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The role of affect in attitude formation toward new technologies: The case of stratospheric aerosol injection

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Abstract:

This paper analyzes determinants of technology acceptance and their interdependence. It highlights the role of affect in attitude formation toward new technologies and examines how it mediates the influence of stable psychological variables on the technology's acceptability. Based on theory and previous empirical evidence, we develop an analytical framework of attitude formation. We test this framework using survey data on attitudes toward stratospheric aerosol injection (SAI), a technology that could be used to counteract global warming. We show that affect is more important than risk and benefit perception in forming judgment about SAI. Negative and positive affect directly alter the perception of risks and benefits of SAI and its acceptability. Furthermore, affect is an important mediator between stable psychological variables – such as trust in governmental institutions, values, and attitudes – and acceptability. A person's affective response is thus guided by her general attitudes and values.

Keywords: technology acceptance; stratospheric aerosol injection; affect; attitudes; values

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1. INTRODUCTION

Fighting climate change is one of the major global challenges of the 21st century. However, even timely and substantial cuts in greenhouse gas emissions may fail to keep global warming well below 2°C.[1] Against this background, new technologies to limit global warming, known as climate engineering or geoengineering, entered the scientific and political debate. Climate engineering technologies could be an effective way to cool atmospheric temperatures and prevent massive damages from climate change. However, many of these technologies carry substantial risks. Stratospheric aerosol injection (SAI), for example, could change precipitation patterns or induce abrupt temperature changes in case of its termination.[e.g., 2]

Public concern about climate engineering technologies is substantial[3–6] and has been voiced in protests against research projects on SAI and ocean iron fertilization[7,8]. Given the far reaching social, ethical, and environmental implications of research or deployment of climate engineering, public perceptions will remain influential in the debate about it.[9] The aim of studying public perceptions is not to guarantee acceptance but to complement experts' judgements with lay persons' perspectives,[10] identify public concerns early on,[9] enable informed decisions on research and possible deployment,[11] and improve communication strategies[12].

In the present study, we analyze the factors that determine the acceptability of climate engineering for the case of SAI. This paper extends previous research and develops a new framework describing attitude formation toward new technologies that carry potentially large risks. We use German survey data to test the framework. Our analysis is guided by the following questions:

(1) How do stable psychological variables – i.e., values, environmental attitudes and risk attitudes, and trust in governmental institutions – influence attitudes toward a technology? Do they enter attitude formation via cognitive or affective pathways?

(2) What is the relative importance of affect, and the perception of risks and benefits in attitude formation?

Our framework links two strands of literature by addressing the influence of stable psychological variables on affect in attitude formation toward technologies. The first strand of literature shows the relevance of affect as determinant and moderating factor in attitude formation but does not include values or environmental attitudes in the analysis. It is based on the psychological studies highlighting the importance of affect in evaluating risks.[13,14] Midden and Huijts[15] demonstrated that trust evokes affect and thereby alters perceived effects and acceptability of CO_2-storage. Analyzing intention to act in favor of hydrogen fuel stations, Huijts et al.[16] confirmed the impact of trust and established problem perception as an additional antecedent of affect and perceived effects of the technology. Using the same data, Huijts and van Wee[17] showed that a person's age and distance to the facility have some influence on affect. In our model, affect and the perception of risks and benefits also play a central role in mediating the impact of other determinants, but we focus on stable psychological variables as potential antecedents of affect and risk and benefit perception.

The second strand of literature reveals the impact of stable psychological variables, such as values and environmental attitudes, in attitude formation but does not analyze whether this impact is mediated by affect. It acknowledges that values and environmental beliefs determine environmental concern and behavior[18,19] and thereby might influence attitudes toward technologies. Whitfield et al.[20] studied the support of nuclear power and highlighted the relevance of traditional and altruistic values, as well as environmental attitudes. Dietz et al.[21] demonstrated that altruistic and egoistic values and environmen-

tal attitudes influence the support of climate policy. Egoistic values also influence the support of climate engineering.[22] De Groot et al.[23] showed that the effect of altruistic and egoistic values on acceptability of nuclear energy is mediated by perceived benefits and risks of the technology. Our framework incorporates findings from both strands of literature and analyzes the role of affect as a mediator between stable psychological variables and technology acceptance.

The rest of this paper is structured as follows. In Section 2, we derive the analytical framework for our analysis. We lay out the survey, the measurement concepts, and the details of the analysis in Section 3. The results are shown and discussed in Section 4. Section 5 concludes and discusses implications for future research.

