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Insights into Flood-Coping Appraisals of Protection Motivation Theory: Empirical Evidence from Germany and France

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Protection motivation theory (PMT) has become a popular theory to explain the risk-reducing behavior of residents against natural hazards. PMT captures the two main cognitive processes that individuals undergo when faced with a threat, namely, threat appraisal and coping appraisal. The latter describes the evaluation of possible response measures that may reduce or avert the perceived threat. Although the coping appraisal component of PMT was found to be a better predictor of protective intentions and behavior, little is known about the factors that influence individuals' coping appraisals of natural hazards. More insight into flood-coping appraisals of PMT, therefore, are needed to better understand the decision-making process of individuals and to develop effective risk communication strategies. This study presents the results of two surveys among more than 1,600 flood-prone households in Germany and France. Five hypotheses were tested using multivariate statistics regarding factors related to flood-coping appraisals, which were derived from the PMT framework, related literature, and the literature on social vulnerability. We found that socioeconomic characteristics alone are not sufficient to explain flood-coping appraisals. Particularly, observational learning from the social environment, such as friends and neighbors, is positively related to flood-coping appraisals. This suggests that social norms and networks play an important role in flood-preparedness decisions. Providing risk and coping information can also have a positive effect. Given the strong positive influence of the social environment on flood-coping appraisals, future research should investigate how risk communication can be enhanced by making use of the observed social norms and network effects.

KEY WORDS: Coping appraisal; floods; protection motivation theory (PMT); risk communication; social vulnerability

1. INTRODUCTION

In recent years, protection motivation theory (PMT) has become a popular theory to explain the risk-reducing behavior of residents and farmers against natural hazards.[1–12] PMT was originally developed in the 1970s to explain health-related behavior[13–15] and has recently seen a revival in the natural hazard domain due to its good explanatory power.[1,3] The growing interest in the decision making of individuals in response to natural hazards stems from the continuously high losses caused by natural hazards[16] and the related shift to more integrated risk management concepts in many countries.[17,18] The latter include a more comprehensive approach to natural hazard management, and

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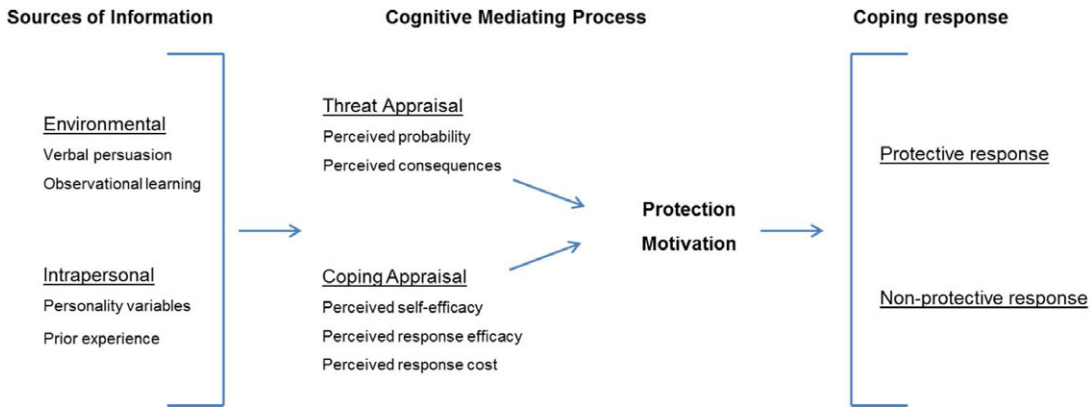

Fig. 1. A schematic overview of protection motivation theory (adapted from Rogers and Prentice-Dunn [19]).

a focus not only on protection against natural hazards, but also on reducing exposure, lowering vulnerability, and managing residual risks. This requires all stakeholders to contribute to risk reduction, including residents.

According to PMT, the decision of individuals to engage in a protective or nonprotective response is driven by two main cognitive processes, namely, threat appraisal and coping appraisal.[19] Threat appraisal comprises the two variables of the perceived probability and perceived consequences that an individual associates with a certain hazard. Threat appraisal is, therefore, also referred to as "risk perception."[1] Once a certain threshold of threat appraisal is exceeded, contemplation of taking possible response measures to reduce or avert the threat begins, which is referred to as "coping appraisal." Coping appraisal consists of three variables: namely, the perceived effectiveness of a certain measure (response efficacy), the perceived ability to implement the respective measure (self-efficacy), and the perceived costs associated with its implementation (response cost). Note that, according to PMT, the response cost not only reflects financial costs but also the time and emotional effort needed to implement the measure. The interplay of threat and coping appraisal influences protection motivation, which is considered as an intervening variable that "arouses, sustains, and directs the activity of individuals to protect the self from danger."[(20), p. 470] If high perceived risks are accompanied by high coping appraisals, this can lead to the adoption of a protective response intended to reduce the risk, such as flood-proofing a building. If high perceived risks are accompanied by low coping appraisals, it can result in nonprotective responses, such as fatalism, denial, or wishful thinking.[21] PMT is schematically depicted in Fig. 1.

According to PMT, different sources of information can trigger the cognitive process of protection motivation.[22] The original version of PMT still focused on fear appeals,[4] which are typically informative communications about a threat and suggested measures to avoid or reduce its negative impacts.[15] The revised version introduced by Rogers ([22]) included additional sources of information referred to as "environmental and intrapersonal sources" (Fig. 1). Environmental sources (not to be interpreted as geographical factors) include verbal persuasion and observational learning. The latter occurs when an individual observes what happens to others such as friends, neighbors, or family. The intrapersonal source, on the other hand, captures personality variables and prior experience with similar threats.[22] Although intrapersonal variables are in principle broader and can relate, for example, to ideology, they are mainly related to socioeconomic characteristics, like gender, age, and income. Moreover, an emerging literature on the social vulnerability of households to flood hazards has used socioeconomic characteristics as observable proxies for some of the life circumstances, beliefs, and constraints that contribute to vulnerabilities, threat, and coping appraisals.[23–25]

[4]It should be realized that communication policies that focus on fear appeals may be regarded as undesirable because of the negative emotional impacts caused by fear, and that well-designed communication policies can raise risk perceptions without inducing fear, as shown by de Boer *et al.*[76]

When it comes to explaining intentions or actual risk-reducing behavior, two meta-analyses of the health-related literature on PMT come to the conclusion that the coping appraisal component has a greater predictive validity than threat appraisal.[14,15] Similar findings have been reported from studies examining protective behavior in the face of natural hazards.[1,3,5] Grothmann and Reusswig,[1] for example, found that threat appraisal could explain an additional 3–6% of the variance in protective behavior, while coping appraisal could explain an additional 2–21%.

Given the importance of threat and coping appraisals in influencing protection motivation and subsequent behavior, it is of interest for policies that aim to improve individual risk preparedness to understand what factors determine the threat and coping appraisals of individuals. A large body of literature exists that examines this aspect in relation to risk perception (called "threat appraisal" in PMT). Several theories have been developed and extensively tested to explain why people perceive a certain event or activity as risky, such as the psychometric paradigm[26,27] or cultural theory, which also seeks to explain individual attitudes towards risk-reducing actions.[28] Various studies also examined the factors that specifically shape risk perceptions of natural hazards.[29–37] In contrast, to our knowledge there are no studies that systematically examine which factors influence all three components of coping appraisals related to natural hazards, despite their higher predictive validity in terms of protective intentions and behavior. While not specifically focusing on PMT, one exception is a study by Lindell *et al.*[38] that examines correlations between mostly socioeconomic variables and the perceived attributes of earthquake preparedness measures, such as the perceived protection of persons and property (related to response efficacy) and the required time, effort, and costs (relating to response cost). Self-efficacy, the third component of coping appraisal in PMT, was not included in the analysis by Lindell *et al.*[38] Instead, it was elicited more generally whether people thought that specialized skills and knowledge were needed for the implementation of a particular measure. Findings from this study show that especially females, respondents with higher risk perceptions, and those with higher hazard intrusiveness exhibited a higher perceived response efficacy.[38] Moreover, Hispanics associated higher response costs (captured by the variable "ResAtt" in Lindell *et al.*, 2009) with implementing measures, while the opposite was the case for whites, older respondents, and homeowners. Babcicky and Seebauer[39] explicitly investigate factors that influence self-efficacy according to PMT of flood-affected households in Austria, but do not study response efficacy and response cost. They find that self-efficacy is lower for women and respondents facing a higher objective risk, while it is positively influenced by income and cognitive social capital. The latter refers to perceived support, trust, social cohesion, and civil engagement.

Systematic insights into the factors that relate to individuals' flood-coping appraisals are needed to better understand their decision-making process in the face of natural hazards in general and floods in particular, and to inform risk communication on how to best stimulate protective behavior.[12] To gain a better understanding of these aspects, we empirically explore a wide range of variables capturing environmental and intrapersonal sources of information possibly influencing coping appraisals of more than 1,600 flood-affected households in Germany and France, using multivariate statistics. An important novel contribution of our study is that we provide systematic insights into the factors influencing all three components constituting coping appraisal as given by PMT, namely, response efficacy, self-efficacy, and response cost, in the context of natural hazards. Our empirical assessment for two countries allows for identifying consistent patterns on a large geographical scale.

