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Impact framing and experience for determining acceptable levels of climate change risk: A lab experiment

Ambika Markanday^a, Steffen Kallbekken^b and Ibon Galarraga^a

This paper explores how individuals determine acceptable levels of risk (ALR) when making investment decisions on climate change adaptation. An incentivised lab experiment (n=161) is conducted on a sample of the Bilbao population. A 2x2 factorial between-subject design measures ALR in response to visual (photo vs. text-only) and numeric (single-value vs. range) impact framings. The effect of experience on ALR is also measured using a 2-period repeated game within-subject design. Findings support an extension of the dual processing model that argues people exert practical rationality, based on both objective reasoning and subjective experience, when making decisions over moral dilemmas, such as climate change. Subjects in visual conditions had lower ALR, due to greater negative affect, concern, and sense of personal duty and responsibility towards climate change. This suggests a moral judgement of the risk in question. The effect of the visual appeal was lower in the range condition, where greater mental effort led to more objective reasoning. Those that experienced damages in period 1 displayed lower ALR in period 2. No difference in ALR was found between periods for those that did not experience damages. The implications of these findings are discussed.

Keywords: climate change adaptation, climate change communication, lab experiment, risk acceptability, risk framing, behavioural economics

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1. Introduction

The science of climate change is multifaceted, covering subject areas as diverse as climatology, physics, economics, sociology, engineering, and ecology. Scenarios of future climate change impacts are probabilistic and uncertain due to difficulties in understanding the complex interactions between natural and human systems across scales, and the sensitivity of these systems to climate changes over time (Refsgaard et al., 2007). While scientists warn us about the potential likelihood of catastrophic climate events, such as extreme floods, heat waves, and drought, these risks are difficult for decision-makers and other stakeholders to interpret, and in some cases can be underestimated (Galarraga et al., 2018), increasing the potential for ineffective adaptation (Camerer and Kunreuther, 1989; Weitzman, 2009; Galarraga et al., 2018). Finding the 'sweet spot' between science and action requires making the science accessible, comprehensible and useful for decision-makers. This means translating highly technical scientific content into concise, affirmative messages able to target broad audiences with different cognitive and analytical capabilities, such as policy-makers, citizens and various other leaders in public and private sectors. But communications science must also acknowledge the psychological and emotional driver and barriers to action. Humans do not always make economically rational choices but may use other forms of emotional and intuitive reasoning based on, for example, social systems, beliefs, and values to make decisions. Investigating how different communication framings can affect psychological responses to climate change risk will be fundamental for understanding what drives people to take action. For the communication process to be effective, a collaborative effort between subject-matter experts, decision scientists, social and communication scientists, and programme designers has been advised (Pidgeon and Fischhoff, 2011).

1.1 The Psychology of Choice: Theories and concepts

As far back as the early 1920s, social marketing literature documented how different 'framings' of advertisements or public messages can persuade individuals to behave or act in certain ways. Edward Bernays (1891–1995) is arguably the earliest known pioneer of such work. Bernays infamously encouraged a rise in female smokers by convincing women's rights activists in New York City to hold up Lucky Strike cigarettes as symbolic 'torches of freedom' during his work for the American Tobacco Company in 1929 (REF). Bernays discovered early on that psychological and social motives could be used to manipulate public opinion (Bernays, 1928, 1942). The suggestion that people could be persuaded to act against their own best interests (that is, decide not to maximise their expected utility when choosing among uncertain payoffs) led economists to question the central assumptions underpinning rational decision-making. The development and empirical testing of Prospect Theory in 1979 was a major discovery in this regard (Kahneman and Tversky, 1979). It showed that decision-makers respond differently to different but objectively equivalent descriptions of the same risk. Since its establishment, a plethora of studies on framing effects in different areas of health, education, business, and environment, have debunked notions of homo economicus, or the 'rational actor' (Levin et al., 1998a; Gintis, 2000).

Extensive research on the psychology of choice has been used to understand occasions wherein humans might depart from rationality. Dual Processing Theory provides a well-supported explanation of why this happens. The theory argues that humans possess two modes of thinking, one automatic and the other deliberate, popularly referred to as the dispassionate System 1 and System 2 (Kahneman and Egan, 2011). On the one hand, System 1 is automatic and fast, grounded on intuition, emotions, and heuristics enabling us to make quick decisions. System 1, for example, is activated when we read the sum $2+2$. On the other hand, System 2 is attentive, rational, effortful, and requires immense concentration for deliberate decisions including complex computations. System 2, for example, is

activated when we read the sum 23×42 . Because humans have limited cognitive capacity, our inability to exert too much mental effort, means we rely largely on System 1 and its shortcuts for making decisions. The feelings and immediate intuitions first experienced by System 1 later feed into System 2 as beliefs and may act to steer decisions a certain way. The problem with the dependence on mental shortcuts within System 1 thinking is that it can at times trigger cognitive biases whereby we fail to notice important complexities that might cause us (unknowingly) to make irrational decisions. Kahneman and Egan (2011) illustrate it with the following problem:

A bat and a ball together cost \$1.10. The bat costs \$1 more than the ball. How much does the ball cost?

The majority of respondents will automatically and intuitively answer "10 cents." But of course, when considered carefully, the true answer becomes apparent. The ball costs 5 cents, the bat costs \$1 more than the ball, so the bat costs \$1.05 and together they cost \$1.10. Heuristics play an interesting role in our thinking, and we employ them much more frequently than one might think.

