via five-point Likert scales from 1 (*not at all*) to 5 (*very much*). After the assessment of risk perception, participants were presented with a warning message. The four components were then assessed again.

2.4. Statistics

A total of 621 participants took part in the survey. For the evaluation of the STAI-T, up to two missing values were replaced by the mean values (Laux, Glanzmann, Schaffner, & Spielberger, 1981). Two participants were removed due to three or more missing STAI-T values. Finally, five participants were excluded that did not report male or female gender, leaving a total sample of 614. STAI-T items (partly reversed) were added up to obtain a STAI-T score. Participants were divided into high and low trait-anxiety by performing a median split. For anticipated emotions, mean values of the three items were calculated. Complete cases were used for all further calculations. Different tests were performed to examine the relationship between hazard type and

age (univariate ANOVA), trait anxiety, gender, and previous experience (chi-square tests). Pearson correlations and univariate ANCOVAs were used to investigate links between the components of risk perception before the warning message receipt and trait anxiety, age, gender, and previous experience. For each hazard type, Pearson correlations were performed for previous experience with age and gender.

After that, for each component of risk perception one repeated measure ANCOVA was conducted with risk perception component as within factor and trait anxiety and hazard type as in between factors. Partial eta squared (η_p^2) was applied as measure of effect size. For all ANCOVAs described below, age, gender, and previous experience were included as covariates.

3. RESULTS

3.1. Descriptive Statistics

In the remaining sample of 614 participants, nearly 1% (0.74%) of the data were missing with missing values ranging from 0 (e.g., age) to 27 (perceived likelihood after warning message receipt) at item level. 32.1% ($N = 197$) filled out paper-pencil questionnaires, while the remaining 67.9% ($N = 417$) participated in the online survey. To examine potential bias, we included sampling method as a covariate in our analysis, but we did not find any significant associations (results available upon request from the first author), therefore we do not report them in this text. The sample included 63.0% ($N = 387$) females and 37.0% ($N = 227$) males. Age ranged from 18 to 96 years ($M = 31.64$, $SD = 17.36$).

Due to randomization, 117–138 participants were surveyed per hazard type. 35.8% ($N = 220$) of the overall sample had previous experience with the particular hazard (severe weather 77.2%, act of violence 22.6%, breakdown of emergency number 14.3%, discovery of a WWII bomb 33.3%, and major fire 29.9%). In the overall sample, mean value for STAI-T was 41.10 ($SD = 10.59$, range = 20–73) with a median of 39 (low anxiety: $N = 302$, $M = 32.46$, $SD = 4.27$; high anxiety: $N = 312$, $M = 49.51$, $SD = 7.81$).

The participants randomized to the different hazard types did not differ by age ($F(4, 614) = 1.85$, $p = 0.177$), trait anxiety ($\chi^2(4) = 1.53$, $p = 0.821$), and gender ($\chi^2(4) = 4.04$, $p = 0.400$). Yet, they differed by previous experience ($\chi^2(4) = 125.95$, $p < 0.001$). The latter seems reasonable, as severe weather, for

example, is experienced far more often than other hazards. For the particular hazard types, no significant correlations were found for previous experience with age and gender.

3.2. Research Questions

RQ1: Do cognitive and affective components of risk perception differ between different hazard types?

At the first point of measurement, all four components of risk perception differed significantly between hazard types, namely perceived severity ($F(4,611) = 44.83$, $p < 0.001$, $\eta_p^2 = 0.23$), anticipatory worry ($F(4,610) = 4.00$, $p < 0.01$, $\eta_p^2 = 0.03$), anticipated emotions ($F(4,612) = 69.42$, $p < 0.001$, $\eta_p^2 = 0.32$), and perceived likelihood ($F(4,595) = 5.22$, $p < 0.001$, $\eta_p^2 = 0.03$). Perceived likelihood was rated higher for severe weather than for all other hazard types. Regarding perceived severity and anticipated emotions, act of violence and major fire were rated higher. For anticipatory worry, severe weather, act of violence, and breakdown of the emergency number were rated higher. Descriptive statistics are summarized in Table I.

RQ2: Do receiver characteristics, such as trait anxiety, influence the components of risk perception?

Regarding sociodemographic characteristics associated with risk perception, female participants reported generally higher risk perception. Moreover, previous hazard experience showed significant associations with different components of risk perception, but without a consistent trend. In contrast to that, no significant relationship between age and risk perception was found. Pearson's correlation coefficients are shown in Table SI.