In addition, we examine whether groups of households can be identified across different types of private flood-damage-reducing measures and the two countries that exhibit identical/similar combinations of ratings for the coping appraisal components and could thus be targeted by tailored risk communication. To this end, we furthermore explore whether this grouping is determined by distinct explanatory variables, such as environmental and intrapersonal characteristics.

The remainder of the article is organized as follows: Section 2 describes our hypotheses, the responsibility of households to contribute to flood-damage reduction in Germany and France, and the surveys conducted among flood-affected households, as well as the statistical methods applied in this study. Results of statistical models of the factors that influence flood-coping appraisals of households as well as the grouping analysis based on individual coping appraisal ratings are provided in Section 3. Section 4 discusses the overall pattern of findings in view of our hypotheses. Section 5 concludes and provides

policy recommendations for flood risk management and communication.

2. HYPOTHESES, CASE STUDIES, DATA, AND METHODS

2.1. Hypotheses

Our study is structured around a set of five main hypotheses concerning potential factors relating to coping appraisals. These hypotheses have been based on the factors that influence coping appraisals as understood in the PMT framework (Fig. 1), the literature on social vulnerability to flooding, and the handful of aforementioned studies that examined determinants of selected coping appraisal variables.

Studies on social vulnerability to flooding typically find that socially vulnerable groups have a higher exposure, a lower capacity to prepare for, and cope with, flooding events, and potentially a lower adaptive capacity.[23–25,40–42] Nevertheless, such groups can also have their own capacities to cope with and manage risk from natural hazards.[43] A variety of indicators have been used to identify vulnerable groups, of which some important variables include a low income, low education level, and older age groups. Moreover, females, older adults, and children may be additionally more vulnerable, that last of which is not relevant for our surveys of only adults. These variables belong to intrapersonal sources according to PMT (Fig. 1). An examination of some of these sources for which data were available from our surveys is operationalized in our analyses by examining how coping appraisals relate to income, age, education level, and gender. It may be expected that socially vulnerable groups have lower coping appraisals, especially in the form of a high perceived response cost and lower perceived self-efficacy. This leads to the first hypothesis (H1).

> **H1**: Socially vulnerable groups in terms of low income, age, low education, and gender have lower coping appraisals, especially in terms of high perceived response cost and lower perceived self-efficacy.

Several studies have shown that prior flood experience and individual flood risk perceptions are strongly positively related,[33] although the effect of experience on risk perceptions declines over time.[44] Past flood experience and high risk perceptions may have the effect that individuals find flood damage mitigation measures appealing. The results of Lindell *et al.*[38] and Terpstra and Lindell[45] suggest this latter effect by showing a positive relation between risk perception and response efficacy. Similar findings are also reported from the literature on hurricanes. Norris *et al.*[46] report a positive relation between past hurricane experience and perceptions of response and self-efficacy, referred to as "controllability beliefs." The finding that the effect of (hurricane) experience on coping appraisals can be ambiguous is reported by Demuth *et al.*[47] They also report a positive relationship between hurricane experience and self- and response efficacy, in case hurricane experience is operationalized in terms of evacuation experience. However, if hurricane experience is operationalized in terms of property damage or emotional impact, a negative relationship is found at least for response efficacy and self-efficacy, respectively. It is thus of interest to gain further insights into how prior flood experience and risk perceptions relate to flood-coping appraisals. Based on the flood-related literature, we hypothesize the following:

> **H2**: Prior flood experience and high flood risk perceptions are positively related to flood-coping appraisals (i.e., higher response and self-efficacy and lower response cost).

Moreover, other intrapersonal variables may matter for shaping coping appraisals, as Fig. 1 suggests. For example, a negative effect on coping appraisals such as perceived response efficacy can arise from fatalism, which corresponds to the belief that nothing can be done to prevent impacts from flooding. A similar effect may be expected from respondents who postpone flood mitigation measures, since these people see less urgency or immediate benefit from flood-proofing their homes.[48,49] Similarly, according to expected utility theory—the standard economic theory of decision making under risk—protection against a risk (here, flooding) is less valued for individuals with a lower degree of risk aversion.[50] This leads to the third hypothesis (H3).

> **H3**: Fatalism, postponement, and low risk aversion are important personality characteristics that are related to lower coping appraisals (i.e., lower response and self-efficacy and higher response cost).

It is commonly expected that having received information about a hazard and ways to protect against it motivates people to better prepare for the hazard. However, only few studies have empirically

examined this assumption, as Haer *et al.*[12] point out. Here, we empirically estimate whether a positive relation exists between coping appraisals and information about flood risk and coping measures:

> **H4**: Information provision about flood risk and flood-coping measures is related to higher flood-coping appraisals (i.e., higher response and self-efficacy and lower response cost).

Previous research has suggested that individuals are more likely to prepare for disasters (e.g., purchase flood insurance) if their neighbors, friends, and family members, do the same.[51–53] For instance, Bubeck *et al.* [3] found that a social environment variable, capturing whether respondents believed that friends, family members, or neighbors took flood damage mitigation measures, has a significant positive influence on the number of flood mitigation measures households take. However, it is not well known through which channel the social environment influences mitigation behavior. This can be related to the verbal persuasion and observational learning sources in PMT (Fig. 1), in the sense that individuals who learn about mitigation behavior from others have more positive coping appraisals themselves. This is formalized in our final hypothesis.

> **H5**: Individuals who believe that friends, neighbors, and family members have implemented flood damage mitigation measures (related to observational learning) have more positive coping appraisals (i.e., higher response and self-efficacy and lower response cost).

2.2. Private Flood-Damage Mitigation in Germany and France

In both Germany and France, households in flood-prone areas are expected to contribute to flood-risk reduction by implementing damage-reducing (also called mitigation) measures. In Germany, the responsibility of households to contribute to risk reduction was increasingly emphasized following major floods along the Rhine in 1993 and 1995 and the Elbe and Danube catchment in 2002, and is also stated in the federal water act as of 2005.[17,54] However, there are currently no clear rules as to what this responsibility encompasses, and no systematic support or financial subsidies are available to households for implementing private flood mitigation measures.[55] Flood insurance coverage is available from private insurers that charge risk-based premiums, which is thus more expensive and difficult to obtain in high-risk areas. Market penetration varies considerably between federal states for historical reasons and ranges from 15% to 95% (as of 2015).[56], [5]

In France, private flood mitigation measures are, in principle, stimulated through so-called Risk Prevention Plans (PPR), which delineate areas potentially at risk of flooding. In these areas, PPRs can define obligatory or recommended flood mitigation measures for private households. Moreover, the so-called Barnier fund can provide subsidies for households to implement flood mitigation measures. In practice, however, several studies have shown that both the PPRs and the Barnier fund hardly stimulate private flood mitigation behaviors, which are predominantly enacted at the initiative of the households themselves.[57] Property insurance is compulsory and thus reaches a market penetration of 99% in metropolitan France. Flood damage is covered by an additional public–private compensation scheme (the so-called Cat Nat system), which private insurers must provide along with property insurance contracts.[57] Insurance premiums are fixed by the government, do not reflect the actual risk, and thus follow the national solidarity principle.[58]

Even though flood risk management systems differ between France and Germany, it can be concluded that households are mostly responsible themselves for implementing and financing flood mitigation measures at the building level. Differences between the two countries exist in terms of flood insurance.

2.3. Household Surveys in Germany and France

To gain insights into the factors that influence flood-coping appraisals of PMT, two surveys were carried out among 752 and 885 flood-affected households in Germany and France, respectively. In addition to details on flood-coping appraisals for different types of private flood mitigation measures, the deployed questionnaires elicited a range of intrapersonal and environmental factors as well as information on risk and coping communication.

[5]Source: http://www.gdv.de/wp-content/uploads/2015/07/GDV-Deutschlandkarte-Versicherungsdichte-Elementarschadenversicherung-06-2015.pdf.

In Germany, computer-aided telephone interviews were conducted among households living along the Rhine River by the Umfragezentrum Bonn of the Rheinische Friedrich-Wilhelms-Universität Bonn in early summer of 2011. In France, the survey was administered by mail by IPSOS, which is a French professional survey research company, and distributed to households living in flood-prone areas in the regions of Ardenness, the Var, and the West Coast. For further details on the two surveys in terms of pretesting, sample characteristics, and representativeness of the sample, the reader is referred to Refs. 3,5,54, and 59.

Since the characteristics of private flood mitigation measures can substantially differ—for example, flood-proofing a building structure versus purchasing flood insurance—also perceptions regarding these measures can vary. Therefore, flood-coping appraisals were elicited for specific types of measures. In Germany, respondents were asked to indicate coping appraisals for structural measures, nonstructural measures, and for purchasing flood insurance. In France, respondents reported their coping appraisals separately for structural and nonstructural measures. Insurance was not elicited in France because households are already obliged to buy it (see Section 2.2). While postponement was only included in the German survey, risk aversion was only elicited in the French survey, allowing for complementary insights. The variables included in the German and French analyses and their coding are described in Tables AI and AII in the Supporting Information.

One important difference between the two samples exists in terms of the timing of flood experience. German households were mainly affected by the large-scale floods that occurred in the Rhine basin in December 1993 and January 1995,[54,60] even though a number of respondents were also affected by smaller and more recent floods. Flood experience of the French households was more recent: the majority of the respondents who were flooded in the past were affected by the storm Xynthia, which caused large flooding in 2010.