In this paper, we will focus on three main types of heuristics: availability, affect and framing. The availability heuristic suggests that people will judge the likelihood of an event based on how easily examples come to mind. Decisions applying this heuristic may be the product of information retrieved from memory or experience, as a result of trial and error, or a familiarity and repetition of past behaviour. The affect heuristic instead, is what happens when decisions are affected by current emotion. Reading the word "death", for example, might trigger feelings of fear or sadness, while reading the word "love" might trigger feelings of pleasure or happiness. Lastly, framing refers to how messages or choices are presented. It exploits the notion "what you see is all there is" (Kahneman and Egan, 2011) by creating reference points for individuals to focus on when making decisions. Bernays used framing to enable women to perceive a cigarette as a revolutionary symbol of freedom, rather than a deadly health hazard.

We will argue that System 1 and System 2 should not necessarily be viewed as two distinct features of cognitive processing. Heuristics and emotions are not always synonymous with subconscious irrationality or 'gut feelings' but can also be symbolic of ethical intuitions and emotions based on long-lasting reflection and deliberation. This is likely to hold true particularly in personal cases where we tend to adopt Kantian perspectives (we make decisions based on whether the action itself is right or wrong rather than its consequences) compared to impersonal cases where we tend to be more utilitarian (maximise utility) (Roeser, 2010). Understanding psychological responses to the risks of climate change and moral or ethical motivations for taking action is likely to be an important missing link in devising effective communication strategies on climate change. Emotions, for one, are important drivers of risk perception, often referred to as "risk as feeling" (Slovic et al., 2007), but tend to be excluded from decision-making when it comes to climate change (Roeser, 2012). When a policy-maker thinks about protecting a town from flooding, for example, they might not only consider the costs of protection and the probability of damages, but their decision might also be influenced by the community and livelihoods that might be affected. In this case, emotional responses may drive a sense of moral responsibility or social rationality towards a greater good, one that supersedes the economic utility of maximising expected values. While notions of social and cognitive rationality within climate change decision-making have been explored (Armaş and Avram, 2009; Terpstra, 2011; Carlton and Jacobson, 2013; Aasen and Vatn, 2018), few studies have attempted to evaluate these decision-making elements in a controlled setting. There is a great need for empirical research exploring the psychological elements of decision-making, particularly in relation to climate change. Certainty, experiments such as the Ultimatum Game and the Public Goods Game have proven a number of irregularities in the way that human behaviour deals with aspects such as loss aversion, pure altruism, habituation, and hyperbolic

discounting the future (Gowdy, 2008). This will help in better understanding decision processes when it comes to high-impact risks as well as providing policy-makers with insights to make well-founded decisions and better design and implement their policies.

1.2 Previous studies

Framing has been studied extensively in relation to climate change communications, particularly valence framings (that is, positive versus negative framings) since the establishment of Prospect Theory (Levin et al., 1998b). Recent studies also test framing in relation to other fundamental drivers of risk perception, such as issue relevance, political and scientific beliefs, concern, attitudes, socio-demographics, and emotions. What these studies demonstrate is that slight differences in the way we choose to describe or characterise climate change can trigger different intuitive, emotional and cognitive judgments, which can lead to different responses (Slovic et al., 2004). For instance, Shih and Lin (2017) find that reducing the psychological distance of climate change, describing it as a local (instead of distant) issue, can cause negative emotional responses and analytic appraisals that make it more personally relevant and increases motivation to take action. Affective judgment has also been found to influence individual risk tendencies and amplify or depress a frame's impact (Druckman and McDermott, 2008). Similarly, when assessing the ability of different frames to stimulate support for mitigation policy, Mossler et al. (2017) find that framing effects are contingent on prior knowledge, attitudes, and level of concern. An interesting study conducted by Swim and Bloodhard (2015) found that when subjects were shown a photo of polar bears under threat and asked to take an empathetic perspective (compared to a no-message, a harm-only, and an objective perspective) environmentalists were motivated to donate money to environmental activist groups through feelings of empathy and hope, while non-environmentalists, were motivated to donate, through feelings of empathy, hope, worry, and personal guilt.

These studies demonstrate that emotional decision making is not necessarily impulsive or based on spontaneous "gut" responses, but rather is indicative of cognitive theories of emotions, such as what Roeser (2010) calls "affectual intuitionism" wherein notions of ethical intuitions and moral emotions are interchangeable. Roeser argues that moral judgments are often treated as based on two distinct concepts: subjective (emotional) moral experience or objective rationality. Instead, Roeser urges us to consider that reflective thought and emotions arising as a result of moral dilemmas can also serve as a different form of (practical or social) rationality when making decisions. An empirical assessment of Roeser's affectual intuitionism that distinguishes between objectively rational, emotionally rational and emotionally reactive decision-making would help substantiate this theory.

The study of visual appeals such as those found in Swim and Bloodhard (2015) is an interesting focus in this respect. Indeed, images of climate change are constantly appearing across a number of social and news media outlets. While visual presentations of climate risks are suspected to be more effective than text alone (Liu et al., 2017), communication studies have highlighted a considerable gap in research on the effects of climate change imagery and decision-making (O'Neill and Smith, 2014). Of equal research importance, but similarly understudied, are numeric appeals. For example, some have called into question certain Bayesian assessments of probability based on the premise that people are better able to interpret clear numerical expressions of uncertainty but struggle with seemingly ambiguous probability expressions such as "unlikely" or "probable" (Pidgeon and Fischhoff, 2011). Similarly, while there is some indication of changes in risk preferences with respect to low-probability, high-impact climate change events (Botzen and van den Bergh, 2012), there is a lack of experimental evidence to support this premise. Further research into the way that people analytically and emotionally process different visual and numeric climate change appeals is clearly needed. In the same vein, there is little experimental evidence on the role of personal experience in the

cognitive processing of uncertain information. Experience has been recognised as a fundamental driver of risk perception and is likely to be an important and salient cognitive reference point when making decisions under risk. Studying the transiency of emotional response based on experience versus emotional responses provoked by long-lasting narratives on climate change (such as those provoked by certain visual and numerical appeals) may offer further insight into extensions of the Dual Processing Model.