Looking at trait anxiety, participants with low and high trait anxiety differed in their risk perception at the first point of measurement: While controlling for age, gender, and previous experience, participants with high anxiety reported higher perceived severity ($F(1,611) = 4.73$, $p < 0.05$, $\eta_p^2 = 0.01$), higher anticipatory worry ($F(1,609) = 16.32$, $p < 0.001$, $\eta_p^2 = 0.03$), and more negative anticipated emotions ($F(1,612) = 14.80$, $p < 0.001$, $\eta_p^2 = 0.02$). For perceived likelihood, no significant differences were found ($F(1,595) = 0.83$, $p = 0.362$, $\eta_p^2 = 0.00$).

Table I. Unadjusted Means of All Components of Risk Perception (Complete Sample and Separated by Hazard Type) Before and After the Receipt of a Warning Message

Risk Perception	Hazard Type											
	Total Sample <i>N</i> = 614		Severe Weather ^a <i>n</i> = 123		Act of Violence ^b <i>n</i> = 124		Breakdown of Emergency Number ^c <i>n</i> = 112		Discovery of a WWII Bomb ^d <i>n</i> = 138		Major Fire ^e <i>n</i> = 117	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
	Before Warning Message											
Perceived severity	3.14	1.24	2.84 ^{b,d,e}	1.00	3.85 ^{a,c,d}	1.00	3.21 ^{b,d,e}	1.30	2.26 ^{a,b,c,e}	1.09	3.70 ^{a,c,d}	1.06
Anticipatory worry	2.16	1.06	2.40 ^{d,e}	1.03	2.25	1.10	2.28	1.06	1.92 ^a	1.06	1.96 ^a	0.97
Anticipated emotions	2.86	1.09	2.35 ^{b,c,e}	0.83	3.84 ^{a,c,d,e}	0.91	2.75 ^{a,b,d,e}	1.02	2.16 ^{b,c,e}	0.84	3.28 ^{a,b,c,d}	0.92
Perceived likelihood (%)	37.77	28.03	55.78 ^{b,c,d,e}	27.02	34.09 ^a	24.88	29.10 ^a	25.01	36.15 ^a	30.08	32.61 ^a	24.40
	After Warning Message											
Perceived severity	3.06	1.20	2.76 ^{b,e}	1.01	3.77 ^{a,c}	1.07	3.01 ^{b,d}	1.30	2.42 ^{b,c,e}	1.12	3.43 ^{a,c,d}	1.00
Anticipatory worry	2.34	1.11	2.55 ^d	0.98	2.44	1.15	2.40	1.11	2.12 ^a	1.18	2.22	1.06
Anticipated emotions	2.77	1.10	2.26 ^{b,e}	0.84	3.78 ^{a,c,d,e}	0.90	2.55 ^{b,e}	1.01	2.24 ^{b,e}	0.91	3.06 ^{a,b,c,d}	1.00
Perceived likelihood (%)	40.24	28.39	58.51 ^{b,c,d,e}	26.9	36.15 ^a	24.60	32.75 ^a	26.41	38.50 ^a	30.58	33.83 ^a	24.55

Notes. *M* = Unadjusted mean; *SD* = Standard deviation; superscripts a, b, c, d, and e indicate statistically significant differences between the hazard types (Bonferroni-adjusted post hoc analysis [*p* < 0.05]) at each point of measurement.

Concerning the pre–post analysis, the associations between hazard type, trait anxiety, and risk perception were observed at both time points.

RQ3: Does the receipt of a warning message cause changes in risk perception? And how do interactions between trait anxiety and hazard type affect changes in risk perception?

In addition to the main effects reported above, pre–post analysis revealed changes in risk perception for some components. Anticipated emotions significantly decreased between the two times of measurement in the overall sample, when controlling for age, gender, and previous hazard experience ($F(1,599) = 11.38, p < 0.01, \eta_p^2 = 0.02$). There were no main effects for warning message receipt for the remaining three components (see Fig. 2).

In addition, anticipated emotions interacted with hazard type ($F(4,599) = 6.28, p < 0.001, \eta_p^2 = 0.04$) in that anticipated emotions decreased for all hazard types, except for discovery of a WWII bomb. For the latter, negative anticipated emotions increased after the receipt of a warning message.

For perceived severity, interactional effects were found for trait anxiety ($F(1,599) = 5.11, p < 0.05, \eta_p^2 = 0.01$) and hazard type ($F(4,599) = 4.54, p <$

$0.01, \eta_p^2 = 0.03$). Perceived severity decreased in participants with low trait anxiety while it remained high in individuals with high trait anxiety. Moreover, perceived severity increased for discovery of a WWII bomb while decreasing for the remaining hazard types.

