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Relationships between climate change perceptions and climate adaptation actions: policy support, information seeking, and behaviour

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Abstract

People are increasingly exposed to climate-related hazards, including floods, droughts, and vector-borne diseases. A broad repertoire of adaptation actions is needed to adapt to these various hazards. It is therefore important to identify general psychological antecedents that motivate people to engage in many different adaptation actions, in response to different hazards, and in different contexts. We examined if people's climate change perceptions act as such general antecedents. Questionnaire studies in the Netherlands ($n = 3,546$) and the UK ($n = 803$) revealed that the more people perceive climate change as real, human-caused, and having negative consequences, the more likely they are to support adaptation policy and to seek information about local climate impacts and ways to adapt. These relationships were stronger and more consistent when the information and policies were introduced as measures to adapt to risks of climate change specifically. However, the three types of climate change perceptions were inconsistently associated with intentions to implement adaptation behaviours (e.g. installing a green roof). This suggests that climate change perceptions can be an important gateway for adaptation actions, especially policy support and information seeking, but that it may be necessary to address additional barriers in order to fully harness the potential of climate change perceptions to promote widespread adaptation behaviour.

Keywords Climate change perceptions · Adaptation · Heatwaves · Information seeking · Policy support

As global temperatures rise, natural hazards become more severe and occur more frequently (IPCC 2021). Governments have limited capacity to fully protect citizens against such hazards. It is therefore critical that individuals and households also take action to adapt to the risks of climate change (Klein et al. 2016). Individuals and households can adapt to climate change through a range of actions, including installing physical measures (e.g. placing hurricane shutters), engaging in preparative actions (e.g. purchasing flood

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insurance), engaging in political action (e.g. supporting the implementation of adaptation policies, voting for parties that put adaptation to climate change on the political agenda), or by seeking information about climate change risks or how to adapt (e.g. checking weather forecasts) (van Valkengoed and Steg 2019b).

Many people do not (yet) take adaptation actions to reduce the risks posed by climate change (van Valkengoed and Steg 2019b). It is therefore important to understand which factors can motivate people to take adaptation actions. So far, research has focused on *behaviour-* and/or *hazard-specific* variables that are associated with a *specific* adaptive behaviour. For example, studies have found that the more people think they are capable of, for example, installing flood prevention measures, the more motivated they are to install these measures (Kievik and Gutteling 2011). Similarly, people are more likely to undertake fire risk reduction behaviours if they think these behaviours are effective in reducing wild-fire risk (Absher and Vaske 2011), and people are more likely to invest in flood insurance if they think other people also invest in flood insurance (Lo 2013).

Studying such *hazard-* or *behaviour-specific* antecedents of different adaptation actions has yielded important insights into what motivates people to engage in specific adaptation actions (van Valkengoed and Steg 2019a). Yet, many people are facing multiple climate change risks simultaneously that require an extensive repertoire of adaptation actions. To illustrate, people in Colombia face increasingly more heatwaves, storms, flooding, and vector-borne diseases such as dengue fever (USAID 2017). Adaptation actions for these hazards include, amongst others, avoiding excess strain during heatwaves, making evacuation plans, taking measures to flood-proof the house, and clearing vector-breeding sites around the home. Similarly, people in the Netherlands face increases in heatwaves, pluvial flooding, tick-borne diseases, and sea level rise (Ministerie van Infrastructuur en Waterstaat 2018), and associated adaptation actions include, amongst others, having a green garden (to catch rainwater runoff and decrease heat), installing a rain barrel, supporting policies for more green space, actively checking for ticks, and moving to a more elevated area. Therefore, we argue that it is also important to investigate *general* antecedents of adaptation actions, namely factors that influence (1) different types of adaptation actions, in response to (2) different climate-related hazards, and (3) in different contexts (cf. Taylor 2019). If such general antecedents can be determined, cost-effective interventions can be designed to target such antecedents and promote widespread adaptation (van der Werff and Steg 2015). In this paper, we examined if people's climate change perceptions act as such general antecedents of adaptation actions.

1 Climate change perceptions and adaptation actions

Climate change perceptions refer to the way in which people perceive and evaluate climate change and its various aspects (Weber and Stern 2011). Three core climate change perceptions have been distinguished: the perceived reality of climate change (i.e. the extent to which people believe that climate change is real), the perceived causes of climate change (i.e. the extent to which people think that climate change is caused by humans or by natural causes), and the perceived consequences of climate change (i.e. the extent to which people expect that climate change will have positive or negative consequences) (Guy et al. 2014; Heath and Gifford 2006; Poortinga et al. 2019; Rahmstorf 2004).

Previous studies on the relationship between climate change perceptions and adaptation actions have yielded inconsistent results. People who perceived climate change as real were more likely to support climate change adaptation policies (Bateman and O'Connor 2016; Mildenerger et al. 2019), but were not more likely to engage in concrete adaptive behaviours such as purchasing flood insurance (Shao et al. 2017), saving water during a drought (Deng et al. 2017), or installing measures to protect one's home against hurricanes (Javeline et al. 2019). Next, people who agreed more that climate change is human-caused were more likely to support adaptation policy (Bateman and O'Connor 2016), but were not more prepared for flooding (Kreibich 2011), or to have taken or have intentions to take measures to protect one's home against hurricanes (Javeline et al. 2019). Also, the more negative people perceived the consequences of climate change, the more willing they were to invest in elevating the home against flooding (Botzen et al. 2012), and the more likely they were to have taken emergency measures against flooding (Kreibich 2011), and to have taken a variety of adaptive measures in and around the house (Brink and Wamsler 2019). Yet, perceiving the consequences of climate change as negative was not related to having taken or having the intention to take measures to protect the home against hurricanes (Javeline et al. 2019) or to have taken preparedness measures against flooding (Kreibich 2011).