2.4. Statistical Analyses

2.4.1. Factors Influencing Flood-Coping Appraisals

Self-reported ratings of response efficacy, self-efficacy, and response cost for structural and nonstructural measures, as well as insurance in the case of the German sample, were used as dependent variables in a series of multiple regression models. A separate regression analysis was performed for each type of measure and each country (Tables I–VI). To account for the ordinal scale of the coping appraisal ratings, ordered logit models were applied. For each model, regression coefficients, significance values, and Nagelkerke R^2 values are reported. Differences in the number of observations included in the models stem from missing answers.

In a first step, a set of typical socioeconomic variables (intrapersonal source of information according to PMT), namely, the level of education, number of household members, age, ownership, gender, and income, were used as explanatory variables. These models are referred to as "socioeconomic" models (see, e.g., Table I).

In a second step, the socioeconomic models for the three coping appraisal variables and the different types of measures were expanded with variables capturing additional intrapersonal and environmental sources of information, including previous flood experience and damage, risk perceptions, respondents' social environment, and aspects of risk and coping communication. The resulting models are referred to as "complete" models (see, e.g., Table I).

2.4.2. Grouping Analysis

In addition to the regression models, we performed a grouping analysis: households with similar combinations of flood-coping appraisal ratings were grouped, and variables influencing this grouping were determined by applying a multivariate grouping analysis that consisted of four steps. All four steps were performed using the software R, version 3.2.2. First, a hierarchical cluster analysis applying Euclidean distance and the Ward.D2 clustering method was performed on the three coping appraisal variables (response efficacy, self-efficacy, and response cost) in order to obtain an algorithm-based grouping for each category of mitigation measure. For instance, all respondents who indicated the highest response and self-efficacy rating and the lowest response cost rating for structural measures were identified as one group. Second, the most prominent groups were manually selected using the hierarchical cluster dendrogram, in which equally sized clusters with similar heights result in the particular groups. Third, an unconstrained principal component analysis (PCA) was conducted with the coping appraisal variables in order to present the Euclidean distance between the combinations in an ordination plot. PCA is a method often used in

ecology, but increasingly also in the social sciences, to reduce the dimensionality of the data, extracting its most important information and revealing patterns of similarity.[61–64] To display the groups in the most representative way, a group overlay was passed to the plot (Fig. 2). Fourth, the R package "envfit" module[65] was used to estimate correlations between explanatory variables that were significant in the regression analysis (see Section 2.4.1) and the first two principal components (PCA axes).

Correlations between explanatory variables and the groups are displayed by the brown arrows (see Fig. 2), which show the correlation strength as well as correlation direction of a variable. In general, longer arrows mean stronger correlations between the particular variable and the two PCA axes. The angles between arrows and axes show how the variable is correlated with each particular axis. The smaller the angle between them, the stronger the correlation.[65] Thus, if the variable arrows point to the same plot region where groups appear, a positive coherence between this variable and the group can be assumed. A negative correlation is indicated by variable arrows pointing in the opposite direction of a group (see Fig. S1 for an illustrative example). For readers unfamiliar with PCA and the interpretation of ordination plots, a detailed example and explanation is provided in the supplementary information.

3. RESULTS

3.1. Factors Influencing Flood-Coping Appraisals

3.1.1. Response Efficacy (RE)

3.1.1.1. German case study. The results of the socioeconomic models predicting RE for the three damage-reducing measures in Germany show that age, ownership, and income level make a significant contribution to at least one of the socioeconomic models (Table I). In terms of structural measures, we find that older adults are less likely to rate structural measures as effective. For nonstructural measures, a positive influence for income is found. As far as the purchase of insurance is concerned, the age of the respondents again has a negative influence on RE, while being a homeowner has a positive influence. Common to all three socioeconomic models is the low level of explained variance, ranging from 3.9% to 5.3%.

The complete models explaining RE reveal that especially the social environment has a positive influence on the perceived effectiveness of the three measures, making a significant positive contribution to all three models (Table I). As far as the complete model for the RE of insurance is concerned, results show that people who believe that they live in an area that is unprotected from flood-defense infras-

Table I. Models of Response Efficacy for Structural and Nonstructural Measures and Insurance Purchase in Germany

	Structural Measures		Nonstructural Measures		Insurance	
Explanatory Variable	Socioeconomic	Complete	Socioeconomic	Complete	Socioeconomic	Complete
Education	0.112	0.145	0.134	0.053	0.002	−0.176*
Household members	0.049	−0.019	−0.052	0.073	−0.079	−0.068
Age	−0.194*	−0.206*	−0.097	−0.104	−0.242***	−0.161
Ownership	−0.158	−0.282	−0.133	−0.522	0.549**	0.406
Female	−0.138	−0.110	−0.173	−0.418	−0.059	−0.064
Income	−0.427	−0.660	0.225*	0.218	0.178	0.502
Perceived consequence	*n.a.*	0.126	*n.a.*	0.074	*n.a.*	0.288*
Perceived probability	*n.a.*	−0.097	*n.a.*	0.210	*n.a.*	−0.260*
Unprotected area	*n.a.*	−0.155	*n.a.*	0.034	*n.a.*	−0.618*
Satisfaction with flood management	*n.a.*	0.029	*n.a.*	0.206	*n.a.*	−0.066
Past flood damage (ln)	*n.a.*	0.009	*n.a.*	0.044	*n.a.*	−0.016
Fatalism	*n.a.*	−0.017	*n.a.*	0.028	*n.a.*	−0.097
Avoidance	*n.a.*	−0.004	*n.a.*	−0.074	*n.a.*	−0.153
Postponement	*n.a.*	−0.021	*n.a.*	0.038	*n.a.*	−0.030
Risk information	*n.a.*	−0.092	*n.a.*	0.247	*n.a.*	0.035
Coping information	*n.a.*	−0.353	*n.a.*	−0.464	*n.a.*	0.004
Social environment	*n.a.*	0.293**	*n.a.*	0.291*	*n.a.*	0.404***
Nagelkerke R^2	0.039	0.105	0.053	0.144	0.044	0.172
N	478	282	484	280	462	271

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

tructure rate the effectiveness of insurance lower. Insurance may be viewed as being a less effective way to cope with flood risk in these high-risk areas because it is more expensive there and more difficult to obtain.[3,56] The same argument holds true for the negative influence found for perceived probability. Also, more educated people perceive insurance to be less effective. In contrast, people who expect a flood's damage to be high exhibit a higher RE rating. The explained variance of the complete models is between 10.5% and 17.2%, which is considerably higher than the socioeconomic models.

3.1.1.2. French case study. The socioeconomic models capturing the RE of French households (Table II) show that women have a significantly higher perceived response efficacy with regard to nonstructural measures than men. Contrary to the German model, no positive effect is found for income. In line with the sample from Germany, the socioeconomic variables have little explanatory power, ranging from 2% to 3% of explained variance in RE.

The complete model explaining RE in France indicates that the perceived damage of a future flood is negatively related to the latter (Table II).

Moreover, response efficacy among French households is related to fatalism in the sense that individuals with a low degree of fatalism have a higher perceived RE. Risk aversion and perceived response efficacy are positively related with regard to nonstructural measures. In line with the findings from Germany, it appears that the social environment has a strong and significant influence on perceived response efficacy for both structural and nonstructural measures. As in the case for Germany, the explanatory power of the complete models for France is, with 12–15% in explained variance, considerably higher than the socioeconomic models.

3.1.2. Self-Efficacy (SE)

3.1.2.1. German case study. With regard to SE, the results show that income, ownership, educational level, and age make a significant contribution to at least one of the three socioeconomic models (Table III). As far as SE for structural measures is concerned, we find a significant positive effect for both income and ownership. As far as nonstructural measures are concerned, income again influences the perceived SE positively. Here, no difference is found for ownership in the socioeconomic model. Regarding the perceived SE of insurance, we again find a positive influence for income. In addition, the educational level also exhibits a positive influence on the perceived SE of buying insurance. In contrast, older people consider themselves less able to purchase insurance. The explanatory power of the socioeconomic model predicting SE regarding nonstructural measures is again low, with only 4% of explained variance. Somewhat higher explanatory power is found for the models predicting SE in terms of structural measures and insurance, with 10.6% and 13.2% in explained variance, respectively.

The complete models explaining SE reveal the importance of the social environment (Table III). People who believed that friends or neighbors implemented one of the three types of measures feel better able to implement these themselves. People who received information on the risk they faced also indicated a higher SE with regard to insurance. In contrast, nonprotective responses, that is, avoidance of insurance, relate negatively to SE. Respondents with a high perceived probability of future flooding also indicated a lower SE for insurance. In line with the results for RE, the explained variance increases considerably for the complete models predicting SE (namely, 13.8–27.4%) compared to the socioeconomic models.

3.1.2.2. French case study. For the French households, we find that education appears to be negatively related to the perceived SE for structural measures in the socioeconomic model (Table IV). A lower perceived SE is also reported for females in the model for structural measures. Older adults also indicate a lower SE for both measures, although effect sizes are low. As is the case for the German sample, income is positively related to SE for structural measures, but not significantly in the model for nonstructural measures. In line with the findings from Germany, the socioeconomic models for SE have a better model fit than was the case for the response efficacy models, and range from 6% to 9% in explained variance.