Regarding anticipatory worry and perceived likelihood, no interactional effects for trait anxiety and hazard type were found.

4. DISCUSSION AND IMPLICATIONS

The present study examined the influence of hazard type, receiver characteristics, and the receipt of a warning message on different components of risk perception. Findings provided information regarding RQ1 by revealing an impact of hazard type on all four components of risk perception, including cognitive and affective appraisals of the five hazard types. Anticipated negative emotions and perceived severity were rated higher for major fire and violent act, which are characterized by a potentially high extent of damage, high uncertainty, or rapidly required adoption of protective actions (Ho et al., 2008; Sheppard, 2011). Severe weather depicts a hazard that occurs more frequently, resulting in higher ratings of perceived likelihood (i.e., probability of

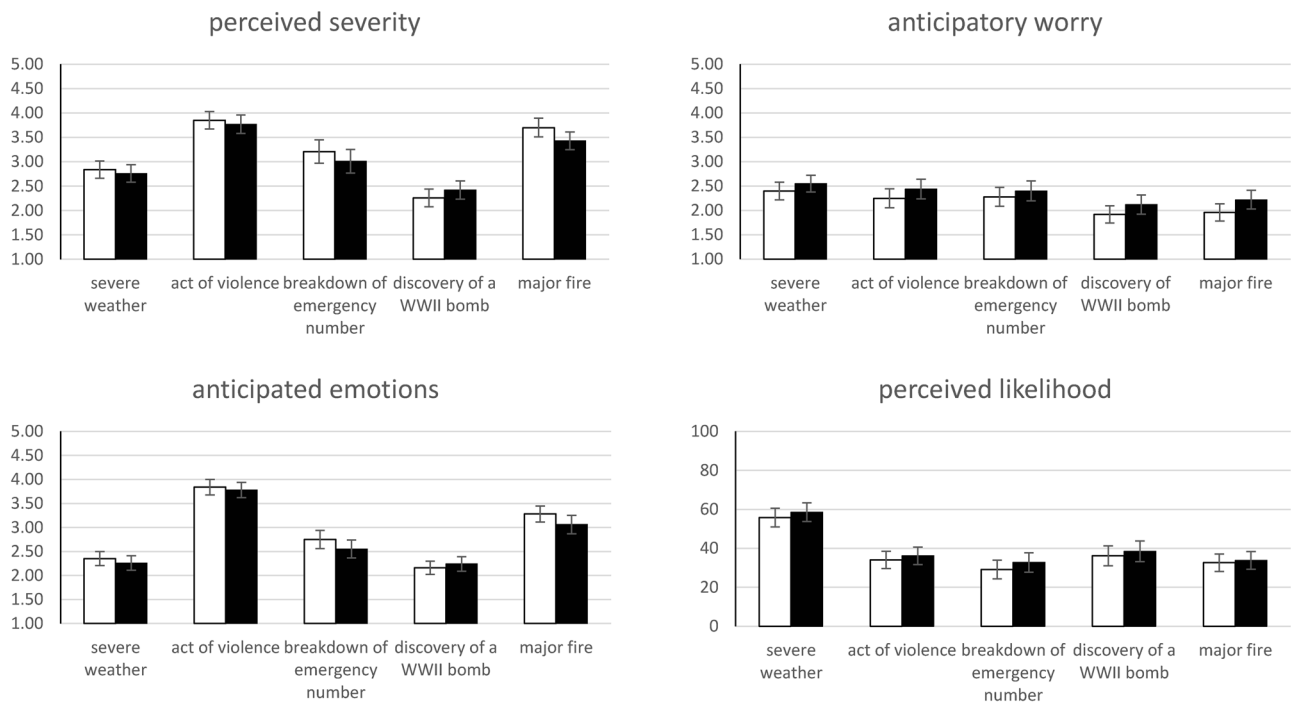


Fig 2. Unadjusted means of the components of risk perception before and after the receipt of a warning message, separated by hazard type. *Notes.* Components of risk perception before (white bars) and after (black bars) the receipt of a warning message. Perceived severity, anticipatory worry, anticipated emotions measured via five-point Likert scales from 1 (not at all) to 5 (very much). Perceived likelihood measured in percentage.

occurrence) and lower ratings of anticipated negative emotions (Frondel, Simora, & Sommer, 2017; Keul et al., 2018).