Overall, the reviewed studies seem to suggest that climate change perceptions are related to policy support, but less consistently predict behavioural intentions and actual behaviours. It may be that the strength of the relationships with behaviour varies across the different types of climate change perceptions. Since the key aim of adaptation is to cope with or prevent the negative impacts of climate change (IPCC 2018), the perceived negative consequences of climate change may be the most relevant determinant of adaptation actions. Indeed, the studies reviewed above suggests that particularly the perceived negative consequences of climate change were related to (some) concrete, preparative adaptation behaviours. Yet, most studies so far have not systematically examined all three climate change perceptions simultaneously (but see Javeline et al. 2019), and it remains unclear whether the perceived negative consequences of climate change are the strongest predictor of adaptation actions.

The studies reviewed above varied greatly in how the different types of climate change perceptions (i.e. perceptions of the reality, causes, and consequences) were assessed, which may have affected the results. To illustrate, perceived reality of climate change has been assessed with the following question: 'Do you think that global warming is happening?' (Mildenerger et al. 2019), as well as with the question 'Do you think the issue of climate change is believable?' (Deng et al. 2017). This latter operationalization may inadvertently measure whether people think the concept of climate change is believable in general, but not whether people themselves believe that climate change is real. In addition, different response scales have been used, with some studies providing only two response options, while other relied on a 7-point scale. A discrete answering scale with limited options can skew participants' responses to more extreme options that may not accurately reflect their underlying climate change perceptions (Motta et al. 2019). A limited number of response options can also cause a lack of variance in the measure, which can lead to low or non-significant correlations with other variables (Goodwin and Leech 2006). Indeed, out of the four reviewed studies that found no significant correlations between climate change perceptions and adaptation actions, three relied on discrete response options with four or less answering options (Javeline et al. 2019; Kreibich 2011; Shao et al. 2017). Conversely,

out of the five studies that found a significant correlation between climate change perceptions and adaptation actions, three relied on response options with five or more answering options (Bateman and O'Connor 2016; Botzen et al. 2012; Brink and Wamsler 2019). All in all, such variation across studies makes it difficult to draw firm conclusions about the extent to which different types of climate change perceptions are related to different adaptation actions.

2 Current research

To address these gaps in the literature, we will examine to what extent different climate change perceptions are general antecedents of various types of climate change adaptation actions in response to different hazards and in different contexts. Specifically, we study three types of adaptation actions: support for adaptation policies, information seeking about climate change risks and adaptation, and preparative adaptation behaviour (i.e. physical measures taken before the onset of climate-related hazards to reduce or avoid their negative impacts; van Valkengoed and Steg 2019b). We examine these actions in response to different types of climate change hazards in different contexts: pluvial flooding and urban heat island effects in the Netherlands (study 1) and heatwaves in the UK (study 2). Particularly, heatwaves and the urban heat island effect are key climate change risks for many people living in urban areas around the world, leading to deaths, illness, discomfort, and large economic losses (Watts et al. 2021; WMO 2019). Yet, the psychological antecedents of adaptation to heat have hardly been studied (van Valkengoed and Steg 2019a), which is a key reason we focus on these particular hazards in the current studies. Lastly, extending previous findings, we assess the three core climate change perceptions (reality, causes, and consequences of climate change) simultaneously, using items from a validated scale (van Valkengoed et al. 2021).

3 Study 1

3.1 Method

3.1.1 Participants and procedure

The study was conducted in late spring in a medium-sized city in the north of the Netherlands, where prevalent climate risks include pluvial flooding and urban heat island effects. Participants were invited to participate in an online study on how people respond to climate change via three channels: via a panel maintained by the local municipality, door-to-door recruitment, and via social media. All participants completed the questionnaire online. Members of the panel signed up voluntarily.¹ Participants gave their informed consent to participate and were not compensated for their participation. The questionnaire was filled in by 3546 participants: 3492 were recruited via the panel, and 54 were recruited

¹ The panel existed already long before the current survey was developed, and respondents receive questionnaires approximately weekly on a wide range of locally relevant topics, including sports, mobility, and politics. As members of the panel that were recruited for this study were already members before the study was announced, selection bias due to the specific topic of the survey is unlikely.

door-to-door and via social media.² The participants' age ranged from 19 to 95 ($M_{age} = 54.5$ years). Most respondents were homeowners (70.9%), while 27.9% rented their house.

3.1.2 Measures

Climate change perceptions We assessed the perceived reality, causes, and consequences of climate change with the following items: 'I believe that climate change is real' ($M = 6.13$, $SD = 1.50$), 'The main causes of climate change are human activities' ($M = 5.93$, $SD = 1.38$), and 'Climate change will bring about serious negative consequences' ($M = 6.20$, $SD = 1.18$). The items were selected from a validated climate change perceptions scale (van Valkengoed et al. 2021). All items were rated on a 7-point scale, ranging from completely disagree to completely agree. The items were translated from English into Dutch by the first author, and back-translated into English by a native English speaker to check the accuracy of the translation. Participants who selected 'completely disagree', 'disagree', or 'somewhat disagree' on the item 'I believe that climate change is real' automatically skipped the items measuring the perceived causes and consequences of climate change ($N = 259$; 8%).

Policy support We asked participants to what extent they would find it acceptable, useful, good, and necessary if the municipality developed more green space in their neighbourhood in order to reduce negative local climate impacts.³ Responses were provided on a 7-point scale, ranging from completely not acceptable/useful/good/necessary to completely acceptable/useful/good/necessary, respectively. Scores on the four items were averaged, a higher score indicating more support for the climate adaptation policy ($M = 6.38$, $SD = 1.17$, $\alpha = .93$).

Information seeking Participants were asked whether they had accessed or had the intention to access two types of information sources, namely the heat and flood map of the city, and general information about the impacts of climate change on the city. Participants could indicate for each information source: 'I have no intention of accessing this information', 'I intend to access this information', 'I have already accessed this information', and 'Don't know/no answer'. Responses for the two different information sources were analysed separately. For each of the items, about 45% of participants answered 'Don't know/no answer', which were coded as missing data.⁴ The other responses are treated as categorical data in the analyses.

