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Let's talk about flood risk – Evaluating a series of workshops on private flood protection

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ABSTRACT

Private flood protection measures can help reduce potential damage from flooding. Few intervention studies currently exist that systematically evaluate the effectiveness of risk communication methods. To address this gap, we evaluated a series of six workshops ($N = 115$) on private flood protection in flood-prone areas in Germany that covers different aspects of flood protection for individual households.

Applying mixed-model analysis, significant increases in self-efficacy, subjective knowledge, and protection motivation were observed. Younger participants, as well as participants who reported lower levels of previous knowledge or no flood experience, showed a higher increase in self-efficacy and knowledge. Results suggest that a workshop can be an effective risk communication tool, raising awareness and motivating behaviour among residents of flood-prone areas.

1. Introduction

Across the world, flooding causes serious health risks and strong monetary losses [43,45] [1]. Over the last two decades, various regions in Germany have been affected by flooding. The most damaging events took place around the rivers Elbe and Danube in 2002 and 2013, with 35 fatalities and combined costs of more than 20 billion Euros [44][2].

Flooding, like other natural hazards, is difficult to predict long in advance; precaution measures are therefore necessary. Recent years have seen big investments in structural flood defence, like flood embankments and retention basins [42]. Yet, full protection through solely structural flood defence strategies is often not possible, as cost-benefit considerations have to be taken into account [3,4]. This has led to the conclusion that integrative flood risk management approaches are needed which include all relevant stakeholders, such as spatial planners, regional authorities, and local residents [5]. Among others, an integrated approach demands that private households take greater responsibility for flood preparedness. In Germany, as of 2005 citizens in flood-prone areas are legally required to take up protection measures that are within the range of their personal capabilities [6].

Private households can increase their flood preparedness through different measures. On the one hand, people can take behavioural precautions, which includes actions that can be performed in everyday life to prepare for a possible flood and practical skills to adapt to an existing flood. On the other hand, property protection measures can be carried out. Property protection measures can be stationary or non-stationary, for example sheet pile walls, stop logs, non-return flaps, and pumps. The effectiveness of private flood protection measures has been confirmed by multiple studies (e.g. Ref. [7–10]). There is a massive potential for loss reduction through private protection measures, such as could be observed in the city of Cologne in the 1990s. After being severely stricken by a flood in 1993, just 13 months later a second flood of comparable strength emerged along the Rhine. The financial damages in 1995 were considerably smaller than those in 1993, which can be explained by the increased knowledge and preparedness of the residents and authorities [11,12]. See Wind et al. [13] for similar results from municipalities along the river Meuse.

1.1. Risk communication

Although households are legally required to take up protection measures, past studies show that even people at risk of experiencing flooding are not always ready to accept this responsibility nor are they properly informed about their personal flood risk [14–16]. Stakeholders

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with expertise in or knowledge about publicly relevant risks necessarily have the responsibility to convey the pertinent information to others [17]. Thus, risk communication tools need to be developed, implemented and evaluated in order to make residents of flood-prone areas aware of flood risk and acquaint them with flood protection measures.

The communication of risks has been a much discussed topic of research in psychology, sociology and other disciplines for decades [18–22]. Risk communication messages should include information on the specific risk and expected consequences and promote adequate protective behaviour [17]. Covello [19] defines risk communication as a two-way exchange of information, which highlights the importance of a feedback loop between all actors of the risk communication process. In current research there is a call for tailored (or custom-made) risk communication methods in order to heed the heterogeneity of people at risk [17,23]. Frequently used risk communication methods in the field of natural hazards and especially flooding are brochures, apps, flyers, and online materials such as interactive maps, which represent a rather top-down transfer of information from the experts to laypeople. A workshop on the other hand is a method which allows two-way communication between the parties.

Evaluating risk communication tools is crucial in understanding their role in flood risk management as well as identifying areas for improvement. While a considerable number of flood risk communication programmes exist, very few studies have systematically evaluated the effectiveness of different communication tools. To address this issue, we developed and evaluated a series of workshops on private flood protection. This specific risk communication tool aims to convey practical information on household-level flood protection measures and thus empower private individuals to take action. Here, we investigate whether the workshop increased people's self-efficacy and motivation to carry out protective action.

1.2. Intervention studies on private flood protection

In recent years natural hazards research has produced a body of enlightening insights on risk perception and risk communication. However, these findings are mostly based on correlational survey data or (expert) interviews. Experimental or quasi-experimental intervention programmes targeting people's flood risk awareness and their protection behaviour are scarce. Similarly, little research has evaluated the effectiveness of specific risk communication tools such as workshops to foster flood-protective behaviour.

As an example, Terpstra et al. [24] evaluated the effects of a small-scale flood risk communication programme in the Netherlands. The researchers applied a quasi-experimental pretest-posttest design, including two types of treatment (workshop, $n = 24$; focus group, $n = 16$) as well as a control group ($n = 40$). The first treatment (workshops) involved a series of activities that gave participants direct experience with flood risk management, including physical encounters with flood protection infrastructure (e.g., visiting dike reinforcements or pumping stations), conceptual experiences (e.g. playing board games on land use planning), and face-to-face communication with stakeholders (e.g. discussions with flood risk experts). The second treatment involved two focus group discussions (participants: local inhabitants) addressing several aspects of flood risk management. All participants were surveyed before and immediately after the treatment, answering questions on flood risk perceptions, negative affect, knowledge about their own risk of experiencing flooding, their ability to control exposure to flooding, trust in local authorities, and local flood protection infrastructure. Results showed small to moderate changes in some of the variables surveyed. Most importantly, the interventions did not influence respondents' flood risk perception or their negative flood-related emotions (e.g. fear of flooding). However, the workshop treatment (vs. control group) increased people's control perceptions regarding flooding but decreased their trust in local authorities. Furthermore, both treatments led to greater confidence in participants' knowledge of flood risk management. Results thus did not provide support for a consistent change of risk perceptions.