Concerning trait anxiety (RQ2), several significant associations with risk perception were found as well, albeit not for every component of risk perception. Individuals with high trait anxiety showed higher anticipatory worry, anticipated negative emotions, and perceived severity after reading a short explanation of one out of five hazards. Regarding these components of risk perception, high anxious individuals seem to feel more threatened overall when confronted with a hazard. This is in line with earlier research (Maner & Schmidt, 2006). However, when it comes to estimating the likelihood of a hazard, the two groups did not differ from each other. This could be since the short explanations given during the data assessment only contained brief descriptions of the hazards and no further information on probabilities. Therefore, the participants did not have any frame of reference for their ratings of perceived likelihood, except for their previous experience. Yet, the question remains open as to what impact trait anxiety has on the adoption protective measures. For the

latter, prior research showed associations between trait anxiety and decreased heat-wave and flood preparedness as well as decreased preparedness behaviors for terrorist attacks, but emphasized the importance of other determinants, such as given resources and disaster education, or cognitive factors, such as self-efficacy and perceived threat (Mishra & Suar, 2012; Wirtz et al., 2019). Other findings indicate no influence of trait anxiety on health-related behavior (Witte & Morrison, 2000). Thus, the effect of trait anxiety on protective behavior remains of interest—be it hindering or fostering.

Regarding RQ3, an influence of warning message receipt on anticipated negative emotions was observed in the overall sample, in that participants reported significantly fewer negative emotions after the receipt of a warning message. Interestingly, for the remaining components, no consistent trends were found for cognitive (perceived likelihood, perceived severity) and affective components (anticipated emotions, anticipatory worry): Some components increased (anticipatory worry, perceived likelihood), while others decreased (anticipated emotions, perceived severity) in the overall sample (see Fig. 2).

This is contrary to general expectations, as warning messages are intended to raise awareness of risk (Mayhorn & McLaughlin, 2014), but may point toward differences in the processing of hazard-related information and warning messages: At the first point of risk perception measurement, participants reported higher negative emotions and perceived severity towards the majority of hazard types. As they only received a short explanation of the particular hazards prior to their initial assessment, it can be presumed that they used their experiential system as proposed by the affect heuristic to make their ratings, which can result in higher ratings of negative emotions (Slovic et al., 2007). When confronted with a warning message and the included recommendations of protective measures, participants may be able to make more rational ratings of risk perception, since they now have more information about the situation (cf. analytical system according to affect heuristic). This, in turn, could lead to an increased perceived likelihood and anticipatory worry towards the hazard, but also a decrease in negative emotions and perceived severity, as the impending threat and protective actions become more salient. Thus, the decrease in some components could be explained if one considers that a warning message can provide a feeling of safety by giving orientation and recommendations on how to be prepared and avoid harm (Slagle, Zajac, Bruskotter, Wilson, & Prange, 2013; Vihalemm, Kiisel, & Harro-Loit, 2012).

Moreover, interactional effects were found for warning message receipt and hazard type: Anticipated negative emotions and perceived severity decreased for all hazard types, except for discovery of a WWII bomb. For this hazard, all components of risk perception increased after the receipt of a warning message, making it a special case that demands further investigation. Discoveries of WWII bombs are somewhat frequent, but not commonplace, events in Germany and central Europe. They can, in some cases, influence public life without giving much scope of action (e.g., when evacuation is ordered by the authorities). The warning message used for this study announces evacuation measures and thereby leaves the receiver with few options to act otherwise than to follow the measures. Thus, the receipt of the message could make this hazard more salient, while leading to an increase in some components of risk perception caused by limited choices for action. In the sense of the EPPM (Popova, 2012; Witte, 1994), it is of interest whether the increase of risk perception is caused by a lack of efficacy appraisals and whether

the observed changes could influence the adoption of evacuation behavior. Since, to the best of our knowledge, there are hardly any studies on this hazard type, further research in this field is essential, as failure to comply with warning messages regarding the discoveries of WWII bombs can cause various forms of harm, as well.

Lastly, one interactional effect was found for trait anxiety and perceived severity, as perceived severity decreased after the receipt of a warning message for low trait anxiety individuals, while no changes in high trait anxiety participants became apparent (see Fig. 3). This could point to high vigilance among high anxious participants. Similarly, a study on bushfires found that high trait anxiety is associated with an attentional bias, in that high anxious individuals tend to show higher vigilance towards bushfire-related threat (Notebaert et al., 2016). In our study, we also found increased levels of perceived severity in participants with high trait anxiety. Future research should investigate the association of perceived severity as against other aspects of risk perception regarding attention bias and information processing in warning messages. Since this effect was not influenced by hazard type, it might indicate a more general aspect of information processing (Wogalter, 2006). This could be an explanatory approach for the findings, assuming these participants rated the hazards as more severe or feel more threatened. Once again, further research on trait anxiety could contribute to a better understanding of warning associated processes.