Empirical research is also lacking a deeper insight into actual behaviour in the context of climate change decision making, particularly when it comes to climate risks. As it stands, communication framing and risk perception studies thus far have focused on hypothetical outcomes such as intent to act, perceived risk, perceived severity, willingness to behave environmentally, willingness to support environmental policies etc. which may give rise to important cognitive and hypothetical biases. The most convincing contribution in this respect is arguably one that measures real decision outcomes based on the costs, risks, and uncertainties of different options (Stern et al., 2006) in an experimental lab or a field setting.

1.3 Current study

Based on the research gaps outlined in the previous section, this study evaluates the effect of visual (climate change impacts presented with or without a photo) and numeric (climate change impacts presented as a single damage cost or as a range of damage costs) framings on levels of risk acceptability in a lab setting. The acceptable level of risk, our dependent variable, refers to how much risk one is willing to accept given the cost of protection, the probability of impacts, and the cost of damages. These framings are intended to provide a deeper insight into the effect of long-lasting narratives on climate change and moral judgements of risks, and different forms of objective and practical rationality in decision-making. The study also explores the influence of experience, and transient emotions, on risk acceptability. The study of experience is intended to provide a greater insight into reactive, or ‘gut’ reasoning. Based on this, the following objectives and research questions are proposed:

1. Do frames that include a photo of climate change impacts, compared to text-only frames, evoke lower levels of risk acceptability? (visual appeal)
2. Do frames that show climate change damage costs as a range of values compared to a single value evoke lower levels of risk acceptability? (numeric appeal)
3. Does "experiencing" damages lead to lower levels of risk acceptability compared to not experiencing them?

To help answer these, we develop and test the following research hypotheses:

- H1A: Communications that include a photo of impacts will result in lower levels of risk acceptability compared to text-only communications.

We surmise that seeing a photo of impacts will trigger availability (easily to recall information) and affect (particularly negative emotion) heuristics (including concern), which will drive reflective long-lasting narratives on climate change, and lead subjects to have moral judgments of the risk at stake, making them more risk-averse. Based on this we suspect subjects will employ an extension of the dual processing model using characteristics inherent to both system 1 and system 2 processing, which will drive a form of practical rationality.

- **H1B**: The communication that uses a photo of impacts and presents damage costs as a range of values ('photo-range' treatment) will have a lower impact on risk acceptability than the communication that uses a photo of impacts and presents damage costs as a single value ('photo-single-value' treatment).

We suspect that the greater cognitive processing required for range conditions will lessen the usage of availability and affect heuristics leading to more logical, rather than intuitive, decision-making. As a result, we expect that there will be a significant difference in risk acceptability between photo and text-only appeals when damage costs are presented as a single-value, but that the effect of the photo will be reduced when damage costs are presented as a range of values.

- **H2**: Communications that frame damage costs as a range of values will result in lower levels of risk acceptability compared to communications that frame damage costs as a single-value.

We suspect that subjects in range conditions ('photo-range' and 'text-only-range' treatments combined) will overweight the likelihood of high-impact events due to the availability heuristic, wherein thinking about the potential for higher damages will have a greater impact on memory and will influence subjects' probability judgment of high impact events compared to single-value conditions ('photo-single-value' and 'text-single-value' treatments combined).

- **H3**: Subjects who experience damages will lower their levels of risk acceptability in subsequent decisions, while risk acceptability will remain unchanged in subsequent decisions for those that do not experience any damages.

We believe two predominant aspects of the availability heuristic will play a role here. First, we assume that subjects who experience damages will apply a trial and error heuristic, whereby, if they experience failure (i.e. receive damages) due to past decision-making, they will adjust their decision-making process so as to reach success in a new situation. Secondly, we suspect that familiarity with the problem (i.e. knowing the outcome and repeating the exercise) will lead subjects that do not experience damages to assume that the circumstances directing past decisions still hold true and that past behaviour can be successfully applied to new decisions. This heuristic implies that if individuals experience success in a past situation (i.e. not receiving damages) they are more likely to continue to apply the same behaviour (are unlikely to change their decision) in the future.

2. Current energy efficiency labels and their effectiveness

A lab experiment was designed consisting of three parts: 1) a general risk elicitation task to measure individual risk preferences, 2) an investment decision-making task to measure the impact of different risk communications ('photo-single-value', 'photo-range', 'text-only-single-value', 'text-only-range') and experience factors (damage vs. no damage) on levels of climate change risk acceptability, and 3) a survey to measure different socio-demographic and cognitive effects pertaining to the various treatments. The experiment comprised a 2 (visual impact: photo and text vs. text-only) x 2 (numeric impact: range of damage costs vs. single-value damage cost) between-subject design for measuring framing effects and a 2-period repeated-game within-subject design for measuring experience effects. So as to experience real gains and losses, subjects were able to earn experimental tokens (€1 was equivalent to 50 tokens) during the first two tasks.

2.1 Measures

A lab experiment was designed consisting of three parts: 1) a general risk elicitation task to measure individual risk preferences, 2) an investment decision-making task to measure the impact of different risk communications ('photo-single-value', 'photo-range', 'text-only-single-value', 'text-only-range') and experience factors (damage vs. no damage) on levels of climate change risk acceptability, and 3) a survey to measure different socio-demographic and cognitive effects pertaining to the various treatments. The experiment comprised a 2 (visual impact: photo and text vs. text-only) x 2 (numeric impact: range of damage costs vs. single-value damage cost) between-subject design for measuring framing effects and a 2-period repeated-game within-subject design for measuring experience effects. So as to experience real gains and losses, subjects were able to earn experimental tokens (€1 was equivalent to 50 tokens) during the first two tasks.