Bosschaart et al. [25] reported the results of a flood risk educational program conducted in the Netherlands (quasi-experimental design, treatment and control groups, $n = 229$). The programme aimed at fostering adolescents' flood risk perceptions and preparedness intentions. It consisted of seven lessons (50 min each) and included a variety of learning activities such as communication of flood risk information, 3D serious games, 2D flood simulations, fieldwork, and group discussions. Respondents (intervention group: $n = 154$, control group: $n = 75$) answered questions on several flood-related constructs before and after the intervention phase (flood exposure, flood consequences, fear, trust in public flood protection, prepared intentions, self-efficacy). Results showed that the intervention had a small to medium-sized positive effect on perceived flood exposure and a small positive effect on self-efficacy, but no effect on students' intention to take up protective measures.

In sum, the findings of the two intervention studies provide tentative support for the effectiveness of flood risk communication programmes, indicating that such programmes may increase participants' flood risk perceptions as well as their efficacy beliefs to protect them from the effects of flooding. For behavioural measures, however, the results were less promising, suggesting that the intervention effects (e.g. on self-efficacy) were too small to affect preparedness intentions. Thus, further research is needed to clarify the feasibility of communication strategies in fostering the adoption of protective behaviour.

1.3. Self-efficacy as a key predictor of flood protection behaviour

As outlined above, integrative flood risk management requires citizens to adopt private protection measures. In a recent meta-analysis, van Valkengoed and Steg [26] summarised factors linked to climate change adaptation behaviour. The study included data from 90 scientific articles with overall 106 independent samples. Most of the studies focussed on behaviour were linked to flooding and other hazards. The findings indicated that self-efficacy is one of the strongest factors predicting adaptive behaviour [26].

Albert Bandura [27,28] describes self-efficacy as the belief in one's capability to perform actions which lead to the desired effects. Meta-analytic evidence supports the positive effect of self-efficacy on different aspects of basic human functioning [29,30]. Self-efficacy is also a prominent factor in theoretical frameworks explaining flood-protective behaviour (see Kuhlicke et al. [31]); for a recent overview of psychological theories used in natural hazards research).

The predominant theory used in today's research for describing flood-protective behaviour is the Protection Motivation Theory (PMT). Rogers [32] originally formulated PMT as a fear appeal theory to explain health-related behaviour such as weight loss or nicotine withdrawal [33,34]. The PMT describes two paths which can lead to protection motivation: threat appraisal and coping appraisal. Threat appraisal can be separated into severity and vulnerability; both are linked to negative affect (fear). Coping appraisal is explained by self-efficacy, response-efficacy, and response costs.

A recent meta-analysis on flood-protective behaviour showed the feasibility of the PMT for explaining people's motivation to protect themselves against flooding [35]. Using data from 35 studies consisting of a total of 47 independent samples, the authors found a positive impact of both coping appraisal ($r+ = 0.30$) and threat appraisal ($r+ = 0.23$) on flood-protective behaviours or intentions.

In this study, we will focus on self-efficacy. The PMT offers a framework to explain people's motivation to adopt private protection measures and therefore serves as the basis of our intervention study.

1.4. Present research

We designed and evaluated a series of six workshops to communicate

different aspects of flood protection for private households. This risk communication tool aimed to increase the flood-related knowledge and efficacy beliefs of residents in flood-prone areas, and motivate them to actively prepare themselves for a potential flood. Applying a pretest-posttest design, our central research question was to investigate whether participation in our workshop leads to increased self-efficacy and protection motivation, but also knowledge about private flood protection (in short: flood knowledge).

The workshops were aimed at raising flood awareness among residents of flood-prone areas and empowering them to perform flood-protective behaviour. Building on the PMT, we focus on two core factors: people's self-efficacy in protecting themselves against flood damage as well as their protection motivation (i.e. intention to perform different protective behaviours). Bandura [27] names four different ways to increase self-efficacy: (1) performance accomplishments (i.e. personal mastery experiences); (2) vicarious experience (model learning, i.e. observing others' successful performance); (3) verbal persuasion; and (4) emotional arousal (e.g., through relaxation and emotional attribution). We focus on the aspect of vicarious experience and verbal persuasion. The participants were provided with information about different private flood protection measures (as well as the opportunity to try out some of the measures) and were given further advice on their successful implementation.

It has been shown that inhabitants of flood-prone areas are often not aware of their personal risk until they are personally affected by an actual flood [2]. Thus, inhabitants of a recently flood-stricken area are better informed than people more inexperienced on the topic. The programme is therefore created especially for people with little knowledge about private flood protection and little or no prior flood experience.