Preparative adaptation intentions and behaviours We assessed preparative adaptation behaviour by asking participants whether they have implemented or are planning to

² The municipality aimed to recruit more participants outside its own participants panel to further increase the reach of the study. However, this method was less successful than anticipated. The responses that were collected from outside the panel were not marked as such in the data file, making it impossible to distinguish them from the panel respondents.

³ All policies, sources of information, and adaptation behaviours were approved to be locally relevant by municipal adaptation policy officers.

⁴ This relatively large amount of do not know/no answer is likely due to the fact that these information services were made publicly available not long before the study, and many respondents may therefore not (yet) have been aware of their existence.

implement the following seven behaviours: greening the garden (replacing stones and concrete with plants), installing a green roof, greening the front garden (removing stones from the sidewalk to plant plants), installing a rain barrel, installing a pond, installing sun blinds, and insulating the home (Huisje Boompje Beter 2019). The behaviours were introduced as measures that can help to reduce local risks from climate change, including pluvial flooding and heat island effects. Participants could indicate for each behaviour the following: 'definitely not planning to do this', 'probably not planning to do this', 'probably planning to do this', 'definitely planning to do this', or 'have already done this'. Participants could also indicate 'not applicable to my home' or 'don't know/no answer'; both these responses were coded as missing values. For the distribution of the responses on these items, see [Supplemental Material](#).

From this scale, we compiled a measure of past behaviour ('have already done this' = 1, all other responses = '0'), as well as a measure of intentions to implement the preparative adaptation behaviours (4-point ordinal scale ranging from 'definitely not planning to do this' to 'definitely planning to do this'; responses 'have already done this' are considered as missing data in this case). Each behaviour was treated separately instead of compiling them into a scale, because we are interested in whether climate change perceptions are associated with different kinds of adaptation behaviours.

3.2 Results

3.2.1 Policy support

We calculated the correlation between climate change perceptions and support for policy for developing more green spaces in the neighbourhood. The more people agreed that climate change is real, human-caused, and will have negative consequences, the more they support the policy ($r_{\text{reality}} = .18, p < .01$, $r_{\text{causes}} = .16, p < .01$, $r_{\text{consequences}} = .19, p < .01$). The correlations represent a small-to-medium effect size and were very similar for the three types of climate change perceptions.

3.2.2 Information seeking

We conducted an ANOVA to examine whether climate change perceptions differed between people who had looked up information, were planning to look up information, or were not planning to look up information, for both types of information (heat and flood map of the city and information about the impacts of climate change on the city). The ANOVA's and post hoc t-tests with Bonferroni corrected alpha levels (see [Supplemental Material](#)) indicate that the more people agreed that climate change is real, human-caused, and will have negative consequences, the more likely they are to have already looked up both types of information or to be planning to look up this information. The effect sizes were again similar for the different types of climate change perceptions (see Table 1).

3.2.3 Preparative adaptation intentions and behaviours

We calculated *t*-tests to examine whether climate change perceptions differed between people who had and who had not implemented preparative adaptation measures (see

Table 1 Summary of the observed effect sizes across different adaptation actions for the three different climate change perception in study 1

Summary of the observed effect sizes across different adaptation actions for the three different climate change perception in Study 1

	Reality	Causes	Consequences
Policy support (<i>r</i>)	.18	.16	.19
Information seeking (<i>d</i>)*			
Heat maps- and flood maps			
<i>Already looked up vs not planning</i>	0.36	0.32	0.44
<i>Planning vs not planning</i>	0.41	0.35	0.44
Information local impacts			
<i>Already looked up vs not planning</i>	0.35	0.58	0.54
<i>Planning vs not planning</i>	0.46	0.47	0.57
Adaptation intentions (<i>rho</i>)			
Green roof	.19	.18	.18
Front garden	.15	.15	.16
Green garden	.24	.21	.16
Pond	.09	.07	.09
Rain barrel	.16	.15	.14
Sun blinds	.06	.03	.03
Insulation	.14	.14	.12
Adaptation behaviour (<i>d</i>)*			
Green roof	0.03	0.15	0.21
Front garden	0.20	0.19	0.18
Green garden	0.27	0.26	0.25
Pond	0.08	0.02	0.05
Rain barrel	0.05	0.05	0.05
Sun blinds	-0.07	-0.04	-0.06
Insulation	0.04	-0.01	-0.05

Note: *r* = Pearson’s correlation coefficient, *rho* = Spearman’s correlation coefficient, *d* = Cohen’s *d*. White cells indicate non-significant relationships, light grey cells indicate a small effect, dark grey cells indicate a medium sized effect (following effect sizes guidelines derived by Lovakov & Agadullina, 2021). * = details of the associated *t*-test are provided in the Supplemental Material.

White cells indicate non-significant relationships, light grey cells indicate a small effect, and dark grey cells indicate a medium sized effect (following effect sizes guidelines derived by Lovakov and Agadullina 2021)

Note: *r* Pearson’s correlation coefficient, *rho* Spearman’s correlation coefficient, *d* Cohen’s *d*

*Details of the associated *t*-test are provided in the Supplemental Material

Supplemental Material). The more people perceived climate change as real, human-caused, and having negative consequences, the more likely they were to have a green garden (Cohen’s *d* ranged from *d* = .25 to *d* = .27, a small-to-medium effect) or a green front garden (Cohen’s *d* ranged from *d* = .18 to *d* = .20, a small effect). The effect sizes were almost identical for all three climate change perceptions. However, none of the climate change perceptions was associated with having taken any other preparative adaptation measures (i.e. having a green roof, having a rain barrel, having a pond, insulating the home, having sun blinds) (see Table 1).