2.1.1 Risk propensity

Before commencing the investment decision-making task, subjects were asked to complete an incentivised risk elicitation task to measure their general risk-taking behaviour. This task was designed following the guidelines of Falk et al. (2016), which proposes a staircase risk procedure for determining risk preferences. Subjects were asked to make five interdependent choices between a lottery and a sure payment. While the lottery stays the same in all decisions, the sure payment adjusts to be higher or lower depending on what the subject selected in his/her previous response. Risk scores between (1 risk-averse to 32 risk-taking) were calculated based on subjects' implied switching row, that is, the point at which subjects switched from preferring the lottery to the sure payment. Subjects could earn a maximum of 150 experimental tokens (€3 equivalent) during this round.

2.1.2 Level of risk acceptability

For the investment decision-making task, subjects were instructed to assume the role of a local policymaker responsible for the coastal town of Zarautz (Basque Country, Spain)¹. They were given some background information on the town (such as its location and size of the beach) and a message from their policy advisors informing them of the potential likelihood of extreme storm events and costs of impacts. In this message, subjects in single-value conditions were shown an average damage cost, while subjects in range conditions were shown a range of damage costs consisting of an average damage cost and a high damage cost. Subjects in photo conditions were shown a photo of damages caused to the Zarautz coastline as a result of an extreme storm event that took place in 2014, procured from online news reports, while those in text-only conditions were not shown this slide.

Two solutions were next described for protecting the town: nourishing the beach with sand (called level 1) and a submerged breakwater structure (called level 2). Subjects were allocated a fixed budget of 850 experimental tokens (€17 equivalent) for protecting their town and were shown a table

¹ It is not unreasonable to expect distinct differences in decision processes for individuals versus actual policy-makers. Individuals are likely to make decisions that affect their own personal gains, while policy-makers are often concerned with the utility of multiple actors (i.e. various organisations, departments, sectors, different societal groups, or society as a whole). Of course, policy-makers might also be concerned about personal gains, but this type of decision-making would undoubtedly require the consideration of more moral or ethical dimensions as choices would affect entities outside of oneself. Moral decision-making is also likely to play a greater role for policy-makers in the public eye, who must consider their level of accountability when it comes to taking decisions with potentially grave consequences. While we would expect participants to be motivated by individual gains (insomuch as their payoffs are determined by the hypothetical choices they make during the experiment), asking them to assume the role of a policy-maker might also activate a greater sense of moral duty and responsibility when deciding between actions and enable a better study of practical versus objective rationality within decision-making.

of their options. The table showed nineteen options, which incrementally increased in cost and water protection height. Subjects could select between a no protection solution (option 1), a level 1 solution (options 2–10) and a level 2 solution (options 11–19). Each incremental increase in investment resulted in a 5 % decrease in the likelihood of incurring a fixed damage cost, wherein option 1 (no protection) had a 95 % of receiving damages and option 19 (maximum protection) had a 5 % chance of receiving damages. Expected values (EV) marginally decreased with each increase in investment, with option 1 having the highest EV and option 19 having the lowest. To make the exercise as simple as possible, whether or not an individual received damages was set-up to replicate the rolling of a 20-sided dice on the computer. Each participant was also given an actual 20-sided die to familiarise themselves with the probabilities of certain outcomes occurring. Once participants selected their option, they were asked to "roll the dice" on the computer to randomly determine whether they had incurred any damages as a result of climate change. All investment costs and any damage costs that a subject incurred was deducted from his/her initial budget. Since different investment amounts corresponded to different impact probabilities, the amount that subjects chose to invest in adaptation was used as a proxy for risk acceptability. This measure was treated as a continuous dependent variable (refer to supplemental files for experimental materials used for the risk decision-making task).

2.1.3 Experience

Subjects were informed that they would be asked to make an investment decision at two points in time, called Period 1 and Period 2, but that all protection costs, probabilities and damage costs would remain the same between the two periods. Once subjects invested and discovered their outcome from Period 1, they were asked to make the investment decision for Period 2. They were instructed to assume that all protection had been stripped from the coast between the two periods and that they were to make the investment decision again, the only difference being that they had the benefit of knowing the outcome from Period 1. The difference in risk acceptability levels for participants that experienced damages, compared to those that didn't, was used as a measure of experience.

2.1.4 Emotions

The well-established scales of positive and negative affect (PANAS) developed by Watson et al. (1988) were used as a measure of subjects' emotional response. An 8-item scale was developed consisting of four negative affect items (fear, guilt, distress, nervousness) and four positive affect items (determination, interest, enthusiasm, empowerment). Subjects were asked to rate how much they felt each item on a 5-point Likert scale ranging from very slightly or not at all to very much. Measures of emotional response were assessed as individual items and as grouped items to give a general indication of positive and negative affect.

2.1.5 Level of concern and climate change beliefs

Subjects were asked to rate their level of concern regarding the impacts of climate change in Zarautz on a 5-point Likert scale that ranged from very slightly or not at all to very much. To measure beliefs, as well as to gauge subjects' sense of moral duty and responsibility towards climate change, the following statement was designed and shown to participants:

"Climate change is happening and observed increases in greenhouse gas (GHG) pollution due to human activities are largely responsible. Over the 20th century, we have seen many changes such as rising global sea levels, extensive melting of snow and rises in global average air and ocean temperature. The consensus in the scientific community indicates if we reduce carbon pollution to an acceptable level the worst effects of climate change can be avoided. We are all responsible for this problem and the

potential consequences for our future and next generations. Climate change is a major challenge that must be addressed by governments, industries, and individuals before it is too late to reverse the worse projected scenarios. Doing something for climate change is a moral duty,"

Subjects were asked to rate how much they agreed with the above statement on a 5-point Likert scale ranging from strongly disagree to strongly agree.