Taken together, we explore the following research questions:

1. Does participation in our workshop motivate people to protect themselves against flood damage by fostering self-efficacy and protection motivation?
2. Is our workshop more effective for people with little or no previous flood knowledge and experience?

The workshops were carried out in different settings, allowing us to explore the effectiveness of different strategies to approach residents of flood-prone areas. A second exploratory research aim touches upon possible spill-over effects of the workshop. We want to find out whether the workshop additionally motivates people to engage in community-based, i.e. collective flood protection activities.

2. Study area and research design

Between May and October 2017, six workshops were conducted in different locations in Germany. Two workshops took place in the city of Magdeburg, one each in the cities of Riesa, Eilenburg, Berlin, and Hamburg (see Fig. 1 and Table 1). Four workshops were set in towns and cities along the river Elbe (Magdeburg, Riesa and Hamburg) and one in the town of Eilenburg, which is located along the Elbe's tributary river Mulde. These municipalities had been affected by the floods in 2002 and 2013, except for Hamburg (workshop 5), which is prone to spring tides. Workshop 6 took part in Berlin, a city with comparably lower flood exposure.

2.1. Workshop setting and sample

Only a few studies have systematically evaluated the effectiveness of risk communication tools or education programmes on the topic of private flood protection. Thus, no recommendations for a suitable setting were available for this specific context. We decided to carry out the workshop in different types of settings, aiming to (1) increase the diversity of our total sample of respondents and (2) identify feasible entry points for risk communication tools supporting the adoption of private protection measures. Our choice of settings was influenced by conceptual as well as practical considerations (e.g. existing co-operations with local stakeholders).

Fig. 1. Workshop locations in Germany.

The aim of the workshop programme is to raise flood awareness among residents of flood-prone areas and to empower them to perform flood-protective behaviour. We thus recruited private residents of flood-prone areas as well as volunteers and professionals who are in contact with people at risk of being flooded, i.e. possible disseminators of flood risk communication.

Two workshops were conducted on local fairs with a focus on civil protection (workshops 1 and 4). Workshop 2 was carried out in a flood-prone urban neighbourhood, combined with a presentation on local structural protection measures. As this neighbourhood had been affected by a flood event in 2013, we expected people to be interested in information on private flood protection. Workshop 3 was conducted at a science night. Visitors of the science night had the opportunity to choose from a programme with plenty of options. We thus expected (mainly) highly interested people to participate in our workshop. Two specific flood events were organised in cooperation with an aid organisation (workshops 5 and 6). The people participating were voluntary members of an aid organisation who are often professionally interested in the topic of flood protection.

In total, 115 of the participants filled in at least one of the two questionnaires (M_{age} = 45.3 years; 30% female, 57% male, 13% no answer). Table 1 displays the distribution of the participants among the different workshop settings. Numbers are listed separately for the two questionnaires before (q1) and after the workshop (q2), because some people filled in just one of the questionnaires. The number of participants ranged from 5 to 50 people. The number of completed

Table 1
Number of questionnaires filled out during six different workshop occasions and demographic information on participants.

N°	Community	Type of setting	n_{q1}	n_{q2}	Average age[a]	Gender[a] %		Previous knowledge[a] %			Flood experience[a] %		Housing situation[a] %	
						f	m	little	average	high	yes	no	owner	tenant
1	Eilenburg	local fair	5	6	49.3	16.7	33.3	33.3	16.7	33.3	50.0	16.7	0.0	66.7
2	Magdeburg	info night in a flood-prone neighbourhood	37	30	65.2	23.7	55.3	7.7	10.3	76.9	87.2	2.6	71.8	17.9
3	Magdeburg	science night	23	24	36.9	29.2	66.7	16.7	41.7	37.5	70.8	25.0	58.3	37.5
4	Riesa	local fair	3	3	54.0	0.0	100.0	0.0	33.3	66.7	100.0	0.0	100.0	0.0
5	Hamburg	specific flood event with an aid	31	29	30.3	48.4	48.4	64.5	35.5	0.0	54.8	41.9	32.3	67.7
6	Berlin	organisation	12	12	39.0	16.7	75.0	58.3	25.0	16.7	33.3	66.7	16.2	83.3
Total			111	104	45.3	57.9	29.8	31.3	26.1	39.1	67.8	25.2	49.6	44.3

Note: Participants of workshops 1-4 were residents of flood-prone areas and interested citizens. Participants of workshops 5-6 were voluntary members of aid organisations.
[a] These variables were presented in q1 (before the workshop, see Table 3). Missing values were excluded.

questionnaires ranged from 3 to 37 (see Table 1). Among the participants were residents of flood-prone areas and interested citizens, as well as professional and voluntary members of aid organisations.

2.2. Procedure of the workshop

The workshop was conceptualised and implemented in cooperation with experts in the field of flood protection. Every workshop followed a similar structure, covered the same topics, and was carried out by an instruction team consisting of an external flood expert and a researcher.