Next, we calculated the correlation (spearman’s *rho*) between the climate change perceptions and intentions to implement preparative adaptation measures (see Table 1). The more people perceived climate change as real, human-caused, and having negative consequences, the stronger were their intentions to have a green roof, green garden, green front garden, rain barrel, and house insulation (*r*’s between .12 and .24, representing a small

to medium effect size). Intention to implement a green garden was most strongly correlated with climate change perceptions. Intention to install a pond was weakly correlated ($r = .09$) with the perceived reality and consequences of climate change, and was not significantly correlated with the perceived causes of climate change. There were no significant correlations between the three types of climate change perceptions and intentions to install sun blinds. The effect sizes were again comparable across the three climate change perceptions.

3.3 Discussion

Overall, stronger climate change perceptions were consistently associated with higher policy support and more information seeking, but were hardly associated with past behaviours and inconsistently with intentions. Specifically, climate change perceptions were associated with having taken only two out of the seven behaviours, namely having a green garden and having a green front garden, and were positively associated with stronger intentions to implement 5 out of 7 behaviours, namely having a green (front) garden, rain barrel, green roof, and house insulation. Possibly, climate change perceptions are more consistently associated with intentions compared to behaviours because people may have adopted these behaviours for other reasons than to reduce climate change risks. For example, people may have implemented sun blinds to make their living room more comfortable in summer without considering climate change risks. Importantly, the adaptation measures were introduced as ways to reduce local risks from climate change specifically. This may have strengthened the relationship between intentions to take these measures and people's climate change perceptions, because people recognise that the behaviour is relevant for adapting to climate change risks, also leading to particularly intentions, compared to behaviours, being more strongly related to climate change perceptions. Relatedly, we found that climate change perceptions were correlated specifically with intentions to engage in adaptation behaviours that people may more clearly perceive as ways to adapt to the risks caused by climate change, such as having a green roof or rain barrel, compared to behaviours that people may not associate with adapting to climate change risks or that people primarily adopt for other reasons, such as having a pond or sun blinds. This suggests that the relationship between climate change perceptions and the intentions to take adaptation measures (but not the behaviours that have already been carried out) may have been strengthened by introducing the measures as climate-related. We will test this proposition in study 2.

Notably, climate change was explicitly mentioned in the description of the adaptation items, which could have increased the semantic similarity between these items and the climate change perception items. This can lead to artificially inflated correlations because people may respond similarly to items that both contain the word 'climate', which is also known as 'common method variance' (Arnulf et al. 2014). Similarly, filling out the items about climate change perceptions at the beginning of the questionnaire may have made climate change more salient. We address this issue in study 2.

Interestingly, we found that the different types of climate change perceptions were equally strongly associated with adaptation actions, as the effect sizes were very similar across the different types of climate change perceptions. This makes it unlikely that inconsistent findings in the literature could be due to the fact that different studies included different types of climate change perceptions.

4 Study 2

In study 2, we examined whether we can replicate the findings of the positive relationships between climate change perceptions and different types of adaptation actions in a different country and in response to a related hazard, namely adaptation to heatwaves in the UK. Furthermore, the results from study 1 suggest that climate change perceptions may be more strongly related to the intention to take preparative adaptation behaviours that people more easily recognise as ways to reduce the risks from climate change. To test whether this is the case, we will experimentally vary how the risks that can be tackled by various adaptation actions are presented to participants: either explicating that the risks are caused by climate change (climate change condition) or without mentioning climate change (heatwave condition). As the experimental manipulation cannot influence preparative adaptation behaviour that people have already implemented, we did not examine past behaviour in this study. We consider a difference between the experimental conditions in the correlations between climate change perceptions and adaptation actions of .10 or larger a practically significant difference. To rule out common method variance, which may have played a role in study 1, we separated the measurement of climate change perceptions and adaptation actions across two measurement points in study 2. This study was preregistered on Open Science Framework (<https://osf.io/rsbpq>).

4.1 Method

4.1.1 Participants and procedure

Participants ($n = 803$, 35% men, 65% women, $M_{age} = 37.8$) were recruited via Prolific (prolific.co; for power analysis, see preregistration)⁵ in late June. Only participants who indicated that their current country of residence was the UK and who were not students⁶ were invited to participate. The questionnaire was completed in Qualtrics. After providing their informed consent to participate in the study, participants were randomly assigned to one of two conditions. In one condition, all adaptation actions were introduced as aimed at dealing with ‘heatwaves caused by climate change’ (the climate change condition, $n = 402$). In the other condition, adaptation actions were referred to as ways to deal with ‘heatwaves’ (the heatwave condition, $n = 401$).⁷ The exact wordings in each condition are given below. We asked respondents about their climate change perceptions one week before we asked the same participants about their adaptation action intentions. Individual responses across the two sessions were coupled using the participants’ unique Prolific IDs.

⁵ Participants who indicated that they already completed some of the adaptation behaviours were excluded from that specific analysis. The total number of participants that was excluded was higher than expected after the target sample size as indicated in the preregistration was reached. To ensure sufficient power for the analyses, we therefore sampled 100 more participants than indicated in the preregistration to reach the target number of 273 participants per condition for each of the adaptation behaviours. For details, see the power analysis in the preregistration.

⁶ The adaptation behaviours in this questionnaire are mostly applicable to homeowners. To increase the percentage of homeowners in the sample, we excluded students.

⁷ The sample size of the current study is smaller than the previous study, as we used the results from study 1 to calculate the sample size required for sufficient power, which yielded a lower estimate than we recruited for study 1. Overall, adequate power was achieved in both studies to detect small effect sizes. For details, see the power analysis in the preregistration.