2.1.6 Place attachment and socio-demographics

Place attachment was measured using an adapted 8-item scale developed by Jorgensen and Stedman (2001). Subjects were asked whether they had ever visited Zarautz and if so to indicate how many times. After which subjects were asked to rate the 8-items using a 5-point Likert scale ranging from strongly disagree to strongly agree. The eight items consisted of two place identity measures ("visiting Zarautz says a lot about who I am" and "I identify strongly with Zarautz"), three place dependence measures ("Zarautz is the best place for what I like to do", "I get more satisfaction out of visiting Zarautz than any other place" and "Doing what I do at Zarautz is more important to me than doing it at any other place"), and three place attachment measures ("Zarautz is a very special place to me", "I am very attached to Zarautz" and "No other place can compare to Zarautz"). Finally, key socio-demographic information such as nationality, age, gender, and education were also collected.

2.2 The sample

A computerised artefactual lab experiment was conducted at the University of the Basque Country in September 2018 on a representative sample of the population in Bilbao, Basque Country (Spain). The independent survey recruitment company CPS in Bilbao was used to capture a sample representative in terms of age, gender, social class, nationality and job type. The experiment was translated to and conducted in Spanish. One-hundred-sixty-one participants were recruited and randomly assigned to one of the four treatments. Each treatment group consisted of approximately 40 participants. Subjects were 51 % female, 49 % male and < 1 % non-binary. Ages ranged from under 18 to over 65, with education levels of primary and secondary level up to university level. 80 % of participants identified as Spanish, 12 % as Basque, and 8 % were from other nationalities.

3. Analysis and results

This section will first describe the results from the risk elicitation task. It will then go through the Analyses of Variance (ANOVA) tests (Snee, 1976) conducted to test each hypothesis, after which details on additional analyses and findings will be presented along with the results from an overall logistical regression analysis. All analyses were conducted using the statistical software package R.

3.1 Risk propensity

A chi-squared goodness-of-fit test was conducted to determine if risk scores were normally distributed. A p-value of <0.001 indicated that the data did not fit a normal distribution. We attribute this to the fact that during the experiment some participants had informed us that they had not fully understood they were supposed to make five consecutive decisions and instead continued to click on their first choice (of lottery or sure payment) until entering the next task. A general 3-peaked distribution of risk scores, with a number of subjects scoring as very risk-averse and very-risk taking, confirms this suspicion. We omitted this noise from the data by excluding risk scores of under 3 and over 30 and repeated the chi-squared goodness-of-fit test. This test still resulted in a significance value of $p=0.007$, and for this reason, we decided to exclude this variable from further analysis.

3.2 The effect of visual appeals on risk acceptability

Subjects invested an average of 125.5 (Standard deviation, D=46.36) tokens in photo conditions compared to 106.2 (SD=45.99) tokens in text-only conditions. ANOVA test confirmed that subjects in photo conditions invested significantly more than those in text-only conditions $F(1,159)=6.595$, $p\text{-value}=0.011^*$, thus hypothesis 1A is not rejected.

As hypothesised, visual framing effects were stronger in single-value conditions $F(1,80)=9.499$, $p\text{-value}=0.003^{**}$ compared to range conditions $F(1,77)=0.573$, $p\text{-value}=0.452$, thus hypothesis 1B is not rejected.

Subjects in photo conditions were found to exhibit significantly greater negative affect responses related to feelings of guilt (M=1.99, SD=1.31 vs. M=1.61, SD=0.98), $F(1,159)=4.411$, $p\text{-value}=0.037^*$ and fear (M=2.04, SD=1.27 vs. M=1.67, SD=1.10) compared to text-only conditions $F(1,159)=3.948$, $p\text{-value}=0.048^*$. In addition, subjects in photo conditions displayed significantly higher levels of concern (M=4.21, SD=0.99 vs. M=3.58, SD=1.09), $F(1,159)=14.78$, $p\text{-value}=0.0002^{***}$, and showed much greater agreement with the statement on climate change (M=4.74, SD=0.65) compared to text-only (M=4.42, SD=1.05) conditions $F(1,159)=5.33$, $p\text{-value}=0.022^*$ (refer to Table 1 and 2 for summary and ANOVA results of treatments).

Table 1: Summary of values for treatments

	Photo ^a	Text ^b	Single-value ^c	Range ^d	Total
Risk acceptability					
Period 1	125.5 (46.36)	106.2 (45.99)	118.3 (45.99)	113.2 (51.43)	115.8 (48.58)
Positive affect					
Interested	3.81 (1.16)	4.03 (0.97)	4.05 (1.00)	3.79 (1.13)	3.92 (1.07)
Determined	3.63 (1.23)	3.51 (1.29)	3.65 (1.31)	3.48 (1.20)	3.57 (1.25)
Enthusiastic	2.71 (1.27)	2.83 (1.27)	2.83 (1.19)	2.71 (1.35)	2.77 (1.27)
Empowered	2.96 (1.33)	2.75 (1.27)	2.96 (1.33)		
Negative affect					
Distressed	1.99 (1.25)	2.25 (1.21)	2.10 (1.21)	2.14 (1.26)	2.12 (1.23)
Guilty	1.99 (1.31)	1.61 (0.98)	2.01 (1.33)	1.57 (0.93)	1.80 (1.17)
Scared	2.04 (1.27)	1.67 (1.10)	1.95 (1.27)	1.75 (1.11)	1.85 (1.19)
Nervous	1.96 (1.30)	1.95 (1.09)	1.92 (1.20)	2.00 (1.20)	1.96 (1.20)
Concern and beliefs					
Concern	4.21 (0.99)	3.58 (1.09)	3.84 (1.14)	3.95 (1.04)	3.89 (1.09)
Beliefs	4.74 (0.65)	4.42 (1.05)	4.62 (0.81)	4.53 (0.96)	4.58 (0.88)
Task difficulty					
Difficulty	1.75 (0.96)	1.83 (0.98)	1.63 (0.92)	1.95 (1.0)	1.79 (0.97)

Note: Values show the mean and standard deviations in brackets.