The workshops addressed different aspects of private flood protection referring to two main topics: behavioural precautions and property protection (Table 2). Behavioural precautions include measures that can be taken in one's day-to-day actions in order to adapt to an existing flood risk and prepare for the next event. For example, an emergency kit containing non-perishable food, toiletries, and other articles was prepared together with the participants. The workshop addresses the essential contents of such an emergency kit, which can be used in case of a flood or potentially another emergency (e.g. a blackout). Aspects of health provision were discussed, including cold protection, the use of a chest wader, and the prevention of contaminant leakage. As a more collective protection measure, the concept of "flood godparenthood" was introduced, which invites participants to look after the elderly and sick in their neighbourhoods, especially in the event of flooding. Ways to search for private risk information were presented. The workshop participants were introduced to apps and regional webpages for individual risk-assessments or current water levels. Additionally, the "Hochwasserpass" (i.e. floodlabel; www.hochwasser-pass.com), a German flood risk assessment tool was discussed, which is recommended to homeowners in Germany by insurance companies (see Ref. [23] for a recent discussion on the floodlabel).

The topic of property protection (Table 2) included measures of household-level building precautions. Examples of flood protection measures for wet- and dry-proofing were explained, such as flood protection walls and white tanks. Additionally, stationary and non-stationary tools for property protection like sheet pile walls, stop logs, non-return flaps, and pumps were introduced. The instructors explained the contents using illustrative material and practical demonstrations throughout the workshop. Participants were invited to share their experiences and ask further questions.

Table 2
Structure and contents of the workshop.

N°	Theme category	Topics
1	Behavioural precaution	preparing an emergency box health provision flood godparenthood using apps and online material Hochwasserpass (German risk analysis tool)
2	Property protection	examples of built flood protection measures for wet- and dry-proofing tools for property protection (e.g. sheet pile walls, stop log, non-return flaps, pumps)

Each of the six workshops lasted from 30 to 45 min. The participants filled in a two-page questionnaire before (q1) and after the workshop (q2) following a pretest-posttest design. Distributing and filling out the questionnaires took approximately 5 min before and after the workshop.

2.3. Questionnaire design

In order to achieve a sufficient response rate, the number of items and questions were kept at a minimum. Questions pertaining to flood-related cognition and emotion (self-efficacy, protection motivation, fear, flood knowledge, community flood engagement) were presented at q1 and q2. Example items and scale reliabilities (Cronbach's alpha) are listed in Table 3. The questionnaire also included a number of items on previous knowledge, community flood engagement, threat appraisal, and flood experience, as well as questions on sociodemographic information, such as age, sex, and housing situation (q1). Finally, we asked the participants to evaluate the workshop using a rating scale and free text field for comments (q2). We did not include any knowledge questions on the workshop's contents.

2.4. Statistical analyses

For an initial overview of the data, descriptive analyses and bivariate correlations were calculated. Due to the nested data structure (i.e. data from six different locations), we used linear mixed models (LMM) to investigate changes in self-efficacy, flood knowledge, fear and protection motivation before (q1) and after the workshop (q2). We estimated fixed effects models with random intercepts for participant ID and workshop location to investigate the overall effects of the workshop on self-efficacy, flood knowledge, fear, and protection motivation. For calculation of degrees of freedom, the Satterthwaite method was used to account for differences in group sizes and variances. We also included previous knowledge, flood experience, and age group as moderator variables in the analysis.

3. Results

3.1. Descriptive results and correlation analyses

Before the workshop started, 31.3% of the participants reported little previous knowledge (scale values 1 and 2), 26.1% medium (scale value 3) and 39.1% high previous knowledge (scale values 4 and 5). About two-thirds of the participants (67.8%) had experienced a flood before; one-fourth had no such experience (25.2%). 49.6% of the participants were owners of the house or apartment they lived in and 44.3% were

Table 3
Measures and items.

Scales measured both before (q1) and after the workshop (q2)		α1	α2
Name	Items		
Flood knowledge	1. I am well informed about the flood risk of my neighbourhood. 2. In the event of an emerging flood I know where I can find information on current water levels, dike security, etc. 3. I know *(1) nothing at all – (5) a lot* about flooding.	.77	.62
Self-efficacy	1. I know how to protect myself and my property from a flood catastrophe. 2. I know property protection measures to protect my house from flooding. 3. I have confidence in my own ability to take precautionary measures against flood damage.	.75	.84
Protection motivation	How strongly do you intend to carry out the following actions within the next days? *(1) = no intention; (5) = strong intention; (99) = already done* 1. Putting together an emergency kit (food and bottled water for 2–3 days, toiletries and medicine, battery-powered radio, torch etc.) 2. Obtaining information on safe evacuation ways and evacuation spaces. 3. Discussing the allocation of responsibilities in the event of a flood with family members (household emergency plan) 4. Storing sandbags in the basement as a precaution. 5. Finding out if and to which extend I am insured against flood.	.80	.93
Fear	The thought of my town being affected by a flood again … 1. Makes me anxious. 2. Frightens me. 3. Worries me.	.92	.91
Single items presented before (q1) and/or after the workshop (q2)		q1	q2
Previous knowledge	How much did you know about flooding before this workshop? *(1) = nothing; (5) = very much*	X	–
Community flood engagement	Are you interested in engaging in flood protection together with fellow citizens of your city? *(1) = no, not interested at all; (5) = yes, strongly interested*	X	X
Threat appraisal	What do you think, how much is your neighbourhood at risk? *(1) = not at all at risk; (5) = strongly at risk*	X	–
Flood experience	Have you experienced a flood in the past? *(yes/no)*	X	–

Note: If not specified otherwise, all items were answered on a 5-point scale ranging from 1 = "does not apply at all" to 5 = "fully applies".

tenants.