4.1. Implications

The given results provide empirical evidence of the integrative view of hazard type, warning message, and receiver characteristics as described by Mayhorn and McLaughlin (2014), moreover offer several implications for research and practice. First, implications for future research support the application of a comparable methodology in the assessment of risk perception, as recently underlined by Wilson et al. (2019). The different trends in the components as shown in this study support the faceted or multi-dimensional approach of risk perception (Sheeran et al., 2014; Sjoberg, 1998; Wilson et al., 2019). In this regard, subsequent studies should also assess the relationship between components of risk perception, warning message induced changes, and the intention to act or protective behavior, since prior findings indicate varying associations (Wachinger et al., 2013). By assessing risk perception and following behaviors,

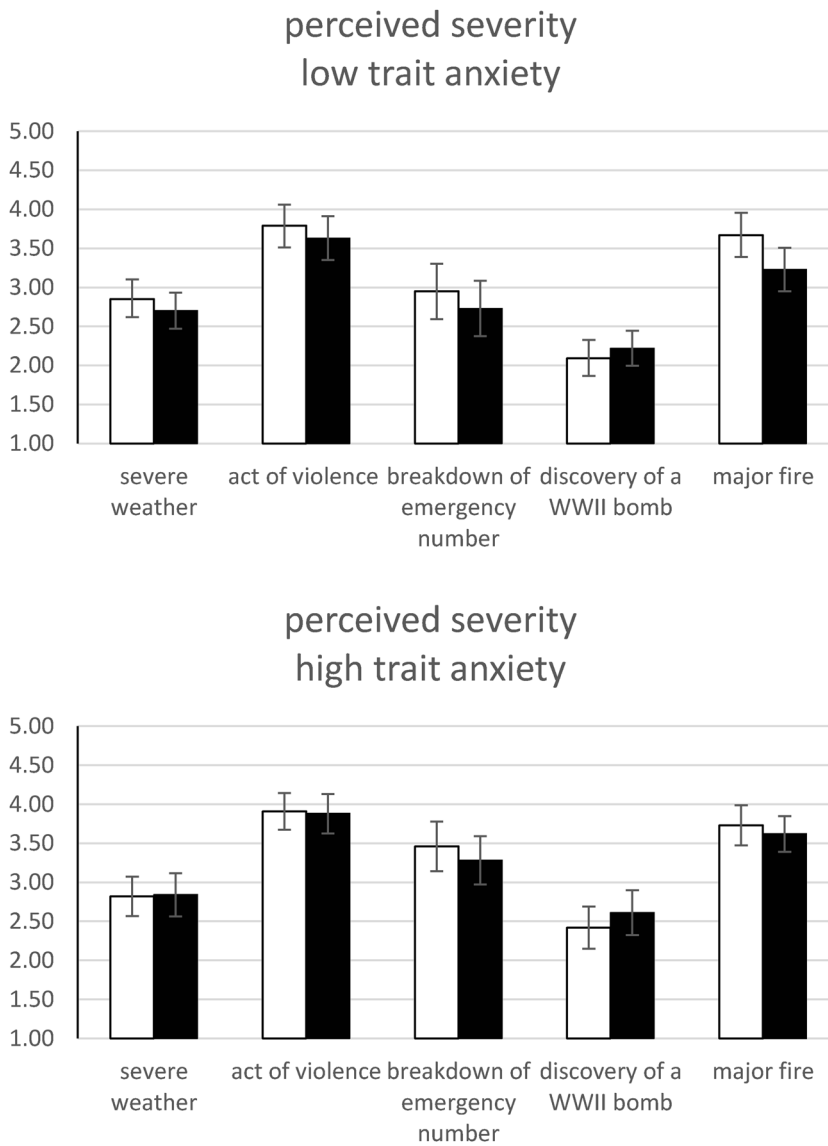


Fig 3. Unadjusted means of the component perceived severity for the different hazard types before and after the receipt of a warning message, separated by low and high trait anxiety. *Notes.* Perceived severity before (white bars) and after (black bars) the receipt of a warning message. Perceived likelihood measured via five-point Likert scales from 1 (not at all) to 5 (very much).

different models, such as the affect heuristic or the EPPM, could be tested in the context of risk communication in the event of hazards and crises to improve the understanding of the processes within the warning message recipient. This could also permit the investigation of what components (i.e., cognition or affect) may have a greater impact on the adoption of protective measures (Gutteling et al., 2018).