^a Considers both ‘photo-single-value’ and ‘photo-range’ treatment groups

^b Considers both ‘text-single-value’ and ‘text-range’ treatment groups

^c Considers both ‘photo-single-value’ and ‘text-single-value’ treatment groups

^d Considers both ‘photo-range’ and ‘text-range’ treatment groups

3.3 The effect of different numeric appeals on risk acceptability

No significant difference in investment amounts was detected between single-value ($M=118.3$, $SD=45.83$) and range ($M=113.2$, $SD=51.43$) conditions $F(1,159)=0.447$, $p\text{-value}=0.505$. Hypothesis 2 is therefore rejected.

Participants in single-value conditions were, however, found to have higher levels of guilt ($M=2.01$, $SD=1.33$) compared to those in range conditions ($M=1.57$, $SD=0.93$) $F(1,159)=5.957$, $p\text{-value}=0.016^*$. There was no significant difference in levels of concern $F(1,159)=0.395$, $p\text{-value}=0.531$, or climate change beliefs $F(1,159)=0.418$, $p\text{-value}=0.52$, between numeric appeals. As expected, task difficulty levels were found to be considerably higher in range conditions ($M=1.95$, $SD=1.0$) compared to single-value ($M=1.63$, $SD=0.92$) conditions $F(1,159)=4.33$, $p\text{-value}=0.039^*$.

Table 2: Summary of ANOVA results

	Photo and text vs. Text-only	Single-value vs. Range
Risk acceptability		
Period 1	6.595 (0.011)*	0.447 (0.505)
Positive affect		
Interested	1.582 (0.21)	2.461 (0.12)
Determined	0.36 (0.55)	0.698 (0.41)
Enthusiastic	0.326 (0.57)	0.36 (0.55)
Empowered	1.047 (0.31)	1.12 (0.29)
PA (grouped)	0 (0.99)	1.618 (0.21)
Negative affect		
Distressed	1.794 (0.18)	0.046 (0.83)
Guilty	4.411 (0.037)*	5.957 (0.016)*
Scared	3.948 (0.048)*	1.179 (0.28)
Nervous	0.004 (0.95)	0.204 (0.65)
NA (grouped)	0.794 (0.37)	0.839 (0.36)
Concern & Beliefs		
Concern	14.78 (0.0001)***	0.395 (0.531)
Beliefs	5.33 (0.022)*	0.418 (0.52)
Task difficulty		
Difficulty	0.253 (0.62)	4.33 (0.039)*

Note: The table shows F values and P values in brackets. * $p<0.05$, ** $p<0.01$, *** $p<0.001$

3.4 The effect of experience on risk acceptability

A paired sample t-test was conducted to assess the impact of experience on risk acceptability levels. As hypothesised, subjects who experienced damages in Period 1 were found to invest significantly more in Period 2 ($p\text{-value}=0.007^{**}$), whereas no significant difference in investment was observed between Period 1 and Period 2 for participants that did not experience damages ($p\text{-value}=0.211$) (Figure 1). Hypothesis 3 is therefore not rejected. Subjects that experienced damages, however, did not exhibit stronger emotional responses, such as positive affect $F(1,159)=0.009$, $p\text{-value}=0.923$, or negative affect $F(1,159)=1.954$, $p\text{-value}=0.164$, levels of concern $F(1,159)=0.04$, $p\text{-value}=0.842$, or climate change beliefs $F(1,159)=0.735$, $p\text{-value}=0.393$ (see Annex A for summary statistics).

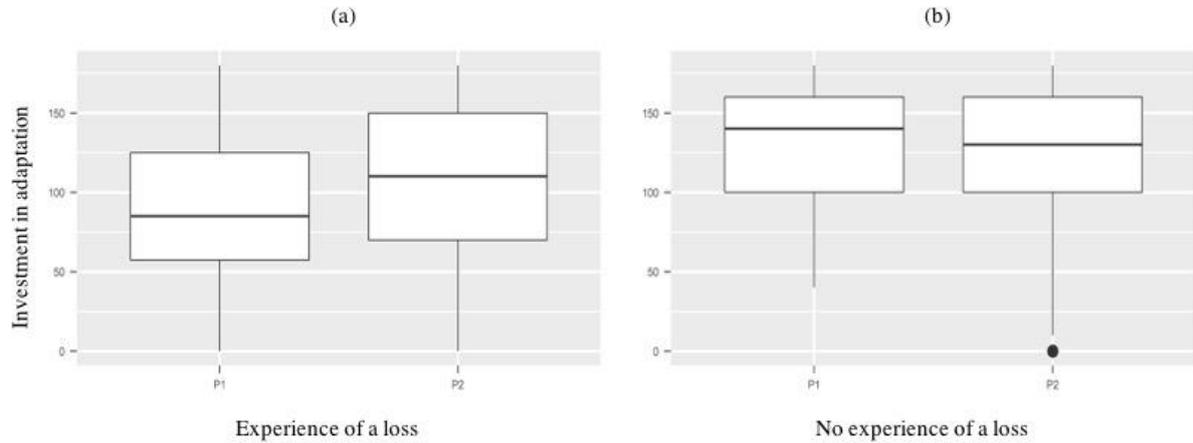


Figure 1: Investment in Period 1 and Period 2 for those that experienced a loss (a) and for those that did not (b) between the two periods

3.5 Conditional analysis

To account for the interaction between the treatments, experience, and control for other important factors, this section adds a conditional analysis. Table 3 shows the results from a logistic regression, with model 1 based on data from period 1 and model 2 based on data from period 2.