Differences in the distribution of sociodemographic variables, the level of previous knowledge, flood experience and housing situation can be seen in Table 1. In workshop 2 (info night in a flood-prone quarter) the participants had the highest age mean, they were mostly house owners and they reported high levels of previous knowledge and flood experience. The participants of both specific flood events with an aid organisation (workshops 5 and 6) were younger. For most of them the topic of flood (protection) seemed of lower personal relevance: They reported a lower average level of previous knowledge and only between one third and half of the group had experienced a flood in the past. The science nights participants (workshop 2) were also younger than average, they reported a mostly medium or high level of previous knowledge and about three quarters stated to have experienced a flood before. The workshop participants at both local fairs (workshops 1 and 4) were older than the overall mean. Due to the small number of participants (less than 10 in total), interpretations on these two subgroups manifestations of sociodemographic background variables shall be made with care.

Bivariate correlations were calculated between flood cognition scales and the sociodemographic background variables (Table 4). Medium to strong bivariate correlations ($r = 0.408$ to .534) were observed amongst previous knowledge, threat appraisal, flood experience, and age. The flood-related cognition and emotion scales of self-efficacy, flood knowledge, fear, and protection motivation and additionally threat appraisal intercorrelated more strongly at q1 than at q2 (Table 4). The strongest significant correlations were between self-efficacy and flood knowledge ($r_{q1} = 0.613$, $p < .001$; $r_{q2} = 0.551$, $p < .001$). Protection motivation correlated on a low level with self-efficacy ($r_{q1} = 0.201$, $p < .005$; $r_{q2} = 0.159$, $p = .112$) and on a medium level with fear ($r_{q1} = 0.437$, $p < .001$; rq2 = 0.431, p < .001). The correlation between protection motivation and flood knowledge was small but increased after the workshop (rq1 = 0.161, p = .100; rq2 = 0.230, p < .005), being an exception in the group of PMT-based scales.

3.2. Effects of the workshop and group differences

In the next step, we calculated LMM and included previous knowledge, flood experience, and age group as covariates in the analysis. The results are displayed in Table 5.

The overall effect of the workshop (time) was significant for self-efficacy, $F(1; 88.699) = 54.549$, $p < .001$, part. $\eta^2 = 0.381$, flood knowledge, $F(1; 90.972) = 48.196$, $p < .001$, part. $\eta^2 = 0.346$, and protection motivation, $F(1; 80.519) = 17.699$, $p < .001$, part. $\eta^2 = 0.180$, indicating that participants reported higher levels of knowledge, efficacy and protection motivation after the workshop as compared to pre-workshop levels (Table 5). The level of fear did not increase throughout the workshop. In fact, it diminished from $M = 2.86$ ($SD = 1.46$, $N = 107$) to $M = 2.75$ ($SD = 1.35$, $N = 100$). This change was not significant, as a repeated-measures ANOVA shows, $F(1, 93) = 0.052$, $p = .821$. Participants showed a slightly higher level of interest in community flood engagement after the event ($M = 3.20$, $SD = 1.23$, $N = 108$) compared to before ($M = 3.14$; $SD = 1.26$, $N = 99$). However, the repeated-measures ANOVA revealed no significant effect, $F(1, 93) = 0.331$, $p = .566$, indicating that the difference was not statistically significant.

Next, we tested whether the effects of the workshop on our central outcomes were different as a function of participants' age, flood experience, and previous knowledge (moderator analysis). Means and standard deviations for different levels of previous knowledge, flood experience, and the participants' age group are displayed in Fig. 2.

Considering previous knowledge, we discovered differences between the three groups (little, $n = 34$; medium, $n = 27$, and large previous knowledge, $n = 35$) regarding their increase in self-efficacy and flood knowledge. As Fig. 2 shows, people with little previous knowledge had a higher increase in both self-efficacy and flood knowledge. Both the main effects of previous knowledge and the interaction effect with time were significant and the partial η^2 ranged from .068 to .217 (Table 5), which can be described as medium to high effect size [36]. Comparable tendencies were observed for flood experiences. Those with flood experience ($n = 69$) reported relatively high flood knowledge both before and after the workshop, but the participants without such experience ($n = 27$) showed a much steeper increase in the scale means (Fig. 2).

We compared people aged 30 years or younger ($n = 34$) to those aged between 31 and 60 ($n = 33$) and those over 60 ($n = 25$). There were moderate to strong correlations between age, previous flood knowledge, and flood experience. The participants over 60 years of age reported a higher level of flood knowledge, self-efficacy, and protection motivation before the workshop. In contrast to the eldest group, the participants in both younger groups had a higher increase in self-efficacy and flood knowledge, as Fig. 2 shows. For protection motivation, though, we see a different picture. The elder participants reported a level of protection

Table 4
Bivariate correlations between PMT constructs and sociodemographics.