The complete models predicting the SE of French households indicate that higher perceptions of flood risk are negatively related to the perceived SE of structural measures (Table IV). In particular, perceptions that one's flood risk is higher than average has a negative significant influence, and already feeling well-protected against the flooding has a positive influence on perceived self-efficacy. These effects were not observed for the German case study, where neither perceived probability,

perceived consequences, nor past flood damage made a significant contribution to the models explaining SE of structural and nonstructural measures. Individual risk aversion, which was not elicited in the German survey, is positively related to the perceived self-efficacy of both structural and nonstructural measures. Moreover, individuals who have received or searched for information on flood protection measures have a higher degree of self-efficacy for structural measures. The social environment variable is positively related to the self-efficacy of nonstructural measures, which is consistent across the two case studies. The explanatory power of the complete models for SE in France again improves considerably compared with the socioeconomic model and ranges from 13% to 15% in explained variance.

3.1.3. Response Cost (RC)

3.1.3.1. German case study. In terms of perceived response cost (RC), education, age, and gender significantly contribute to at least one of the three socioeconomic models (see Table V). Respondents with a higher education level perceive the costs of structural measures to be lower. In addition, older people and women consider insurance to be less costly. The explanatory power of all three socioeconomic models is again low and explains only between 1.6% and 4.8% of the variance in perceived RC.

The complete models predicting RC provide mixed results (Table V). In terms of structural measures, we find that older people perceive this type of measure as more costly. People who believe in greater consequences of future flood events consider structural and nonstructural measures to be less costly. A negative coefficient is furthermore found for the variable of fatalism, indicating that people who agree with the general statement that "there is nothing that can be done to prevent flood damage" rate the costs of structural measures as lower. The explained variance significantly increases again for the complete models and ranges between 10.7% and 17.4%.

3.1.3.2. French case study. For the French sample, several socioeconomic variables have an important influence on RC (see Table VI) in the socioeconomic models. Older people perceive structural and nonstructural measures as less costly, but effect sizes are very low. Homeowners perceive structural measures as more costly, which probably reflects the fact that the costs of flood-proofing a house are more obvious for homeowners compared to tenants. We also find that people with higher income consider costs lower in all models, which is a marked difference from the German sample. The explanatory power of the socioeconomic models is again low.

The complete models reveal that the perceived consequences of flooding relate to higher perceived costs for both measures. Also, experience with flood damage in the past relates to perceived higher costs of nonstructural measures, but effect size is very low. Respondents who feel well-protected against flooding perceive structural measures as less costly. This could be related to the fact that these respondents believe that only minor investments are needed given the already good protection level. Also, respondents who perceived that their social environment implemented flood mitigation measures consider the cost of nonstructural measures to be lower. Explained variance again increases considerably and reaches 15% for RC of structural measures and 13% for nonstructural measures.

3.2. Grouping Analysis

The results of the grouping analysis show that several distinct groups exhibiting very similar ratings of response efficacy, self-efficacy, and response cost can be identified for the different types of examined mitigation measures. The distinct groups that could be identified based on their similar rating across the three coping appraisal components are described in Table VII and the number or respondents belonging to these groups (% in brackets) for each of the examined measures is provided.

The first result of the grouping analysis is that the identified groups do not appear uniformly across all examined measures (Table VII). The group "Low coping appraisal" was only identified for insurance. The group "Only low self-efficacy" was found only as a distinct group for structural measures. The group "Only high response cost" was found for both nonstructural measures and insurance. The only group that occurred for all examined measures was "High coping appraisal." Interestingly, while the identified groups are not uniform across the different mitigation measures, we find identical groups for the French and German samples, as indicated in Table VII and depicted in the ordination plots in Figs. 2(a)–(d). For "structural measures," the groups "High coping appraisal" and "Only low self-efficacy" are both found within the German and French data (Figs. 2(a) and 2(b)), whereas "nonstructural

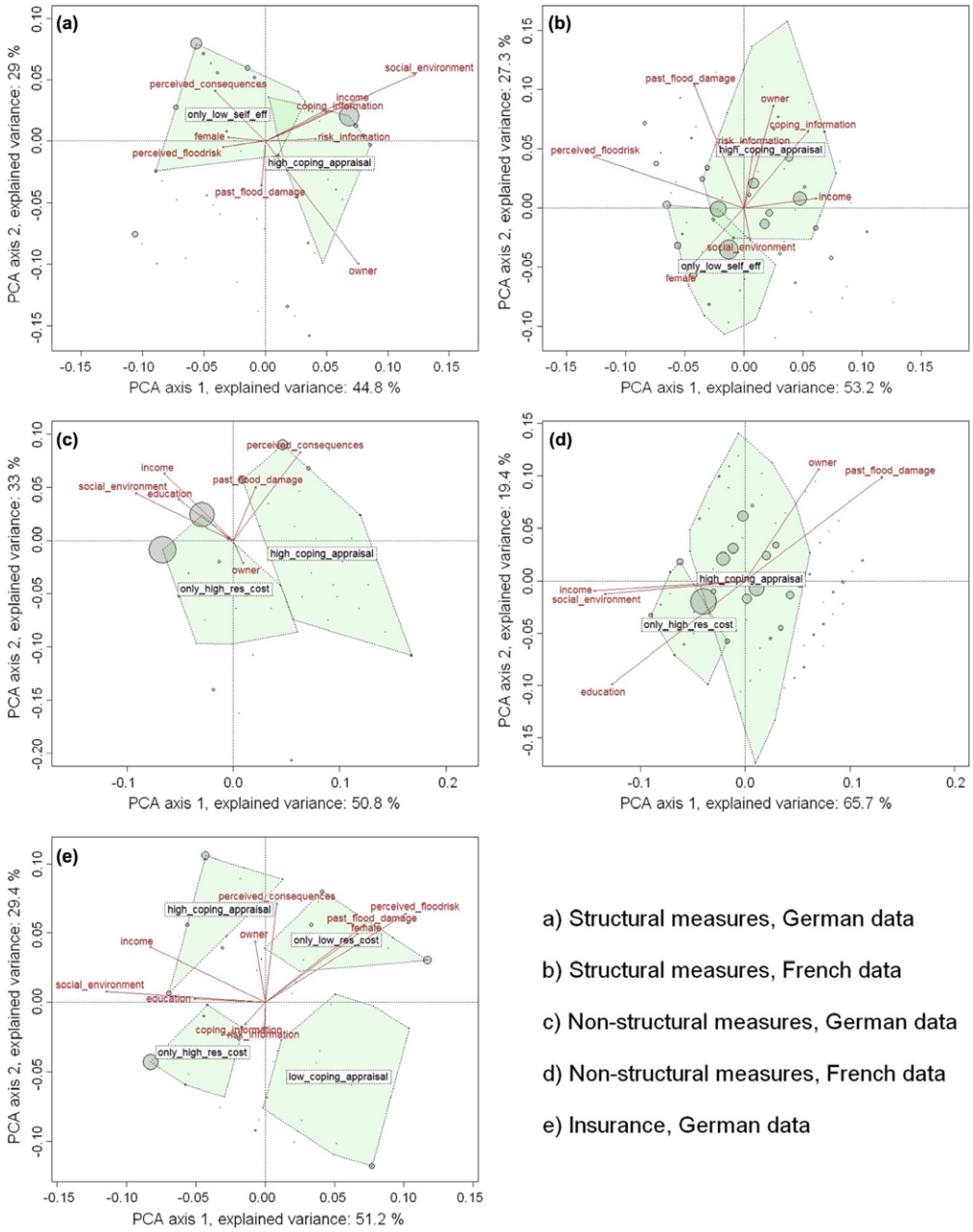

Fig. 2. PCA ordination plots of the German and French data for different mitigation measure types.

measures" consist of the groups "High coping appraisal" and "Only high response cost" (Figs. 2(c) and 2(d)). The category "insurance," which was not elicited for the French survey, comprises all groups except for "Only low self-efficacy" (Fig. 2(e)).

Moreover, Figs. 2(a)–(e) reveal that the grouping is influenced by different explanatory variables, which is resembled by the brown arrows. In the case of structural measures in Germany, the social environment has a strong significant positive effect on the group "High coping appraisal" (Fig. 2(a)), while the effect on "Only low self-efficacy" is negative. In addition, being a homeowner also shows a significant positive influence on the "High coping appraisal," group whereas households with worse perceived consequences of flooding tend to show "Only low self-efficacy." Coping information, income, and risk information also show a positive

Table II. Models of Response Efficacy for Structural and Nonstructural Measures in France

	Structural Measures		Nonstructural Measures	
Explanatory Variable	Socioeconomic	Complete	Socioeconomic	Complete
Education	0.05	0.05	0.10	0.09
Household members	0.05	−0.01	−0.05	−0.05
Age	−0.01	−0.01*	−0.0004	−0.005
Ownership	−0.17	−0.08	−0.43	−0.31
Female	0.04	0.04	0.34*	0.33
Income	0.07	0.0002	0.08	0.02
Perceived consequences	*n.a.*	−0.11	*n.a.*	−0.23*
Perceived flood risk	*n.a.*	−0.04	*n.a.*	−0.06
Feeling protected	*n.a.*	0.15	*n.a.*	−0.02
Public defenses	*n.a.*	0.31*	*n.a.*	0.19
Past flood damage	*n.a.*	−0.003	*n.a.*	−0.003
Low degree of fatalism	*n.a.*	0.25*	*n.a.*	0.24**
Risk aversion	*n.a.*	0.17	*n.a.*	0.37**
Risk information	*n.a.*	−0.14	*n.a.*	−0.10
Coping information	*n.a.*	−0.13	*n.a.*	−0.01
Social environment	*n.a.*	0.52*	*n.a.*	1.01**
Nagelkerke R^2	0.02	0.12	0.03	0.15
N	582	545	556	521

*$p < 0.05$, **$p < 0.01$.