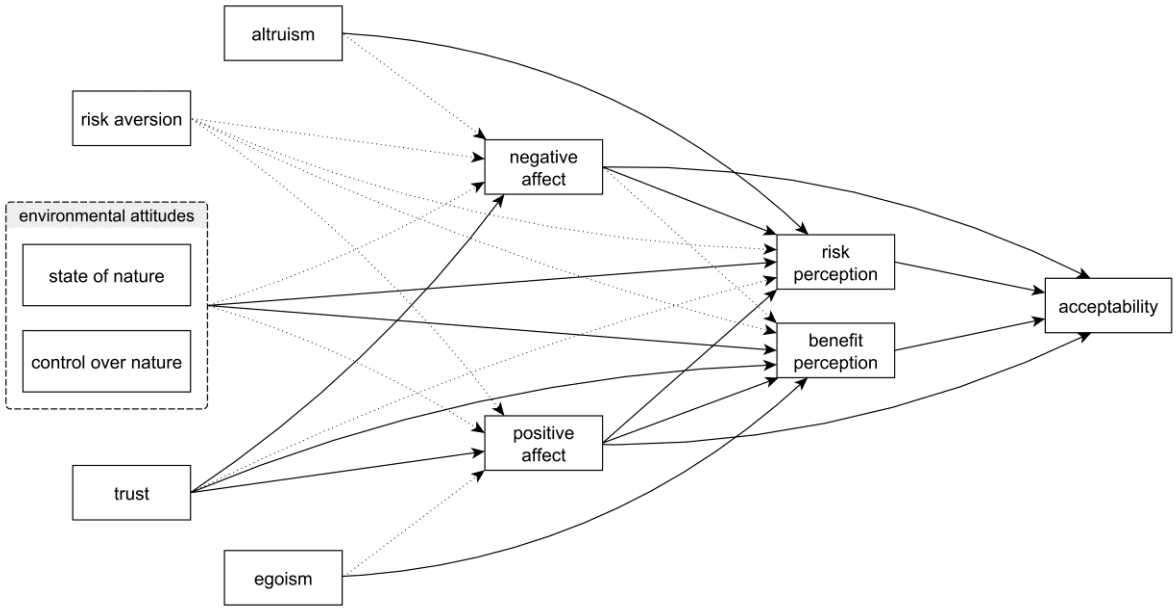
2. ANALYTICAL FRAMEWORK

Our model builds on established theories of risk perception and attitude formation and combines them into a comprehensive framework. It describes how citizens form an attitude toward (i.e., an evaluation of) a technology, which is a key determinant for behavior relating to the technology.[24] We follow Huijts et al.[12] in referring to the attitude toward a technology as its acceptability.

The framework accommodates the value-belief-norm theory[18,25] and the theory of planned behavior[24] in assuming that the acceptability of a technology is determined by domain-specific beliefs – i.e., perceived benefits and risks of the technology. These domain-specific beliefs, in turn, are influenced by stable psychological variables, such as values, environmental attitudes, and trust. In addition, the framework accommodates the affect heuristic[13] and the risk-as-feeling hypothesis[14] that highlight the influence of affect in decision making. It hence allows positive and negative affect to influence acceptability. It is further assumed that affect, in turn, may be influenced by stable psychological variables.

By including both domain-specific beliefs and affect, the framework can address whether a person's stable psychological variables – her altruistic and egoistic values, her environmental attitudes, her trust, and her risk attitude – influence attitude formation via the cognitive pathway, the affective pathway, or both. The full framework is depicted in Figure 1.[1] Its components are described below together with previous empirical evidence.

Figure 1: Analytical framework for attitude formation toward environmental technologies



Note: Dotted paths are theoretically plausible but lack supporting empirical evidence. Solid paths are both theoretically plausible and backed up by empirical evidence. All indicated paths are part of the initial path model in the analysis.

[1] The value-belief-norm theory acknowledges the possibility of additional direct effects from values to attitudes.[18,25] By contrast, our analytical framework only includes effects on acceptability that enter attitude formation via either affect or the perception of risks and benefits. Our empirical part checks for additional direct paths.

2.1. Risk and Benefit Perception

Attitudes form in part from a weighing of risks and benefits.[26] Consequently, the perceptions of risks and benefits of a technology are direct antecedents of its acceptability. Their impact, however, is not equally strong. De Groot et al.[23] found a positive impact of perceived benefits as well as a negative impact of perceived risks on the acceptability of nuclear power. The effect of perceived risks, however, was smaller. Terwel et al.[27] demonstrated that perceived benefits are more relevant than perceived risks in predicting the acceptability of CCS. In the context of SAI, Mercer et al.[28] showed that the rating of the importance of risks is not significantly different between respondents who support and those who oppose the technology. The rated importance of benefits, however, was higher for supporters of the technology than for detractors.