Table 3: Results of regression analysis for Period 1 and Period 2

	Period 1 ^(model 1)		Period 2 ^(model 2)	
	Coeff (std. error)	p-value	Coeff (std. error)	p-value
Treatment				
Photo ^a	27.76 (11.39)	0.016*	9.20 (11.18)	0.412
Range ^b	-4.13 (11.16)	0.712	9.74 (10.80)	0.369
Treatment interaction	-22.96 (16.00)	0.153	-0.69 (15.67)	0.965
Emotions				
Interest	1.97 (10.48)	0.851	5.57 (10.23)	0.587
Distress	-3.24 (13.38)	0.813	-3.31 (13.22)	0.803
Excitement	17.38 (9.42)	0.067	15.12 (9.19)	0.102
Empowerment	-14.92 (9.92)	0.135	-13.60 (9.66)	0.161
Guilt	19.40 (13.34)	0.148	12.70 (13.08)	0.333
Fear	-12.75 (14.20)	0.371	1.31 (13.73)	0.924
Determination	1.86 (9.03)	0.837	-3.37 (8.76)	0.701
Nervousness	14.60 (14.37)	0.311	14.37 (13.87)	0.302
Concern, attachment, beliefs				
Concern	3.72 (9.25)	0.688	-4.30 (9.04)	0.635
Beliefs	-10.14 (13.71)	0.461	-14.30 (13.25)	0.283
Place attachment	-0.07 (0.46)	0.875	-0.43 (0.44)	0.336
Task difficulty				
Difficulty	18.83 (19.01)	0.324	-24.61 (18.72)	0.191
Time				
Time taken	-1.59 (1.38)	0.252	1.50 (1.34)	0.267

Socio-demographics				
Age	7.07 (9.30)	0.396	-5.08 (8.01)	0.527
Gender	-8.60 (8.68)	0.323	-2.93 (8.40)	0.727
Education	-11.18 (7.93)	0.161	-5.82 (7.74)	0.453
Experience				
Damage			-24.05 (8.35)	0.005**
R²	0.18		0.18	
Adjusted	0.07		0.07	
P-value	0.050		0.067	

Note: *p<0.05, **p<0.01, ***p<0.001

^a Measures whether or not treatments included a photo of impacts

^b Measures whether or not treatments included damage costs as a range

The significant effect of the photo in model 1, and experiencing damage in model 2 confirms the acceptance of hypotheses 1A and 3. We tested hypothesis 1B by adding an interaction term for visual and numeric treatments. We find that the combination of a visual appeal and framing climate impacts as a range has a lower (and non-significant) impact on levels of risk acceptability). Thus, hypothesis 1B is accepted. The lack of a significant difference in levels of risk acceptability when framing climate change damage costs as a range compared to a single-value in model 1 supports the rejection of hypothesis 2.

To account for the influence of other important factors we included further independent variables in the conditional analysis. No significant correlation was found between place attachment and levels of risk acceptability (R²=0.009, p-value=0.228), positive affect (R²=4.273e-06, p-value=0.979), negative affect (R²=0.003, p-value=0.499), level of concern (R²=0.0001, p-value=0.894) or climate change beliefs (R²=0.008, p-value=0.248).

Further ANOVA tests confirm no difference in levels of risk acceptability between men and women F(1,158)=3.255, p-value=0.073, but find that women felt more interested F(1,159)=14.3, p-value=0.0002***, enthusiastic F(1,158)=9.397, p-value=0.0026**, and empowered F(1,158)=9.659, p-value=0.0022** during the exercise, compared to men.

4. Discussion

In this section, we will discuss the findings while reflecting upon their contributions to the literature on climate change communication and risk decision-making, before concluding with limitations of the study.

4.1 On the use of visual and numeric appeals for communicating climate change impacts

The results from visual framings on climate change indicate that visual appeals can be a strong motivator for encouraging positive action on climate change, driven by a sense of social or moral rationality and emotional reasoning. It seems that when subjects are visually reminded of the potential environmental or social devastation caused by climate change the problem becomes more personal, their moral judgment is guided by emotional responses, such as guilt and fear, which connects them to the issue. Their concern about impacts in the region is increased, and they exhibit a stronger sense of personal duty and responsibility towards the issue of climate change in general. The investment

decisions made in visual framings are more in line with Kantianism, wherein a moral obligation or ethical duty towards a greater good supersedes expected gains.

As the problem becomes harder, these ethical intuitions seem to weaken. More complex mental computations require more logical, less intuitive, thought processes, and as such, the impact of affect and availability heuristics are reduced. As a result, investment decisions in the range condition, even when a photo was present, were more dependent on cognitive rationality and utility maximising objectives. These complex numeric appeals, on the whole, were ineffective at driving greater emotional response, concern or a stronger sense of personal duty and responsibility towards climate change compared to the simpler numeric frames.

Pidgeon and Fischhoff (2011) assert that scientists must "maintain a rhetorical stance of non-persuasive communication, trusting the evidence to speak for itself, without spin or colouring." This is an important assertion, which holds true for all logical problems that require purely analytical decision making. But what if the problem requires both moral and logical reasoning? As Roeser (2012) states, the dominant, technocratic approaches to risk lack normative-ethical dimensions that are fundamental to decision-making on acceptable risk. Communication methods that appeal to emotions when it comes to moral decision-making might be an important missing constituent here. Rather than being reduced to a manipulation or nudge, provoking ethical reflection and deliberation could be the key to a different form of decision-making based on practical rationality. Roeser argues that in the context of climate change communication moral emotions should be integrated for two reasons. The first is that moral emotions can enable us to have more substantiated moral insights about climate change, and the second is that they can provide the motivation to change our behaviour in response to climate change.