Table III. Models of Self-Efficacy for Structural and Nonstructural Measures and Insurance Purchase in Germany

	Structural Measures		Nonstructural Measures		Insurance	
Explanatory Variable	Socioeconomic	Complete	Socioeconomic	Complete	Socioeconomic	Complete
Education	−0.051	−0.067	0.071	−0.046	0.253***	0.113
Household members	0.031	−0.233*	−0.051	0.048	0.008	−0.016
Age	0.004	−0.119	−0.087	−0.002	−0.226**	−0.228*
Ownership	0.985***	1.162***	−0.127	−0.609	0.144	0.362
Female	−0.255	0.005	−0.171	0.219	−0.243	−0.260
Income	0.671*	0.717	0.248**	0.376**	0.749**	1.315**
Perceived consequence	*n.a.*	−0.053	*n.a.*	−0.049	*n.a.*	0.147
Perceived probability	*n.a.*	−0.179	*n.a.*	0.020	*n.a.*	−0.484***
Unprotected area	*n.a.*	−0.147	*n.a.*	−0.393	*n.a.*	−0.414
Satisfaction with flood management	*n.a.*	−0.043	*n.a.*	0.014	*n.a.*	0.115
Past flood damage (ln)	*n.a.*	−0.005	*n.a.*	0.030	*n.a.*	−0.033
Fatalism	*n.a.*	−0.057	*n.a.*	0.135	*n.a.*	−0.047
Avoidance	*n.a.*	−0.027	*n.a.*	−0.125	*n.a.*	−0.243*
Postponement	*n.a.*	−0.170	*n.a.*	0.168	*n.a.*	−0.024
Risk information	*n.a.*	0.110	*n.a.*	0.310	*n.a.*	0.716*
Coping information	*n.a.*	−0.015	*n.a.*	0.200	*n.a.*	0.157
Social environment	*n.a.*	0.284**	*n.a.*	0.427***	*n.a.*	0.357**
Nagelkerke R^2	0.106	0.161	0.046	0.138	0.132	0.274
N	457	275	482	281	455	267

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

relation to the "High coping appraisal" group, although the significance is relatively low. The same applies for being female and the likelihood of belonging to the "Only low self-efficacy" group. Again, here the significance is low but the tendency is obvious. The French data display a very similar picture (Fig. 2(b)). The plot indicates that homeownership, income, and coping information have a positive influence on the "High coping appraisal" group. Being female again has a positive—in this case more significant—effect on the "Only low self-efficacy" group. Contrary to the German data, the social

Table IV. Models of Self-Efficacy for Structural and Nonstructural Measures in France

	Structural Measures		Nonstructural Measures	
Explanatory Variable	Socioeconomic	Complete	Socioeconomic	Complete
Education	−0.13*	−0.13*	−0.04	−0.10
Household members	0.11	0.12	0.03	0.05
Age	−0.01*	−0.01*	−0.03**	−0.03**
Ownership	0.31	0.24	0.18	0.15
Female	−0.39**	−0.31*	−0.30	−0.20
Income	0.12*	0.11	0.17	0.17
Perceived consequences	*n.a.*	0.002	*n.a.*	−0.09
Perceived flood risk	*n.a.*	−0.38**	*n.a.*	0.18
Feeling protected	*n.a.*	0.34**	*n.a.*	0.11
Public defenses	*n.a.*	−0.027	*n.a.*	0.16
Past flood damage	*n.a.*	0.001	*n.a.*	−0.003
Low degree of fatalism	*n.a.*	0.0005	*n.a.*	0.08
Risk aversion	*n.a.*	0.17*	*n.a.*	0.20*
Risk information	*n.a.*	0.11	*n.a.*	0.13
Coping information	*n.a.*	0.52**	*n.a.*	0.31
Social environment	*n.a.*	−0.09	*n.a.*	0.65**
Nagelkerke R^2	0.06	0.13	0.09	0.15
N	666	615	613	572

*$p < 0.05$, **$p < 0.01$.

Table V. Models of Response Cost for Structural and Nonstructural Measures and Insurance Purchase in Germany

	Structural Measures		Nonstructural Measures		Insurance	
Explanatory Variable	Socioeconomic	Complete	Socioeconomic	Complete	Socioeconomic	Complete
Education	−0.127*	−0.108	0.015	0.027	−0.012	−0.037
Household members	−0.020	−0.121	−0.012	−0.094	−0.056	−0.115
Age	0.094	0.228*	0.038	0.061	−0.163*	−0.216*
Ownership	−0.005	0.142	−0.057	0.278	−0.254	0.022
Female	−0.241	−0.068	−0.316	−0.051	−0.544**	−0.593*
Income	0.364	0.648	0.087	0.042	0.212	0.134
Perceived consequence	*n.a.*	−0.276*	*n.a.*	−0.358***	*n.a.*	−0.182
Perceived probability	*n.a.*	−0.089	*n.a.*	0.072	*n.a.*	−0.321*
Unprotected area	*n.a.*	0.301	*n.a.*	0.209	*n.a.*	0.052
Satisfaction with flood management	*n.a.*	0.131	*n.a.*	0.227	*n.a.*	0.135
Past flood damage (ln)	*n.a.*	−0.022	*n.a.*	−0.032	*n.a.*	−0.028
Fatalism	*n.a.*	−0.242*	*n.a.*	0.013	*n.a.*	−0.002
Avoidance	*n.a.*	0.017	*n.a.*	0.079	*n.a.*	0.001
Postponement	*n.a.*	−0.078	*n.a.*	−0.089	*n.a.*	−0.033
Risk information	*n.a.*	−0.115	*n.a.*	−0.262	*n.a.*	−0.251
Coping information	*n.a.*	−0.014	*n.a.*	0.472	*n.a.*	−0.051
Social environment	*n.a.*	0.085	*n.a.*	0.168	*n.a.*	0.154
Nagelkerke R^2	0.021	0.107	0.016	0.111	0.048	0.178
N	456	267	475	278	437	254

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

environment is not significant and therefore shows no influence on the grouping.

As far as nonstructural measures are concerned (Figs. 2(c) and 2(d)), again very similar patterns are found for the two countries, although the plots differ in their visual appearance. Social environment is significant and shows a positive relation to the group "Only high response cost" in both Germany and France. Besides this, certain other explanatory variables reveal similar trends. High damage incurred in the past, for example, seems to influence the affiliation to "High coping appraisal" positively.

Table VI. Models of Response Cost for Structural and Nonstructural Measures in France

	Structural Measures		Nonstructural Measures	
Explanatory Variable	Socioeconomic	Complete	Socioeconomic	Complete
Education	0.05	0.08	−0.04	−0.06
Household members	0.01	−0.02	0.03	0.02
Age	−0.01*	−0.01*	−0.03**	0.008
Ownership	0.78**	0.79**	0.18	0.59**
Female	−0.07	−0.07	−0.30	−0.13
Income	−0.19**	−0.18**	−0.17**	−0.22**
Perceived consequences	*n.a.*	0.19*	*n.a.*	0.23*
Perceived flood risk	*n.a.*	0.18	*n.a.*	−0.20
Feeling protected	*n.a.*	−0.33**	*n.a.*	−0.09
Public defenses	*n.a.*	−0.12	*n.a.*	−0.07
Past flood damage	*n.a.*	0.001	*n.a.*	0.004*
Low degree of fatalism	*n.a.*	0.02	*n.a.*	0.05
Risk aversion	*n.a.*	−0.02	*n.a.*	−0.15
Risk information	*n.a.*	−0.24	*n.a.*	−0.33
Coping information	*n.a.*	−0.03	*n.a.*	0.26
Social environment	*n.a.*	−0.004	*n.a.*	−0.58*
Nagelkerke R^2	0.04	0.15	0.09	0.13
N	604	564	613	534

*$p < 0.05$, **$p < 0.01$.

Also, higher education and income levels show a positive connection to the "Only high response cost" group and therefore a negative connection to "High motivation." The positive connection between owners and "High coping appraisal" could only be found within the French data (Fig. 2(d)). In Germany, on the other hand, worse perceived consequences of flooding seem to result in a higher coping appraisal regarding structural measures.

For insurance, which was only elicited for the German sample, Fig. 2(e) shows that the social environment, income, and education all positively relate to the groups "High coping appraisal" and "Only high response cost." It could be argued that high perceived consequences also lead to a higher motivation. On the contrary, being female, incurring past flood damage, and, especially, perceiving greater flood risks relate to the group showing "Only low response cost."

4. DISCUSSION

Below, the results of Section 3 are discussed in relation to the hypotheses formulated in Section 2.2.