4.1.2 Measures

Climate change perceptions The perceived reality ($M = 6.36$, $SD = 1.04$), causes ($M = 5.99$, $SD = 0.97$), and consequences ($M = 6.18$, $SD = 0.98$) of climate change were measured in the same way as in study 1. Participants who selected ‘completely disagree’ or ‘disagree’ for the perceived reality of climate change were not provided with the items about the causes and consequences of climate change ($N = 13$; 1.6%).⁸

Policy support Participants indicated to what extent they opposed or supported the implementation of three different policies to reduce the negative consequences of heatwaves (caused by climate change)⁹: investing public money in heat warning systems in every city so that people can better protect themselves against heatwaves (caused by climate change) ($M_{\text{heatwave}} = 4.18$, $SD_{\text{heatwave}} = 1.43$, $M_{\text{climate}} = 4.47$, $SD_{\text{climate}} = 1.39$), investing public money in making sure there are enough air-conditioned locations publicly available during heatwaves (caused by climate change) ($M_{\text{heatwave}} = 4.49$, $SD_{\text{heatwave}} = 1.60$, $M_{\text{climate}} = 4.55$, $SD_{\text{climate}} = 1.55$), investing in additional health care personnel to check on vulnerable populations such as the elderly and the chronically ill during heatwaves (caused by climate change) ($M_{\text{heatwave}} = 5.53$, $SD_{\text{heatwave}} = 1.31$, $M_{\text{climate}} = 5.59$, $SD_{\text{climate}} = 1.29$).¹⁰ Responses were provided on a 7-point scale, ranging from ‘strongly oppose’ (1) to ‘strongly support’ (7). All policies were analysed separately.

Information seeking Participants indicated the likelihood (on a 5-point scale, ranging from ‘not at all likely’ (1) to ‘very likely’ (5)) that they would consult three different information sources to help them prepare for heatwaves (caused by climate change): the National Health Service web page on coping with heatwaves (caused by climate change) ($M_{\text{heatwave}} = 2.37$, $SD_{\text{heatwave}} = 1.21$, $M_{\text{climate}} = 2.64$, $SD_{\text{climate}} = 1.14$), newspaper articles on coping with heatwaves (caused by climate change) ($M_{\text{heatwave}} = 2.39$, $SD_{\text{heatwave}} = 1.14$, $M_{\text{climate}} = 2.60$, $SD_{\text{climate}} = 1.13$), and weather forecasts and weather warnings for heatwaves (caused by climate change) ($M_{\text{heatwave}} = 3.91$, $SD_{\text{heatwave}} = 1.07$, $M_{\text{climate}} = 3.71$, $SD_{\text{climate}} = 1.10$). All information seeking items were analysed separately.

We next offered participants the possibility to look up information on adaptation to heatwaves (based on Kievik and Gutteling 2011). Specifically, participants indicated (‘yes’ or ‘no’) whether they would like to receive more information on how to reduce the negative consequences of heatwaves (caused by climate change) (% $\text{yes}_{\text{climate}} = 30.8$, % $\text{yes}_{\text{heatwave}} = 33.2$ %). At the end of the survey, participants who had indicated that they wanted more information were provided with a link to a webpage by the UK National Health Service on coping with heatwaves (caused by climate change).¹¹ It was recorded whether people clicked on the link or not (% $\text{clicked}_{\text{climate}} = 24.2$ %, $\text{clicked}_{\text{heatwave}} = 27.1$ %).

⁸ In study 2, we used a less strict cut-off point for classifying climate change deniers (i.e. participants who selected ‘somewhat disagree’ on the reality of climate change still received items about the causes and consequences of climate change). This is in line with the original scale on which the items are based (van Valkengoed et al. 2021). Since only a small percentage of participants selected the option ‘somewhat disagree’ (1.8% in study 1 and 1.1% in study 2), this likely had little effect on the results reported here.

⁹ Throughout the “Method” section, the additional wording provided in the climate change condition is provided between parentheses

¹⁰ All policies, sources of information, and adaptation behaviours were obtained by searching British policy documents, official government websites, and newspapers on locally relevant measures to cope with heatwaves.

¹¹ <https://www.nhs.uk/live-well/healthy-body/heatwave-how-to-cope-in-hot-weather/>

Preparative adaptation intentions We included eight preparative adaptation intentions: four that people could implement inside their home (putting up thermal curtains, replacing halogen or incandescent light bulbs with LED lights¹², applying weather strips to doors and windows to keep warm air out, and applying sun-blocking film to windows) and four that people could implement outside their home or that required structural changes to the home (properly insulating loft and walls, planting plants and trees near property, painting external roof/walls in lighter colours, and installing awnings, overhangs, or other sun blinds for windows; based on Murtagh et al. 2019). To measure intentions, participants were asked to indicate how likely they were to take these measures within the next year to reduce the negative effects of heatwaves (caused by climate change). Responses were given on a 5-point scale ranging from ‘not at all likely’ to ‘very likely’. We also included the option ‘have already done this’, and included the option ‘not applicable’ for the outdoors/structural measures, since the measures may not be possible to complete for every participant (e.g. it is not possible to plant plants around the house if one does not have a garden). Respondents who indicated that they have already taken the measure or for whom the measure is not applicable are not included in the analyses, as only intentions are considered as relevant outcomes in the current study. All adaptation intentions were analysed separately, as we are interested in whether climate change perceptions are associated with different kinds of adaptation behaviours. The distribution of responses on these items is available in the [Supplemental Material](#).

Manipulation check We assume that if climate change is not explicitly mentioned, it is less likely that people consider climate change when thinking about natural hazards and ways to deal with them. We therefore asked participants at the end of the study to what extent they were thinking about climate change while completing the questionnaire (1 = ‘not at all’, 7 = ‘very much’).

4.2 Results

We first examined whether the experimental manipulation was successful. In both conditions, only a minority did not think at all about climate change (11% and 3.2% of participants selected response option ‘1’ in respectively the heatwave and the climate change condition). Yet, overall, participants in the climate change condition indeed thought more about climate change while completing the questionnaire than people in the heatwave condition ($M_{climate} = 5.45$, $M_{heatwave} = 4.59$, $t(773.7) = 6.99$, $p < .001$), suggesting that the manipulation did make climate change overall more salient in the climate change condition. There were no a priori differences across conditions in perceptions of the reality ($t(794.8) = -0.59$, $p = .55$), causes ($t(785.2) = -0.26$, $p = .80$), and consequences of climate change ($t(788) = -1.10$, $p = .27$).