Additionally, as this study has shown again, receiver characteristics should always be borne in mind when it comes to the assessment of risk perception. For instance, trait anxiety influenced three components of risk perception, and additionally one component when receiving a warning message. Yet, it

is not clear whether trait anxiety has a promoting or hindering impact on the adoption of protective measures as given in hazard warning messages (Mishra & Suar, 2012; Wirtz et al., 2019).

Moreover, a comparative view on different hazard types proves beneficial, as the warning messages in this study caused different reactions within the warning message receivers. In this context, the proximity in time or space to the hazard could also be examined, since proximity to the hazard source is also associated with risk perception (Zhang, Hwang, & Lindell, 2010). Studies on risk perception and infrequent occurring hazards or hazards with low severity depict a research desideratum. For example, as

shown for discovery of a WWII bomb or breakdown of the emergency number, there is a lack of studies on these hazard types, which deal with the components of risk perception in association with protective measures.

Although often neglected in scientific research, further investigation of these hazard types can help to improve crisis communication and thus protect the public, as well. Standardized disaster or hazard taxonomies could be helpful here to systematically classify findings (Drabek, 1999).

The realization of further research and the transfer into practice may take place via virtual reality, as this approach allows to observe human behavior during various kinds of hazards and crises, and at the same time to modify aspects of the situation and the warning message (Duarte, Rebelo, & Wogalter, 2010; Markwart et al., 2019).

Second, implications for practice point towards the idea that the type of hazard should always be considered when communicating risk, as there is no “one warning fits all.” Different types of hazards can cause different reactions within those at risk, which should be borne in mind by stakeholders who issue warning messages. Besides the type of hazard, evidence from the present study implies that warning messages should be individualized (Wogalter, Racicot, Kalsher, & Noel Simpson, 1994). These findings may be helpful, for example, when messages are tailored to groups of people who have already experienced a hazard several times or never before.

Finally, while considering receiver characteristics and hazard type, thoughtful risk and crisis communication can help to take good preventive action, cope with fears or uncertainties, and prevent or mitigate harm to life and property (Gray & Ropeik, 2002; Veil, Reynolds, Sellnow, & Seeger, 2008).

4.2. Limitations

The present study clearly has some limitations, which are typical for survey designs. Although the collection of data was prospective, no context factors from the participants’ surroundings were assessed. Therefore, it was not possible to control (especially when participating online) under which circumstances participants completed the survey. Nevertheless, analyses of covariance showed that the sampling method did not influence the four components of risk perception.

Also, German convenience sample was collected, which impedes representative results for the

German population, as well as a transcultural comparison of risk perception (Keul et al., 2018).

Previous hazard experience was assessed as a covariate, but not differentiated into direct or indirect experience with the particular hazards. As prior research implies the importance of hazard experience on risk perception (Wachinger et al., 2013), future studies should assess hazard experience more detailed. Furthermore, no intermediary variables, such as self-efficacy or response efficacy, were surveyed (Sheeran et al., 2014). This applies as well for the intention to act and protective behavior itself. Thus, the results cannot clarify whether the examined factors or changes influence the adoption of protective measures.

The five hazard types examined in this study varied in terms of frequency and extent of damage. Yet, as we used original but anonymized warning messages, we could neither systematically vary the content and design of the warning messages nor characteristics of the hazards. Nevertheless, empirical research shows that a variation of different aspects of the hazards impacts risk perception. For example, proximity to hazard sources is positively associated with perceived personal risk regarding floods, hurricanes, and chemical hazards (Zhang et al., 2010). This can be interpreted according to the psychometric paradigm, which states that risk perception is rather driven by common qualitative risk characteristics (e.g., controllability, knowledge, and dread) of hazards and less by the hazard type itself (Marris, Langford, Saunderson, & O’Riordan, 1997; Slovic, Fischhoff, & Lichtenstein, 1986). On the other hand, the naturalistic approach used in the present study results in a higher ecological validity of the given results. Future studies should try to merge the variation of risk characteristics and hazard types with the use of authentic warning messages to derive conclusions for science and practice. Despite these limitations, this study has gone some way toward enhancing the understanding of risk perception, hazard type, and receiver characteristics in crisis communication.

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