H1: Our results confirm that several intrapersonal characteristics relate to flood-coping appraisals, partly confirming H1. With 16 out of 30 possible instances, age is the intrapersonal variable that contributes most often to all models (socioeconomic [= 9 times] and complete models [= 7 times]). Effects on flood-coping appraisals are mixed, though. While we find negative relations with response efficacy, it is positive in terms of response cost (i.e., older people perceive these measures as less costly) in the French sample and for insurance in Germany. Contrary to this, older adults in Germany consider structural measures as more costly. Regarding self-efficacy, results differ between the two samples, with positive signs in Germany and negative ones in France. While these results confirm that age significantly relates to flood-coping appraisals as stated in our hypothesis, a general direction of that influence could not be established. In addition, concerning the grouping analysis, age was not significantly related to different groups.

In addition to age, we find that especially income relates to flood-coping appraisals, significantly contributing to 11 out of 30 models (socioeconomic [= 7 times] and complete models [= 4 times]). In line with our hypothesis, people with lower income tend to have lower coping appraisals, particularly in terms of self-efficacy. Lower income relates negatively to SE for several measures in both samples. Lower-income groups also consider structural and nonstructural measures as more costly in the French

Table VII. Groups Showing Very Similar Coping Appraisal Ratings across Different Mitigation Measures

Group	Group Definition Determined by Coping Appraisal Ratings	Str. (DE)[a]	Str. (FR)[b]	N-Str. (DE)[c]	N-Str. (FR)[d]	Ins. (DE)[e]
High coping appraisal	Households indicating a high response efficacy, high self-efficacy, and low response cost	97 (35.8%)	226 (42.2%)	103 (35.9%)	265 (51.2%)	48 (18.9%)
Low coping appraisal	Households indicating a low response efficacy, low self-efficacy, and high response cost					45 (17.7%)
Only low self-efficacy	Households indicating a high response efficacy but low self-efficacy, and low response costs	110 (40.6%)	184 (34.3%)			
Only high response cost	Households indicating a high response efficacy, high self-efficacy, but high response costs			166 (57.8%)	134 (25.9%)	58 (22.8%)
Only low response cost	Households indicating a low response efficacy, low self-efficacy, but low response costs					46(18.1%)
Mixed	Households indicating a combination of response efficacy, self-efficacy, and response cost that occur in a low number of cases and cannot be reasonably categorized; these respondents were therefore excluded from the PCA plots	64 (23.6%)	126 (23.5%)	18 (6.3%)	119 (23.0%)	57 (22.4%)

[a]Structural measure (Germany).
[b]Structural measure (France).
[c]Nonstructural measure (Germany).
[d]Nonstructural measure (France).
[e]Insurance (Germany).

sample (Tables III–VI). The grouping analysis also shows that income relates positively to the "High coping appraisal" groups with regard to structural measures and insurance in Germany (Figs. 2(a)–2(e)). These findings, which are in line with Babcicky and Seebauer,[39] who find that self-efficacy is lower for lower-income groups, indicate that financial support may be needed to overcome the negative influence of low income on coping appraisals. To enable low-income households to invest in flood risk mitigation measures, income support could be provided in the form of subsidies or low-interest loans to help these households pay for the often high upfront investment costs of implementing flood-proofing measures. To address the issue of affordability, also the distribution of insurance vouchers has been discussed.[66] Contrary results are reported by Ge *et al.*[67] for a sample of 599 households in Florida, who found that income was not significantly related to respondents' expectations of participating in a mitigation assistance program.

Mixed results are found for education, which contributes to five out of 30 possible models (socioeconomic [= 3 times] and complete models [= 2 times]). It relates positively to the SE of buying flood insurance, which is in line with Atreya *et al.*,[68] but negatively to implementing structural measures in France. Further, the grouping analysis indicates that education is positively related to high response costs of nonstructural measures, both in Germany and France. Our hypothesis that education relates positively to flood-coping appraisals is thus hardly confirmed, given the mixed effects and the small number of models to which it significantly contributes.

Significant gender differences are detected in five out of 30 models (socioeconomic [= 3 times] and complete models [= 2 times]), partly confirming our hypothesis. In the French sample, for instance, women feel less able (= SE) to implement structural and nonstructural measures. These findings are generally in line with Babcicky and Seebauer,[39] who also find that self-efficacy is lower for women. As far as insurance purchase is concerned, we find a different result. In our case, women rate the costs of insurance considerably lower than men, as indicated by comparably large effect sizes. The grouping

analysis also shows that gender has a significant influence as far as structural measures and purchasing insurance are concerned (Figs. 2(b) and 2(e)). These findings are generally in line with Babcicky and Seebauer,[39] who find that self-efficacy is lower for women and low-income groups.

Overall, it has to be noted that almost all socioeconomic models have a very low explanatory power across almost all types of measures and both countries (Tables I–VI). The only socioeconomic models that have a somewhat higher explanatory power are the ones predicting self-efficacy regarding structural measures and insurance in Germany (Table III). The low explanatory power of socioeconomic results is in line with findings indicating that socioeconomic characteristics are only weakly related to flood and also earthquake mitigation behavior.[1,2,69]

> **H2**: The hypothesis that flood experience positively relates to flood-coping appraisals is generally not confirmed by our results. The experience of flood damage in the past significantly contributes to only one out of 15 possible complete models, that is, RC of structural measures in the French sample. The same is found in the group analysis. The weak influence of flood experience on flood-coping appraisals in our study could be explained by the way in which this variable was operationalized. Demuth *at al.*[47] measure hurricane experience in several different ways, such as through property losses, emotional impact, or evacuation experience, and examine the relations of each variable with SE and RE. In line with our study, no significant effect is found for SE and a negative influence for RE is found, if experience is operationalized in terms of property damage. However, if operationalized in terms of evacuation experience, a positive relation with SE and RE is indeed found. This is explained by the fact that prior evacuation experience provides specific knowledge about this action and its utility and thus raises SE and RE.

Risk perception, that is, the perceived consequences and perceived probability (or risk, in the case of France) of a threat, makes a significant contribution to 10 out of 15 complete models, initially confirming our hypothesis. Mixed results are found for the effects of risk perceptions on coping appraisals. In terms of RE, the perceived probability in the German sample relates negatively only to the purchase of flood insurance. This could be explained by the risk-based premiums and the setup of the German insurance system, which previously denied cover to households in high-risk areas.[56] The same argument holds true for the negative influence of perceived probability on SE and RC regarding insurance (Tables III–VI).

In contrast, people who expect greater negative consequences of a flood indicate a higher RE for insurance. An analysis of the mean and median values of response efficacy ratings across the three measures, moreover, shows that insurance is generally considered less effective (mean = 2.64; median = 3.0) compared to structural (mean = 3.09; median = 4.0) and nonstructural measures (mean = 3.52; median = 4.0). This can be explained by the fact that insurance does not protect lives or property from being damaged and is not useful for any other purposes. Instead, it merely protects the financial replacement value of the property that may have been damaged or destroyed by a flood.[38]

For the French sample, perceived consequences relate negatively to the RE of nonstructural measures. Inconclusive results are found between the two samples regarding the relation between perceived consequences and RC. While German respondents who believe in greater consequences of future flood events consider structural and nonstructural measures to be less costly, the opposite is indicated for the French sample. This could possibly result from the different time periods in which the flood events occurred, where the flooding was more recent in France. More recent negative experiences with high levels of flood damage and greater perceived future consequences may imply that individuals expect that substantial mitigation efforts will be needed to limit future flood damage to their homes, which would trigger high RC. For instance, Bin and Landry [44] find that individual flood risk perceptions are high right after a flood has occurred, but decline steadily after a flood event. The difference between the two samples could also stem from differences in flood types. In the French sample, some of the households experienced a coastal flood, which is more destructive.[70] This could again imply that respondents feel that substantial mitigation efforts will be needed to limit future flood damage, triggering high RC. These findings are generally also further supported by the grouping analysis. For flood insurance, for instance, a higher perceived probability and past flood damage strongly relate

to low coping appraisals, in this case "Only low response cost" (Fig. 2(e)). This is again related to the aforementioned difficulty for households in high-risk areas to obtain insurance in Germany.

The overall rather weak influence of risk perceptions on coping appraisals is in line with findings indicating that high risk perceptions do not necessarily lead to risk-reducing behavior.[2,71]

H3: Hypothesis 3, stating that fatalism, postponement, and low risk aversion are important personality characteristics that are related with lower coping appraisals is partly confirmed. Nonprotective responses, such as fatalism, avoidance, and postponement, make a significant contribution to only four models out of 15 complete models, all in the expected direction (except for fatalism in the model depicting response cost of structural measures in Germany). For instance, French respondents with a low degree of fatalism indicate a higher SE for structural and nonstructural measures.

Also, risk aversion is a significant variable in three out of six complete models. It has to be noted, though, that this variable was only elicited in the French survey. In all models, it contributes in the expected way and in line with expected utility theory:[50] people with a higher risk aversion indicate a higher level of response and self-efficacy.

H4: Hypothesis 4, stating that risk and coping information positively relates to coping appraisals, is partly confirmed. The two variables only contribute significantly to two out of 15 complete models. Risk information relates positively to the SE of insurance, and coping information relates positively to structural measures in France, indicating that people who received or sought for information on how they could protect themselves indeed reported a higher SE for these measure categories. Since both information provision and seeking for information were elicited in the same question in the French survey, the two different ways how information reached the respondent cannot be distinguished. Although we are not aware of other studies that examined the influence of coping information on changing flood-coping appraisals, a meta-analysis of PMT studies applied to health risk shows that communicating about coping variables can effectively change people's beliefs about coping measures.[15]

The group analysis reveals a low significant positive relation between risk and coping information and groups with higher coping appraisals concerning structural measures in Germany and France (Figs. 2(a) and 2(b)). These results indicate that coping information material can have a positive effect on coping appraisals, especially in terms of self-efficacy, but that this effect is rather modest.