	N°		*M*	*SD*	Flood-related cognition and emotion before workshop				Flood-related cognition and emotion after workshop				Community flood engagement		Sociodemographic background variables			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flood-related cognition and emotion before workshop	1	Self-efficacy 1	2.62	.96	1 *111*													
	2	Flood knowledge 1	3.16	1.06	.613** *111*	1 *111*												
	3	Fear 1	2.86	1.46	.256** *107*	.297** *107*	1 *107*											
	4	Protection motivation 1	1.99	.88	.201* *106*	.161 *106*	.437** *102*	1 *106*										
Flood-related cognition and emotion after workshop	5	Self-efficacy 2	3.32	.95	.454** *100*	.208* *100*	.008 *96*	-.069 *97*	1 *104*									
	6	Flood knowledge 2	3.69	.76	.479** *100*	.588** *100*	.257* *96*	.043 *97*	.551** *104*	1 *104*								
	7	Fear 2	2.75	1.35	.194 *98*	.246* *98*	.846** *94*	.387** *95*	-.084 *100*	.234* *100*	1 *100*							
	8	Protection motivation 2	2.34	1.13	.187 *97*	.160 *97*	.377** *93*	.694** *96*	.159 *101*	.230* *101*	.431** *97*	1 *101*						
	9	Community flood engagement 1	3.14	1.26	.296** *108*	.301** *108*	.352** *106*	.393** *103*	.188 *97*	.171 *97*	.305** *95*	.349** *94*	1 *108*					
	10	Community flood engagement 2	3.20	1.23	.245* *97*	.200* *97*	.353** *93*	.393** *95*	.250* *99*	.290** *99*	.328** *99*	.400** *96*	.829** *94*	1 *99*				
Sociodemographic background variables	11	Previous knowledge	2.08	.85	.585** *111*	.662** *111*	.448** *107*	.231* *106*	.156 *100*	.398** *100*	.407** *98*	.168 *97*	.296** *108*	.234* *97*	1 *111*			
	12	Threat appraisal	2.94	1.58	.329** *108*	.455** *108*	.684** *106*	.354** *103*	.016 *97*	.366** *97*	.589** *95*	.291** *94*	.309** *107*	.235* *94*	.512** *108*	1 *108*		
	13	Flood experience	.73	.45	.399** *107*	.511** *107*	.394** *105*	.054 *102*	.096 *96*	.305** *96*	.421** *94*	.018 *93*	.167 *107*	.089 *93*	.534** *107*	.408** *106*	1 *107*	
	14	Age	45.25	20.75	.310** *102*	.440** *102*	.559** *100*	.312** *97*	-.127 *92*	.184 *92*	.526** *90*	.320** *89*	.065 *101*	.101 *89*	.531** *102*	.534** *101*	.490** *101*	1 *102*

Note. Below each correlation, the corresponding *n* is displayed in italics. Pooled correlations are significant at $^{**}p < .001$; $^{*}p < .005$. All scales were presented in questionnaire 1, except those marked with a "2".

Table 5
Fixed effects of mixed-model analysis on self-efficacy, flood knowledge, and protection motivation.

		F	*df1*	*df2*	*p*	part. η^2
Self-efficacy	Time	54.549	1	88.699	<.001	.381
	Previous knowledge	8.749	2	92.892	<.001	.159
	Flood experience	.220	1	91.608	.640	.002
	Age group	1.169	2	94.336	.315	.024
	Time* previous knowledge	3.198	2	87.770	.046	.068
	Time* flood experience	.812	1	87.026	.370	.009
	Time* age group	2.763	2	88.518	.069	.059
	n	101				
Flood knowledge	Time	48.196	1	90.972	<.001	.346
	Previous knowledge	12.918	2	93.323	<.001	.217
	Flood experience	3.860	1	92.208	.052	.040
	Age group	.296	2	94.597	.745	.006
	Time* previous knowledge	4.258	2	89.519	.017	.087
	Time* flood experience	2.204	1	88.352	.141	.024
	Time* age group	1.376	2	90.747	.258	.029
	n	101				
Protection motivation	Time	17.699	1	80.519	<.001	.180
	Previous knowledge	1.102	2	86.698	.337	.025
	Flood experience	.430	1	84.434	.514	.005
	Age group	6.185	2	87.018	.003	.125
	Time* previous knowledge	.066	2	80.180	.936	.002
	Time* flood experience	.125	1	79.767	.725	.002
	Time* age group	.781	2	80.459	.461	.019
	n	97				

*Note: Differences in *n* are due to missing values.

motivation which was approximately one standard deviation above those of the younger groups. All three age groups showed a comparable increase on this scale after the workshop. The fixed effect of age on protection motivation was significant (Table 5) and revealed a partial η^2 of .125 which describes a medium effect size.

4. Discussion and conclusion

The study shows the potential of a workshop on private flood protection as a risk communication tool to raise awareness on the topic. Both self-efficacy and flood knowledge increased substantially through the workshop, meaning that the participants felt more personally capable of protecting themselves and their property while having learned helpful information. Self-efficacy stands in a strong relationship to climate change adaptation behaviour [26]. Adaptation to natural hazards is one method of climate change adaptation. Thus, the fact that a workshop on private flood protection increased the participants' self-efficacy is a meaningful finding.

Past intervention research in risk communication produced an ambiguous picture [24,25,37]. Our research shows that a workshop is a helpful method to foster people's intentions to engage in protection behaviour. This was underlined by the increased protection motivation after the intervention: the participants stated a stronger intention to employ protection measures within the following days than they did before the workshop.