4.2.1 Policy support

In both conditions, stronger climate change perceptions were significantly associated with stronger support for policies to reduce the impact of heatwaves. Specifically, the

¹² Replacing halogen or incandescent lightbulbs with LED lights can not only be considered a mitigation behaviour (as LED lights are more energy-efficient), but also an adaptation behaviour, as LED lights generate less residual heat, reducing indoor temperatures.

more people agreed that climate change was real, caused by humans, and that climate change has negative consequences, the more they supported policies to reduce the negative impacts of heatwaves (r 's ranging from .11 to .38 across conditions, a small to medium-large effect size, see Table 2). The only exception occurred in the heatwave condition: there was no significant correlation between perceptions of the causes and consequences of climate change and supporting the policy to increase publicly available air-conditioned locations. The correlations in the climate change condition were at least .10 stronger than their counterparts in the heatwave condition, which we consider a practically significant difference (see Table 2). The strength of the correlations was comparable across the different climate change perceptions.

4.2.2 Information seeking

In the heatwave condition, climate change perceptions were in most cases only marginally significantly positively associated with intentions to seek information (r 's ranging from .02 to .11, representing a non-significant effect to small effect). In the climate change condition, the more people agreed that climate change is real, caused

Table 2 Summary of the observed effect sizes across different adaptation actions for the three different climate change perception in study 2

	Heatwave condition			Climate change condition		
	Reality	Causes	Consequences	Reality	Causes	Consequences
<i>Summary of the observed effect sizes across different adaptation actions for the three different climate change perception in Study 2</i>						
Policy support (r)						
Heat warning systems	.22	.12	.16	.33	.30	.28
Air conditioned locations	.11	.02	.05	.22	.16	.16
Health care personnel	.18	.14	.18	.34	.35	.38
Information seeking intentions (r)						
NHS	.11	.02	.06	.17	.15	.08
Newspapers	.09	.07	.09	.14	.13	.10
Weather warnings	.09	.06	.09	.25	.19	.23
Information seeking behaviour (d)*						
Request information	.22	.18	.19	.19	.18	.17
Clicked link	.23	.01	.02	.01	.38	.28
Adaptation intentions (r)						
Curtains	-.03	-.01	-.07	.12	.11	.03
Lights	.03	.00	-.01	.07	.05	-.04
Weather strips	-.06	-.08	-.06	.08	.05	-.04
Film	.04	.00	-.01	-.01	-.06	-.10
Insulation	-.05	.01	-.06	.11	.10	.03
Plants	.11	.04	.05	.13	.14	.09
Paint	.04	-.05	-.01	.01	-.01	-.07
Awnings	.00	-.03	-.02	.04	.05	-.03

Note: r = Pearson's correlation coefficient, ρ = Spearman's correlation coefficient, d = Cohen's d . White cells indicate non-significant relationships, light grey cells indicate a small effect, dark grey cells indicate a medium sized effect (following effect sizes guidelines derived by Lovakov & Agadullina, 2021). * = details of the associated t -test are provided in the Supplemental Material.

White cells indicate non-significant relationships, light grey cells indicate a small effect, and dark grey cells indicate a medium sized effect (following effect sizes guidelines derived by Lovakov and Agadullina 2021)

Note: r Pearson's correlation coefficient, ρ Spearman's correlation coefficient, d Cohen's d

*Details of the associated t -test are provided in the Supplemental Material

by humans, and has negative consequences, the stronger their intention to seek information on heatwaves (r 's ranging from .08 to .25, generally representing a small to medium-sized effect, see Table 2). There were two exceptions: there were no significant correlations between perceptions of the consequences of climate change and intentions to consult the National Health Service web page or newspaper articles. The relationships between climate change perceptions and information seeking intentions were overall stronger in the climate change condition compared to the heatwave condition: the difference was greater than .10 for 4 out of 9 correlations, which we consider a practically significant difference. Again, the correlations were comparable between the different climate change perceptions.

In both conditions, we found that the more people perceived climate change as real, human-caused, and having negative consequences, the more likely they were to request information on coping with heatwaves (caused by climate change) at the end of the questionnaire (see Table 2). The strength of the relationship did not vary across the experimental conditions or the climate change perceptions (Cohen's d ranging from .17 to .22, representing a small effect). The climate change perceptions were however not associated with whether people actually clicked the link to access the information (see Table 2), with the only exception that people in the climate change condition were more likely to click the link when they more strongly believed that climate change is human-caused ($M_{click} = 6.34$, $M_{no\ click} = 6.01$, $t(51.3) = 1.88$, $p = .03$). Due to the small number of people that actually clicked the link and the high scores on the climate change perception items for people who requested to see more information, this comparison may be underpowered and prone to ceiling effects.

4.2.3 Preparative adaptation intentions

In both conditions, the climate change perceptions were hardly associated with intentions to take most measures. In the heatwave condition, climate change perceptions were not associated with intentions to implement any of the adaptation measures, with one exception: people who more strongly believed that climate change was real had slightly stronger intentions to plant plants around the home ($r = .11$, $p = .05$) (see Table 2). In the climate change condition, just four out of 24 correlations were significant: people had slightly stronger intentions to plant plants around the home the more they believed that climate change was real ($r = .13$, $p = .03$) and caused by humans ($r = .14$, $p = .02$). Also, people who more strongly believed that climate change was real had slightly stronger intentions to put up sun-blocking curtains ($r = .12$, $p = .04$). In contrast to what was expected, there was a weak significant negative correlation between the perceived consequences of climate change and intentions to implement sun-blocking film ($r = -.10$, $p = .04$): the more people expect negative consequences from climate change, the less they intend to apply sun-blocking film to their windows. Yet, all effect sizes are very small and barely significant.