H5: Hypothesis 5, stating that observational learning from the social environment has a positive influence on coping appraisals, is largely confirmed by our results. The social environment variable, which captures whether respondents perceive that friends, neighbors, and family members have taken mitigation measures, significantly contributes to 10 out of 15 complete models in the expected direction. Particularly strong relationships are found in terms of RE and SE and, to a lesser extent, also RC. In addition, the grouping analysis indicates a strong relation between the social environment and the "High coping appraisal" groups for structural measures and insurance in Germany (Figs. 2(a) and 2(e)). These findings are in line with the PMT and other framework as well as previous studies that demonstrated the influence of the social environment on an individual's protective behavior.[3,12,39,72,73] For most people, it can be difficult to evaluate the effectiveness, feasibility, and costs of a measure without prior flood experience and without actually installing the measure. For instance, it can be difficult for someone to tell how hard (or easy) it will be to claim damage from the insurance company or to deploy sandbags. The fact that one's neighbors have implemented a certain type of measure can thus provide an important cue in terms of its effectiveness, practicality, and expected cost–benefit relationship.[74,75]

5. CONCLUSION

Our results confirm other studies that also found that several socioeconomic characteristics are related to individual coping appraisals of flood

preparedness measures, although we find that the overall explanatory power of models that include only socioeconomic variables is weak. Significant relationships between coping appraisals and other intrapersonal characteristics have been found, such as with psychological characteristics like fatalism, postponement, avoidance, and risk aversion. These findings suggest that models that focus solely on socioeconomic characteristics to explain coping appraisals and related mitigation behavior are unlikely to have strong descriptive validity.

Our findings regarding the observed relationships between coping appraisals on the one hand and flood experience and risk perceptions on the other hand can have important implications for policies that aim to stimulate flood-proofing after flood events. In the aftermath of a flood disaster, there are often calls to "build back better" and there may be possibilities to reconstruct damaged properties in such a way that future flood damage is minimized. Risk perceptions are often assumed to be high after a flood and one may expect that a high threat appraisal will result in a high degree of willingness on the part of households to flood-proof their home. However, we find that flood experience and high risk perceptions may not go hand in hand with higher coping appraisals, and that, in contrast, these variables may even have negative relations to coping appraisals. This highlights the need for policies targeted at improving individual coping appraisals following flood events in order to encourage flood-proof rebuilding.

Communication policies can be an effective way to improve individual coping appraisals. We find that risk and coping information contributes to a greater motivation to implement structural measures or to buy insurance. These findings suggest that effective information provision should focus on both creating risk awareness and providing information on coping measures. Still, risk and coping information is found to make a significant contribution in only a few models. A significantly larger influence than information provision is found for the social environment variable, which takes into account whether respondents perceive that friends and neighbors implement flood risk mitigation measures. This suggests that social norms and networks play an important role in flood-preparedness decisions.

One fruitful avenue for future research could be to investigate how the effect of information campaigns on flood risk and coping options can be enhanced by making use of observed social norms and network effects. Moreover, future research can examine whether or not our findings about the determinants of coping appraisal are applicable to other regions. Although we observe several consistent patterns in our French and German case studies, we also find inconsistent results between the two case studies, as could be expected. These differences could also result from the fact that several items were measured in a slightly different way.

A possible limitation of the present study relates to the consideration of the objective risk, which could also be an important determinant of coping appraisals. This is indicated by our results showing that respondents who live in an unprotected area rate the response efficacy of insurance as lower or exhibit a higher degree of SE in terms of structural measures in France. While we accounted for differences in objective risk by including a variable in the regression models that indicated whether or not respondents think or feel that they live in an area that is protected by structural flood defenses, this is only a rather rough indication of the objective risk. Further insights into the relationship between objective risk and coping appraisals could be gained in future studies by including a more detailed differentiation in terms of the objective risk, for example, due to distance from the river, housing type, or elevation.

Given the substantial research efforts that have been devoted to analyzing flood risk perceptions around the world, we believe that coping appraisals have received insufficient attention. This is remarkable, given the large influence coping appraisals have on flood-preparedness behavior. We hope that our study provides a useful starting point for similar studies in other countries.

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REFERENCES

1. Grothmann T, Reusswig F. People at risk of flooding: Why some residents take precautionary action while others do not. Natural Hazards, 2006; 38(1–2):101–120.
2. Bubeck P, Botzen WJW, Aerts JCJH. A review of risk perceptions and other factors that influence flood mitigation behavior. Risk Analysis, 2012; 32(9):1481–1495.
3. Bubeck P, Botzen WJW, Kreibich H, Aerts JCJH. Detailed insights into the influence of flood-coping appraisals on mitigation behaviour. Global Environmental Change, 2013; 23(5):1327–1338
4. Koerth J, Vafeidis AT, Hinkel J, Sterr H. What motivates coastal households to adapt pro-actively to sea-level rise and increasing flood risk? Regional Environmental Change, 2013; 13(4):897–909.
5. Poussin JK, Botzen WJW, Aerts JCJH. Factors of influence on flood damage mitigation behaviour by households. Environmental Science & Policy, 2014; 40:69–77.
6. Bockarjova M, Steg L. Can protection motivation theory predict pro-environmental behavior? Explaining the adoption of electric vehicles in the Netherlands. Global Environmental Change, 2014; 28:276–288.
7. van Duinen R, Filatova T, Geurts P, van der Veen A. Coping with drought risk: Empirical analysis of farmers' drought adaptation in the south-west Netherlands. Regional Environmental Change, 2015; 15(6):1081–1093.
8. Zheng Y, Dallimer M. What motivates rural households to adapt to climate change? Climate and Development, 2016; 8(2):110–121.
9. Gebrehiwot T, van der Veen A. Farmers prone to drought risk: Why some farmers undertake farm-level risk-reduction measures while others not? Environmental Management, 2015; 55(3):588–602.
10. Eriksson L. The importance of threat, strategy, and resource appraisals for long-term proactive risk management among forest owners in Sweden. Journal of Risk Research, 2017; 20(7):868–886.
11. Keshavarz M, Karami E. Farmers′ pro-environmental behavior under drought: Application of protection motivation theory. Journal of Arid Environments, 2016; 127:128–136.
12. Haer T, Botzen WJW, Aerts JCJH. The effectiveness of flood risk communication strategies and the influence of social networks—Insights from an agent-based model. Environmental Science & Policy, 2016; 60:44–52.
13. Rogers RW. A protection motivation theory of fear appeals and attitude change. Journal of Psychology, 1975; 91(1):93–114.
14. Floyd DL, Prentice-Dunn S, Rogers RW. A meta-analysis of research on protection motivation theory. Journal of Applied Social Psychology, 2000; 30(2):407–429.
15. Milne S, Sheeran P, Orbell S. Prediction and intervention in health-related behavior: A meta-analytic review of protection motivation theory. Journal of Applied Social Psychology, 2000; 30(1):106–143.
16. UNISDR. Making development sustainable: The future of disaster risk management. Global assessment report on disaster risk reduction. Geneva, Switzerland: United Nations Office for Disaster Risk Reduction (UNISDR), 2015.
17. Bubeck P, Kreibich H, Penning-Rowsell E, Botzen WJW, de Moel H, Klijn F. Explaining differences in flood management approaches in Europe and the USA—A comparative analysis. Journal of Flood Risk Management, 2015; Available at: https://doi.org/10.1111/jfr3.12151.
18. Kreibich H, Bubeck P, Vliet M, Moel H. A review of damage-reducing measures to manage fluvial flood risks in a changing climate. Mitigation and Adaptation Strategies for Global Change, 2015; 20(6):967–989.
19. Rogers RW, Prentice-Dunn S. Protection motivation theory. Pp. 113–132 in Gochman DS (ed). Handbook of Health Behavior Research I. Personal and Social Determinants. New York: Pleanum Press, 1997.
20. Maddux JE, Rogers RW. Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. Journal of Experimental Social Psychology, 1983; 19(5):469–479.
21. Festinger L. A Theory of Cognitive Dissonance. Stanford, CA: Stanford University Press, 1957.
22. Rogers RW. Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. Pp. 153–177 in Cacioppo JT, Petty R (eds). Social Psychophysiology: A Sourcebook. Guilford, 1983.
23. Cutter SL, Finch C. Temporal and spatial changes in social vulnerability to natural hazards. Proceedings of the National Academy of Sciences, 2008; 105(7):2301–2306.
24. Montgomery MC, Chakraborty J. Assessing the environmental justice consequences of flood risk: A case study in Miami, Florida. Environmental Research Letters, 2015; 10(9):095010.
25. Koks E, Jongman B, Husby T, Botzen WJW. Combining hazard, exposure and social vulnerability to provide lessons for flood risk management. Environmental Science & Policy, 2015; 47:42–52.
26. Slovic PE. Perception of risk. Science. 1987; 236(4799):280–285.
27. Slovic PE. The Perception of Risk. New York: Earthscan Publications, 2000.
28. Douglas M, Wildavsky A. Risk and Culture: An Essay on the Selection of Technological and Environmental Dangers. Berkeley, CA: University of California Press, 1983.
29. Lindell MK. Perceived characteristics of environmental hazards. International Journal of Mass Emergencies and Disasters, 1994; 12(3):303–326.
30. Mileti DS, Darlington JD. The role of searching in shaping reactions to earthquake risk information. Social Problems, 1997; 44(1):89–103.
31. Siegrist M, Gutscher H. Flooding risks: A comparison of lay people's perceptions and expert's assessments in Switzerland. Risk Analysis, 2006; 26(4):971–979.
32. Botzen WJW, Aerts JCJH, Van Den Bergh JCJM. Dependence of flood risk perceptions on socioeconomic and objective risk factors. Water Resources Research, 2009; 45(10): W10440.
33. Kellens W, Zaalberg R, Neutens T, Vanneuville W, De Maeyer P. An analysis of the public perception of flood risk on the Belgian coast. Risk Analysis, 2011; 31(7):1055–1068.
34. Kellens W, Terpstra T, De Maeyer P. Perception and communication of flood risks: A systematic review of empirical research. Risk Analysis, 2013; 33(1):24–49.
35. Bosschaart A, Kuiper W, van der Schee J, Schoonenboom J. The role of knowledge in students' flood-risk perception. Natural Hazards, 2013; 69(3):1661–1680.
36. Lo AY. The role of social norms in climate adaptation: Mediating risk perception and flood insurance purchase. Global Environmental Change, 2013; 23(5):1249–1257.
37. Botzen WW, Kunreuther H, Michel-Kerjan E. Divergence between individual perceptions and objective indicators of tail risks: Evidence from floodplain residents in New York City. Judgment and Decision Making, 2015; 10(4):365–385.
38. Lindell MK, Arlikatti S, Prater CS. Why people do what they do to protect against earthquake risk: Perceptions of hazard adjustment attributes. Risk Analysis, 2009; 29(8):1072–1088.
39. Babcicky P, Seebauer S. The two faces of social capital in private flood mitigation: Opposing effects on risk perception, self-efficacy and coping capacity. Journal of Risk Research, 2017; 20(8):1017–1037.