The workshop's effects on self-efficacy, flood knowledge, and protection motivation varied depending on the participant's flood experience and previous knowledge. Having experienced a flood in the past goes along with higher reported previous flood knowledge, which corresponds with research on risk perception [7,38]. Participants who reported higher previous flood knowledge and had experienced a flood before showed a higher level of both self-efficacy and flood knowledge before the workshop compared to those who did not. Their levels on both scales increased significantly and are still the highest after the workshop. The "flood-inexperienced" participants (lower previous knowledge, no personal flood experience), however, showed a steeper increase in self-efficacy and flood knowledge. Hence, while both groups gained self-efficacy and flood knowledge through the workshop, the "flood-inexperienced" participants gained more. Accordingly, our results recommend that it might be most feasible to address especially those new to the topic of flooding. Nevertheless, the workshop is beneficial for "flood-experienced" citizens as well.

Partially comparable results were found for the age level, which is rooted in the fact that elder people were more likely to have personally experienced a flood and reported higher previous knowledge. Participants over the age of 60 started off with the highest levels of self-efficacy and flood knowledge before the workshop. After the workshop, the younger participants had partly equalled or even topped the 60+ group's means on both scales after the workshop. For protection motivation, though, we see a different picture: elder participants reported the highest level of protection motivation both before and after the workshop. A review by Kellens et al. [38] reports that higher age generally comes with an increased risk perception, which can be confirmed with our results.

Our study only partially support the assumption made by the PMT. Due to the reduced questionnaire, we did not include all constructs of the theory. The central variable of self-efficacy is present and correlated with protection motivation, however, as did negative affect (fear) and threat appraisal. However, the correlations between these scales decreased throughout the intervention. In our case, PMT does not explain the complexity of protection behaviour and its influences on a satisfactory level. There are other promising theories that have already been applied in the research on flood risk behaviour (for an overview see Ref. [31], such as the Protective Action Decision Model (PADM [17,39]), which includes more aspects of predecisional processes, decision making, and the behavioural response. The Risk Information Seeking and Processing Model (RISP [40]), addresses factors in the information seeking process and can enrich risk communication research. To date, however, the PMT has been used frequently in researching flood protection behaviour. Future research must open up to other theoretical frameworks in order to represent the complexity of human behaviour in natural hazards contexts.

4.1. Lessons learned on workshop planning

One novelty of this study is the heterogeneous sample that the workshops addressed. Some settings turned out to draw more participants than others, which offers us the possibility to propose recommendations for future workshops in the field of private flood protection. The type of setting and the participants' socio-demographic