4.3 Discussion

Overall, we found that stronger climate change perceptions were associated with stronger policy support and more information seeking, replicating the findings from study 1. However, we mostly did not replicate the finding that stronger climate change perceptions were associated with stronger intentions to take preparative adaptation measures, as we found only four positive significant correlations (out of 48). We found that explicitly introducing

the adaptation actions as measures to adapt to climate change increased the strength of the relationship between climate change perceptions and policy support and information seeking intentions, but it did not strengthen the relationship between climate change perceptions and intentions to take preparative adaptation measures. Moreover, we found that people with stronger climate change perceptions were more likely to request information on adapting to heatwaves, irrespective of the experimental condition. Yet, we did not find consistent evidence that people who had stronger climate change perceptions were more likely to actually click the link to see more information, irrespective of the condition, but the test of this comparison was underpowered. Again, we did not find that any of the climate change perceptions was more strongly associated with the different indicators of adaptation actions than others.

5 General discussion

Individuals and households need to take measures to adapt to the consequences of climate change. It is therefore important to understand what motivates people to take such actions. So far, the literature has primarily focused on *behaviour- or hazard-specific* variables that are associated with the respective *specific* adaptive action. Yet, climate change causes a broad range of hazards that vary across different geographical contexts, and for which a broad repertoire of adaptation actions is needed. It is therefore important to also examine whether we can identify *general* antecedents of adaptation actions that are associated with (1) different types of adaptation actions, in response to (2) different climate-related hazards, and (3) in different contexts. This study was the first to comprehensively test to what extent perceptions of the reality, causes, and consequences of climate change are related to three different types of adaptation actions, namely policy support, information seeking, and preparative adaptation behaviours and intentions. We examined these relationships in two different countries (the Netherlands and the UK) and we looked at different climate risks (pluvial flooding and urban heat island effects, and heatwaves, respectively). Below, we present the results for policy support, information seeking, and adaptation behaviour across both studies.

5.1 Policy support

Across the two studies, stronger climate change perceptions were consistently associated with stronger support for adaptation policy, with small to medium strength effect sizes. These relationships were stronger when the policies were introduced as ways to adapt to climate change. Overall, these findings are consistent with previous studies, which also generally found a positive relationship between climate change perceptions and policy support (Bateman and O'Connor 2016; Mildemberger et al. 2019). Expanding the previous findings, we demonstrated that these relationships hold even when climate change perceptions and policy support are measured one week apart, indicating that these findings are not likely to be the result of common method variance (Arnulf et al. 2014). More generally, our findings further confirm previous studies that have shown that climate change perceptions are associated with support for climate policies in general (see also Hornsey et al. 2016).

5.2 Information seeking

The pattern of results for information seeking was mostly similar to policy support: across both studies, stronger climate change perceptions were generally associated with more information seeking (intentions). Yet, in study 2, the correlations with information seeking intentions were only significant if the information was explicitly introduced as relating to hazards caused by climate change. Importantly, climate change perceptions were also associated with actual information seeking (in the form of requesting to see more information at the end of the study), further highlighting the real-world implications of these findings. Interestingly, explicating that the risks were caused by climate change did not strengthen the relationship between climate change perceptions and actual information seeking. We further found that the relationship holds even when climate change perceptions and information seeking are measured one week apart, further underpinning the robustness of these findings. To our knowledge, this paper is one of the first to show that climate change perceptions are associated with seeking information about climate change risks and ways to adapt.

5.3 Preparative adaptation behaviour

There was mixed evidence for the relationship between climate change perceptions and preparative adaptation intentions and behaviour (i.e. actions taken before the onset of climate-related hazards to reduce or avoid their negative impacts). In study 1, stronger climate change perceptions were associated with a higher likelihood that people had engaged in only two of the seven adaptive behaviours, namely having a green garden and a green front garden. Furthermore, stronger climate change perceptions were associated with stronger intentions to implement a green roof, a green (front) garden, house insulation, and a rain barrel, but not with intentions to implement sun blinds or a pond. These findings were however only partly replicated in study 2, where climate change perceptions correlated only with intentions to plant plants around the home and intention to install sun-blocking curtains, but not with intentions to implement six other adaptation behaviours. It is unlikely that the reason why we detected more significant results in study 1 was due to the larger sample size in this study, as the observed effect sizes were also larger in study 1. Moreover, an a priori power calculation indicated that study 2 was sufficiently powered to find effect sizes similar to those found in study 1.

These findings mirror previous studies that also showed that climate change perceptions are inconsistently associated with preparative adaptation behaviour. Yet, our study expanded upon these previous studies in several ways. First, we measured all three types of climate change perceptions (reality, causes, and consequences) in both studies, and did not find that any one of these three perceptions was more consistently associated with adaptation behaviour than others. The inconsistent findings are therefore likely not attributable to the type of climate change perceptions that were assessed. Second, based on the findings of study 1, we tested whether the strength of the relationship may depend on whether people recognise that certain behaviours are a way to reduce the risks of climate change. Yet, even if the measures were explicitly introduced as measures to adapt to climate change, there were few significant correlations between the climate change perceptions and preparative adaptation behaviour intentions. The inconsistent findings across studies are therefore not likely due to the fact that people may not see the adaptation measures as ways to adapt to climate change.

Third, by consistently using the same items across both studies to measure climate change perceptions, we ruled out that the inconsistent findings may be due to differences in the item wording across studies. Also, it is unlikely that the inconsistent results were caused by a measurement error for the specific types of climate change perceptions, since the pattern of results was consistent across different climate change perceptions. Importantly, the climate change perceptions scale that we employed used a 7-point scale, and is therefore able to capture climate change perceptions more accurately than measures with fewer response options used in previous studies, which further reduces possible measurement error due to reduced variance. Note, however, that the mean scores on all climate change perceptions were rather high (approximately 6 on a 7-point scale in both studies), which could have caused a ceiling effect and may partly explain why the correlations between climate change perceptions and other constructs are often only small to medium in size, or non-significant. Yet, this ceiling effect reflects the fact that most people accept the scientific consensus on climate change (Steg 2018). Despite this ceiling effect, we found that stronger climate change perceptions were associated with stronger policy support and information seeking, even when there were few response options in the dependent variable (e.g. three response options for information seeking in study 1). The inconsistent findings of the relationships between climate change perceptions and adaptation behaviour are therefore not likely due to ceiling effects.