4.2 On the role of experience as a motivator for action

The effect of experience is convincing; investment behaviour changed for those who experienced damages, while it stayed the same for those who didn't. This effect is consistent with the literature on the drivers of risk perception, which shows us that recent personal experience with climate change can strongly influence the way we value its risks (see for example: Takao et al., 2004; Krosnick et al., 2006; Plapp and Werner, 2006; Thielen et al., 2007; Patt and Schroter, 2008; Whitmarsh, 2008; Botzen et al., 2009; Zaalberg et al., 2009; Horney et al., 2010; Soane et al., 2010; Terpstra, 2011; Bradford et al., 2012; Lawrence et al., 2014; van der Linden, 2014). Interestingly, however, this change in decision-making from a description-based to an experience-based understanding of risk does not seem to be based on particularly strong emotional responses or levels of concern, but rather an intuitive reaction that is salient and transient. This type of decision making is more indicative of the systematic biases that System 1 is so often criticised for, one not based on reflective thought but on 'gut reaction'. Indeed, since there was no information change between period 1 and period 2, whether subjects experienced damages should not imply a change in decision-making between the two periods. This suggests that policy-makers that experience an extreme event, even if it is a low-probability event, might decide to implement protective actions immediately after the event occurrence, despite the risk being acceptable to them before. It is important to distinguish between these two types of emotional response. Responses to visual cues are slow, thoughtful and likely based on long-lasting narratives of the problem. While responses based on experience are quick and charged, based on reaction. This type of decision-making could lead to ineffective adaptation or 'maladaptation' in the long-run. We would argue that while there is room for the first in communication efforts, the second is more emblematic of the types of biases that might arise from the persuasive communications that Pidgeon and Fischhoff (2011) warn against. Having said that, it is difficult to say how people would react after experiencing extreme climate events such as floods, heat waves and drought in real life. Of course, we would expect to find heightened long-term emotional responses as a result of indirect factors. For example, trying to deal with the aftermath

of a flood might induce stress and anxiety because of cost factors (Foudi et al., 2017). Future research should look at both the short-term and long-term effects of extreme events on both psychological states and on observed behaviour.

4.3 Limitations of the study

While some clear effects have been observed, particularly in the case of the visual framing, future research would ideally focus on even more idiosyncratic risks, such as those pertaining to the actual region where subjects reside and test how personal relevance of the issue (i.e. in relation to place attachment) might affect emotional and cognitive reasoning. In addition, the exploration of diverse media forms, such as the arts, video, and radio, and numerical expressions, such as different graphical and uncertainty interpretations, would allow for a more holistic offering to communications research. While aspects such as individual level of concern and climate change beliefs were measured in the post-experiment survey, these indicators could be measured both before and after the experiment (post-test and delayed post-test) to check for more precise framing effects. Income effects were not measured in this study but could also be an important determining factor of investment and risk decision-making on climate change. An interesting next step would be to test how actual decision-makers in public and private sectors react to the presentation of information, since their responses might differ from those of the general population. Testing the influence of these framing effects on individuals with different numerical and analytical capabilities could also provide important insight into how different actors might respond to climate risks. Finally, it is important to note that subjects were asked to make decisions based on the notion of risk, wherein all options, consequences and probabilities were known to them. In reality, like many other problems that humans face, climate change is characterised by conditions of uncertainty. The fundamental difference between the two is that uncertainty requires decision-making based on imperfect information. While not measured in this study, humans are likely to employ other, perhaps distinct, forms of heuristics for problem solving in situations of uncertainty (Neth and Gigerenzer, 2015; Le Roux, 2018). Empirical research into the distinct differences in cognition and rationality when it comes to risk and uncertainty might offer new perspectives on how humans make critical decisions in response to climate change.

5. Conclusions

We contribute to the literature by providing (lab experiment) data on the effect of framing and experience on responses to climate change risks, based on subjects that make real decisions based on costs, risks and uncertainties of different options. Our findings suggest that visual communications combined with simple numerical expressions of risk can help decision-makers make deliberate choices on the levels of risk they are willing to accept or risk appetite, and thus on climate change adaptation based on both logical and emotional reasoning. Our findings further indicate that using more complicated messages lessens the effect of important ethical and emotional rationalisation when people are deciding between actions. Decision scientists should look further into the distinct differences in emotional response based on long-lasting narratives versus reactive reasoning. The second may be responsible for important biases that could lead to less rational responses to risk. Future research should strive to explore these fundamental differences further, both empirically and based on real outcomes. This will become especially relevant in future years as climate risks increase and dramatic outcomes occur more frequently. Reaching this aim will enhance understanding and lead to more effective risk communication strategies that will enable better preparedness in light of climate change risks and impacts.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Annex A

Summary statistics for subjects who experienced damages between Period 1 and Period 2 versus those that did not.

	<i>Damages (n=60)</i>	<i>No Damages (n=101)</i>
Period 1		
<i>Risk acceptability</i>		
Mean IC*	86.5	133.17
SD (σ)	52.65	36.33
Variance (σ^2)	2772.29	1319.86
Period 2		
<i>Risk acceptability</i>		
Mean IC*	103.0	129.21
SD (σ)	54.35	38.64
Variance (σ^2)	2953.56	1493.37
<i>Concern**</i>	3.92 (1.18)	3.88 (1.03)
<i>Beliefs**</i>	4.5 (0.91)	4.62 (0.87)
<i>Positive affect**</i>	13.15 (3.82)	13.09 (3.85)
<i>Negative affect**</i>	8.23 (3.85)	7.42 (3.42)

Note: *IC= Investment in adaptation, ** Values represent mean values with standard deviation in brackets

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