40. Adger N. Vulnerability. Global Environmental Change, 2008; 16(3):268–281.
41. Phillips BD, Morrow BH. Social science research needs: Focus on vulnerable populations, forecasting, and warnings. Natural Hazards Review, 2007; 8(3):61–68.
42. Thomas DSK, Philips BD, Lovekamp WE, Fothergill A. Social Vulnerability to Disasters. London and New York: CRC Press, Taylor and Francis Group, 2013.
43. Lazrus H, Morrow BH, Morss RE, Lazo JK. Vulnerability beyond stereotypes: Context and agency in hurricane risk communication. Weather, Climate, and Society, 2012; 4(2):103–109.
44. Bin O, Landry CE. Changes in implicit flood risk premiums: Empirical evidence from the housing market. Journal of Environmental Economics and Management, 2013; 65(3):361–376.
45. Terpstra T, Lindell MK. Citizens' perceptions of flood hazard adjustments: An application of the Protective Action Decision Model. Environment and Behavior, 2013; 45:993–1018.
46. Norris FH, Smith T, Kaniasty K. Revisiting the experience–behavior hypothesis: The effects of Hurricane Hugo on hazard preparedness and other self-protective acts. Basic Applied Social Psychology, 1999; 21:37–47.
47. Demuth JL, Morss RE, Lazo JK, Trumbo C. The effects of past hurricane experiences on evacuation intentions through risk perception and efficacy beliefs: A mediation analysis. Weather, Climate, and Society, 2016; 8(4):327–344.
48. Rippetoe PA, Rogers RW. Effects of components of protection-motivation theory on adaptive and maladaptive coping with a health threat. Journal of Personality and Social Psychology, 1987; 52(3):596–604.
49. Steel P. The nature of procrastination: A meta-analytic and theoretical review of quintessential self-regulatory failure. Psychological Bulletin, 2007; 133(1):65–94.
50. Von Neumann J, Morgenstern O. Theory of Games and Economic Behavior (2nd rev. ed.). Princeton, NJ: Princeton University Press, 1947.
51. Kunreuther H. Disaster Insurance Protection: Public Policy Lessons. New York: John Wiley & Sons, 1978.
52. Mileti DS, Fitzpatrick C. The causal sequence of risk communication in the Parkfield Earthquake prediction experiment. Risk Analysis, 1992; 12:393–400.
53. Mileti DS, Darlington JD. The role of searching in shaping reactions to earthquake risk information. Social Problems, 1997; 44:89–103.
54. Bubeck P, Botzen WJW, Kreibich H, Aerts JCJH. Long-term development and effectiveness of private flood mitigation measures: An analysis for the German part of the river Rhine. Natural Hazards and Earth System Sciences, 2012; 12(11):3507–3518.
55. Thieken AH, Kienzler S, Kreibich H, Kuhlicke C, Kunz M, Mühr B, Müller M, Otto A, Petrow T, Pisi S, Schröter K. Review of the flood risk management system in Germany after the major flood in 2013. Ecology and Society, 2016; 21(2):51. Available at: http://doi.org/10.5751/ES-08547-210251.
56. Thieken AH, Petrow T, Kreibich H, Merz B. Insurability and mitigation of flood losses in private households in Germany. Risk Analysis, 2006; 26(2):383–395.
57. Poussin JK, Botzen WJW, Aerts JCJH. Stimulating flood damage mitigation through insurance: An assessment of the French CatNat system. Environmental Hazards, 2013; 12(3-4):258–277.
58. Van den Bergh R, Faure M. Compulsory insurance of loss to property caused by natural disasters: Competition or solidarity? World Competition, 2006; 29(1):25–54.
59. Poussin JK, Wouter Botzen WJW, Aerts JCJH. Effectiveness of flood damage mitigation measures: Empirical evidence from French flood disasters. Global Environmental Change, 2015; 31:74–84.
60. Chbab E. How extreme were the 1995 flood waves on the rivers Rhine and Meuse? Physics and Chemistry of the Earth, 1995; 20(5):455–458.
61. Wold S, Esbensen K, Geladi P. Principal component analysis. Chemometrics and Intelligent Laboratory Systems, 1987; 2(1–3):37–52.
62. Legendre P, Gallagher ED. Ecologically meaningful transformations for ordination of species data. Oecologia, 2001; 129(2):271–280.
63. Abdi H, Williams LJ. Principal component analysis. Wiley Interdisciplinary Reviews: Computational Statistics, 2010; 2(4):433–459.
64. Gaotlhobogwe M, Laugharne J, Durance I. The potential of multivariate analysis in assessing students' attitude to curriculum subjects. Educational Research, 2011; 53(1):65–83.
65. Oksanen J, Kindt R, Legendre P, O'Hara B, Simpson GL, Solymos P, Stevens MHH, Wagner H. The vegan Package, 2008. Available at: http://cran.r-project.org/, http://vegan.r-forge.r-project.org/.
66. Michel-Kerjan E, Kunreuther H. Redesigning flood insurance. Science, 2011; 333(6041):408–409.
67. Ge Y, Peacock WG, Lindell MK. Florida households' expected responses to hurricane hazard mitigation incentives. Risk Analysis, 2011; 31:1676–1691.
68. Atreya A, Ferreira S, Michel-Kerjan E. What drives households to buy flood insurance? New evidence from Georgia. Ecological Economics, 2015; 117:153–161.
69. Lindell MK, Perry RW. Household adjustment to earthquake hazard: A review of research. Environment and Behavior, 2000; 32(4):461–501.
70. Nadal NC, Zapata RE, Pagán I, López R, Agudelo J. Building damage due to riverine and coastal floods. Journal of Water Resources Planning and Management, 2009; 136(3):327–336.
71. Wachinger G, Renn O, Begg C, Kuhlicke C. The risk perception paradox—Implications for governance and communication of natural hazards. Risk Analysis, 2013; 33(6):1049–1065.
72. Lindell MK, Perry RW. The protective action decision model: Theoretical modifications and additional evidence. Risk Analysis, 2012; 32(4):616–632.
73. Brenkert-Smith H, Dickinson KL, Champ PA, Flores N. Social amplification of wildfire risk: The role of social interactions and information sources. Risk Analysis, 2013; 33(5):800–817.
74. Kunreuther H, Michel-Kerjan E. At War with the Weather: Managing Large-Scale Risks in a New Era of Catastrophes. Cambridge, MA: MIT Press, 2009.
75. Kunreuther H, Meyer R, Michel-Kerjan E. Strategies for better protection against catastrophic risks. Risk Management and Decision Processes Center, The Wharton School of the University of Pennsylvania, 2007.
76. de Boer J, Botzen WJW, Terpstra T. More than fear induction: Toward an understanding of people's motivation to be well-prepared for emergencies in flood-prone areas. Risk Analysis, 2015; 35(3):518–535.

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's website:

Table AI: Variable Definitions of the German Survey Analysis
Table AII: Variable Definitions of the French Survey Analysis
Table AIII: Intercorrelation Table for the German and French Samples
Fig. S1. Example of a PCA ordination plot with hypothetical data.