5.4 Future research directions

One reason for the inconsistent relationship between climate change perceptions and preparative adaptation intentions and behaviour could be that people also engage in adaptation behaviours for reasons other than climate change. For example, people may want to install a green garden for aesthetic purposes or as a hobby. These other motives could be stronger predictors of adaptation behaviour than climate change perceptions, but we did not include this in our current studies. Future studies could test the role of such other motivations to engage in adaptive behaviour.

Another explanation could be that the relationship between climate change perceptions and preparative adaptation behaviour is influenced by place-, hazard-, or behaviour-specific factors. General factors such as climate change likely predict adaptation behaviour better if people translate such perceptions into perceptions of local risks and link them to a need to adapt. Moreover, as mentioned in the introduction, studies have found that behaviour-specific barriers can affect the likelihood that people engage in adaptation behaviour (van Valkengoed and Steg 2019a). On the basis of protection motivation theory, we suggest that people's perceived ability of implementing the behaviour (i.e. self-efficacy), and the perceived effectiveness of the behaviour to reduce the negative impacts of climate change (i.e. outcome efficacy; Grothmann and Patt 2005; Rogers 1983), may be relevant behaviour-specific variables that could influence the extent to which climate change perceptions are related to adaptation behaviour. While we experimentally manipulated whether the adaptation behaviours were explicated as measures that would reduce the risks of climate change in study 2, we did not manipulate the perceived efficacy of these behaviours in reducing climate risks. Hence, people may have perceived the measures as not very effective to address climate change risks or as too costly, which could explain why people did not intend to implement the behaviours even if they had strong climate change perceptions. Future studies could examine the role of such place-, hazard-, or behaviour-specific factors in adaptation behaviour, and whether the relationship between climate change perceptions

and adaptation behaviour is stronger when people's perceived self-efficacy and outcome efficacy are high.

Studies on adaptation action have so far primarily been conducted in the USA and Australia, and have focused on adaptation to risks such as floods and hurricanes (van Valkengoed and Steg 2019a). We contributed to this body of literature by testing the relationships between climate change perceptions and adaptation to pluvial flooding and urban heat island effects in the Netherlands and adaptation to heatwaves in the UK, and found similar results. To further test the generalizability of these findings, future research could test the relationship between climate change perceptions and other adaptation actions, in response to other climate change risks, and in other geographical contexts. Especially important is testing these relationships in geographical areas that remain understudied in the literature, but that are particularly vulnerable to climate change impacts, such as Asia, Africa, and Latin America, as widespread adaptation is a critical need there (van Valkengoed and Steg 2019a). Moreover, future studies could test different types of adaptation actions that we did not examine in the current study, such as purchasing insurance, permanently retreating from areas, and engaging in local political action (Carman and Zint 2020; van Valkengoed and Steg 2019b). In doing so, it can be tested to what extent these actions vary in their perceived difficulty and the extent to which people may perceive them as effective to reduce the risks of climate change, which would provide insight into the effects of self-efficacy and outcome efficacy on the relationship between climate change perceptions and adaptation actions.

Another unexplored area where the role of climate change perceptions may be relevant are maladaptive behaviours: behaviours that contribute to reducing the impacts of climate-related hazards in the short run, but that increase climate change risks in the long run, for example by increasing CO₂ emissions (Barnett and O'Neill 2010). An example of a (mal) adaptive behaviour that may inhibit climate change mitigation is the use of air conditioners (Viguié et al. 2020). Examining the drivers of maladaptive behaviour, where climate change perceptions likely are also of importance, is critical to avoid large-scale maladaptation at the level of individuals and households.

5.5 Practical implications

Our findings have important implications for the design of interventions to promote adaptation actions. Our results showed that the relationship between climate change perceptions and information seeking intentions and policy support was stronger if the policies and/or information are explicitly introduced as measures to adapt to climate change. This suggests that information seeking and policy support can be enhanced when both are introduced as ways to adapt to climate change. Moreover, interventions could be developed that strengthen people's climate change perceptions to promote both policy support and information seeking in response to different hazards. For example, climate change perceptions can be increased by exposing people to information on the scientific consensus of climate change (van der Linden et al. 2015). Yet, to promote preparative adaptation behaviours, it may not be sufficient to clarify that the measures contribute to adapting to climate change risks, or to strengthen climate change perceptions. Rather, it may be important that behaviour-specific barriers such as a lack of perceived self-efficacy and outcome efficacy are addressed too, in order to enable people to translate their climate change perceptions into action. This can be done for example by providing information on the ease and effectiveness of adaptation measures, providing people with expert help, or using subsidies to lower

the costs of adaptation measures. Moreover, people may engage in adaptation behaviours for reasons that are not directly related to climate change. Tapping into these other reasons for adaptation behaviour may potentially also be a relevant strategy to motivate adaptation behaviour.

In summary, stronger climate change perceptions were consistently associated with stronger policy support and information seeking in response to pluvial flooding and urban heat island effects in the Netherlands, and heatwaves in the UK. Yet, we found mixed effects for preparative adaptation behaviours: climate change perceptions were associated with some behaviours and intentions to adapt to pluvial flooding and urban heat island effects in the Netherlands, but hardly related to intentions to adapt to heatwaves in the UK. Overall, our findings suggest that climate change perceptions can be an important gateway for different types of adaptation actions including policy support and information seeking. However, in order to motivate people to implement preparative adaptation behaviours, it may be necessary to address additional factors to enable people to translate their climate change perceptions into action.

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Author contribution All authors contributed to the research idea and study design. AV collected and analysed the data for both studies. All authors contributed to writing the manuscript.

Data availability All data, materials, and code are available via Open Science Framework: https://osf.io/gqbws/?view_only=703861cb5b4c48d69d47a3c0ec5b5e1d.

Declarations

Conflict of interest The authors declare no competing interests.

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