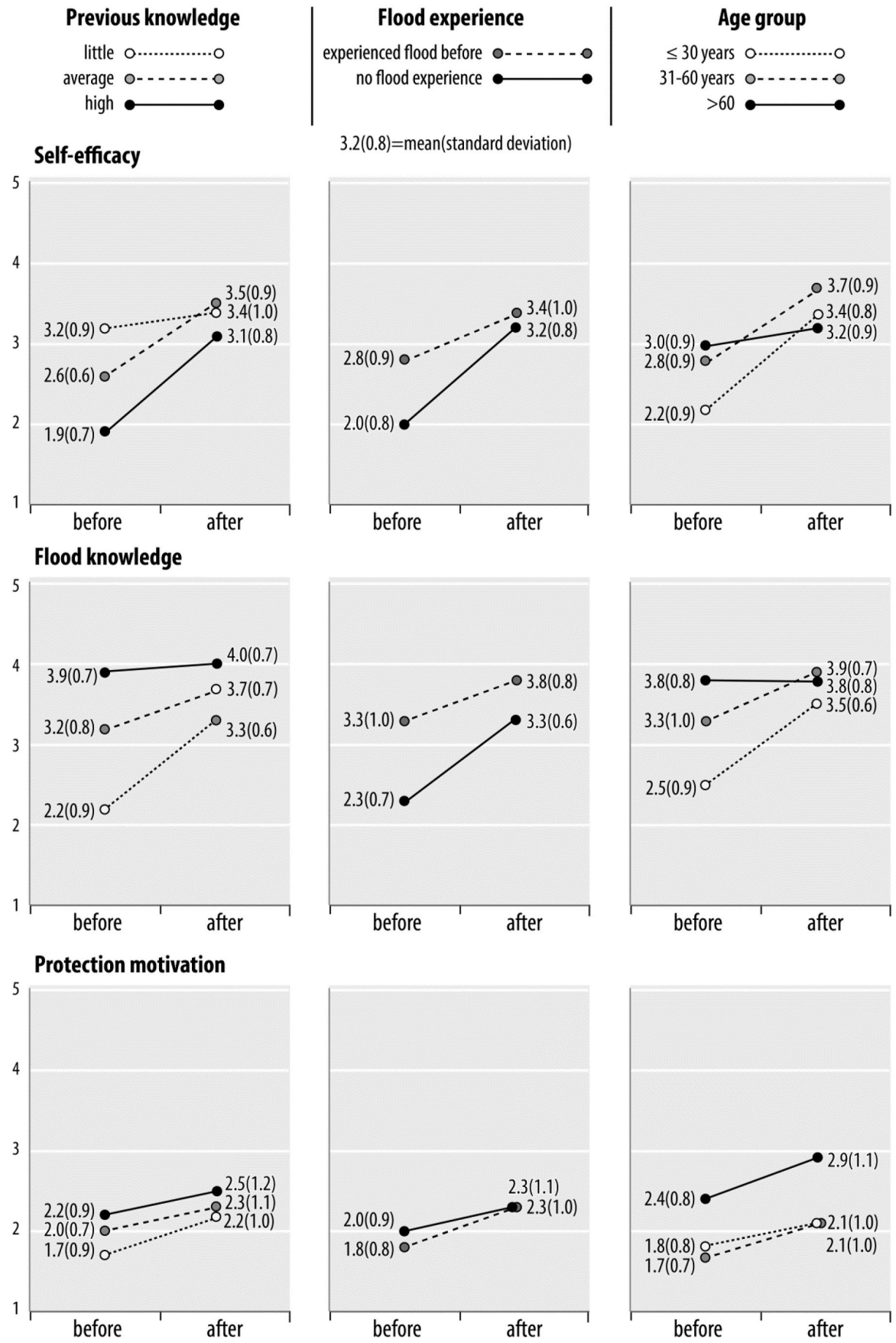

Fig. 2. Group means (and standard deviations) of the scales of self-efficacy, flood-knowledge, and protection motivation before and after the workshop regarding the participants' previous knowledge, flood experience, and age group. All items were answered on scale ranging from 1 = "does not apply at all" to 5 = "fully applies".

backgrounds are clearly two confounding factors in our study. Thus, the following interpretations of the different results should be made with care.

Across the four different workshop settings (info night in a flood-prone neighbourhood, science night, specific flood event with an aid organisation, and local fair), some sociodemographic background variables varied strongly. The info night's participants' mean age was higher than the average age at the other events. Additionally, the audiences initially addressed differed: workshops 1 to 4 were advertised amongst residents of flood-prone areas and interested citizens, while workshops 5 and 6 were only accessible to members of aid organisations. Members of the second group reported lower experience and knowledge in the topic of flooding.

Nevertheless, recommendations can be given for different ways to approach potential participants. This study further aimed to find out which setting works best in reaching relevant attendees. The different settings each produced a dissimilar number of participants. The info night in a flood-prone neighbourhood and the science night were highly frequented; they reached between 20 and 50 participants each, but unfortunately not everyone filled out a questionnaire. The events were advertised in the local press and thus reached interested individuals around the whole city. Both workshops, which were organised together with an aid organisation, were advertised internally. Between 12 and 35 people attended each workshop, which we rated as a satisfactory number. However, it has to be kept in mind that this workshop's participants were primarily not the relevant target group of flood-prone citizens. Participant acquisition for the two workshops at local fairs was difficult in comparison. We carried out two workshops at local fairs which were loosely linked to the topic of disaster management. Merging entertainment and information into one event proved to be unfeasible. Most visitors to the fairs came to socialise; many brought their children and only a few were willing to sit down and join an informative workshop.

To summarise, we recommend large events with a scientific theme that are organised for the general public as a frame for successful and well-attended workshops. Here, potential participants tend to be more interested in the information presented and willing to join a workshop. The workshops need to be easily accessible for people at risk and therefore it is advisable to locate the event in a flood-prone neighbourhood. Furthermore, different promotion channels should be used to reach different target groups, such as social media and the local press.

4.2. Limitations

The workshop had a positive impact on participants' immediate self-reported self-efficacy, flood knowledge, and protection motivation. We cannot make a statement on long-term effects, because a follow-up survey after the workshops in addition to the direct posttest questionnaire was not practical in our case. For future research, the pretest-posttest design should be expanded with a further questionnaire later on following the workshop and potentially another one before the intervention. This is necessary to ensure that the workshop on private flood protection leads not only to short-term but also long-term benefits. Furthermore, the lack of a control group negatively affects the internal validity of our design, thus no causal relationship between the constructs we measured has been proven. However, a number of practical thoughts on how to establish such a control group in the future must be discussed in advance. A compromise could be found in the conceptualisation of a waiting group design, which would include a control group that would be provided with the same questionnaires at the same time as the intervention group, but would join the workshop at a later time. Voluntariness is clearly an ethical imperative of field research. Since we conducted our workshops in public and everyone who was informed about the event in advance had the same opportunity to participate the intervention was subjected to self-selection. Thus, we did not only reach those people at risk the workshop was designed for, but also those interested and able to join our events.

4.3. Conclusions and outlook

Finally, we propose some additional considerations for future workshops. The potential of modern media to be used for risk communication purposes has been suggested by a few studies, such as Zaalberg and Midden [37]; who explored the effect of a 3D animation of a flood incident compared to watching a film with a sample size of $n = 55$. The experiment produced the tentative assertions that flooding experiences in virtual reality (VR) lead to higher coping responses and motivation to evacuate and buy flood insurance. Future workshops will be able to address more and different participants if they decide to include elements of VR or serious games.

Furthermore, we have to evaluate whether the focus on merely individual (private) protection is enough and will lead to sustainable action. We found out that our workshop did not produce such spill-over effects: it did not increase the participants' interest in joining (potential) flood action groups in their neighbourhood. In a recent study, the buffering effect of collective-level support on wellbeing after a flood event has been shown [41]. The workshop may also serve as a socially connecting element, if it facilitates the sharing of experiences and needs. However, collective action may not necessarily arise from an informative event on its own. A workshop should thus be organised and planned both for and with members of a community.

Altogether, this study demonstrated the benefits of a workshop on private flood protection. We hope that in the future more workshops or other (participative) interventions will be conducted and evaluated to further improve their effectiveness and reduce flood damage in the long run.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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