A precise account of the relationship between acceptability and perceived risks and benefits, however, relies on the consideration of affective pathways. Accounting for affect in attitude formation, Midden and Huijts[15] showed that perceived risks do not significantly impact acceptability of CO_2-storage. Acceptability of CO_2-storage in general is based only on perceived benefits and affect. Acceptability of local storage, by contrast, is completely determined by affect. However, Siegrist et al.[29] found that both benefit and risk perception significantly influence the willingness to buy nanotechnology foods even when affect is taken into account. To test the relevance of both risk and benefit perception when affect is accounted for, we include paths from both variables to acceptability in our analytical model. We thereby deviate from Huijts et al.[16] and Huijts and van Wee[17], who aggregate perceived risks and benefits in one variable.

2.2. Affect

Affect is an important component determining the perception of risks and benefits of new technologies. In particular when knowledge about a technology is low, people tend to rely heavily on affect in evaluating risks and benefits of a technology.[15,30,31] Affect serves as an initial overall evaluation of the technology that provides a basis for the assessment of its risks and benefits.[13,14,31–34]

Affect toward objects can simultaneously be positive and negative.[35] Both affective directions should be analyzed separately, as they each have a distinct role in shaping technology acceptability. Midden and Huijts[15], for example, found that positive affect toward CO_2-storage increases perceived benefits and reduces perceived risks of storage, while negative affect only increases perceived risks but does not influence perceived benefits. Also the strength of the affective directions is asymmetric. Huijts et al.[16] showed that perceived costs, risks, and benefits of a local hydrogen fuel station depend more strongly on positive affect than on negative affect.

In addition to influencing domain-specific beliefs, affect also influences attitudes directly.[36] This direct pathway has also been demonstrated in the context of technology acceptance. Midden and Huijts[15] found that both positive and negative affect directly influence attitudes toward CO_2-storage. Huijts and van Wee[17] obtained a similar result explaining acceptability of a local hydrogen fuel station. Our model allows for direct and indirect pathways and hence includes paths from positive and negative affect to risk and benefit perception and to acceptability.

2.3. Trust in Institutions

Trust in institutions associated with the technology is a consistent predictor of technology acceptance.[15,37–39] Especially when knowledge about the technology is insufficient, trust stemming from a perceived similarity of values[e.g., 38] or from a positive assessment of organizational competence[e.g., 27] is

used to assess a technology's risks and benefits. Trust in relevant institutions generally increases acceptability, as it increases benefit perception and reduces risk perception. This has been shown for judgements about gene technology[40,41], nuclear power[38,42,43], hydroelectric power[42], and CCS[27].

The influence of trust on risk and benefit perception is likely mediated by affect. Analyzing purchase decisions of nanotechnology foods, Siegrist et al.[29] found that trust in industry and scientists influences risk and benefit perception indirectly via affect, but not directly. In a model explaining attitudes toward CO_2-storage, Midden and Huijts[15] also found that trust in government influences affect. Over and above the influence via affect, trust directly influences perceived benefits, but does not directly influence perceived risks of CO_2-storage. Montijn-Dorgelo and Midden[44] demonstrated the same pattern of trust in government and industry in attitude formation toward hydrogen systems. Huijts et al.[16] showed both direct and indirect effects of trust in the municipality on perceived risks and benefits of hydrogen fuel stations, but combined perceived risks and benefits into one factor. Our model includes paths from trust to perceived risks and benefits and to positive and negative affect.[2] As governmental institutions are the only ones that would currently be involved in international decision-making regarding SAI, our model focuses on trust toward the federal government, the EU, and the UN.

2.4. Egoistic and Altruistic Values

Values are guiding principles in the life of a person.[47] As stable characteristics they direct attention and form beliefs and attitudes across an array of contexts.[19] For environmental behavior, egoistic and altruistic values are particularly relevant.[18] In attitude formation toward technologies with environmental consequences, these values guide a person's focus in weighing perceived risks and benefits.[48,49]

[2] This causal model of trust is particularly suitable for assessments of new technologies on which people have little information but are knowledgeable of actors involved.[39] The associationist model of trust, by contrast, supposes that the acceptability of a hazard influences perceived risks and trust in authorities. The associationist model is particularly suitable if people are knowledgeable about a hazard, but not about actors involved. For example, the acceptability of a hazard may be used to assess the trustworthiness of regulatory authorities.[45,46]

People with strong egoistic values display a preference for social power, wealth, authority, and influence; they tend to mainly consider perceived risks and benefits for themselves. By contrast, people with strong altruistic values display a preference for equality, world peace, and social justice and tend to focus on perceived risks and benefits for others.

The influence of values on acceptability will thus depend on the technology's distribution of risks and benefits. In the context of nuclear energy, which is cheap but carries health risks for many people, egoistic values have been shown to increase its perceived benefits, while altruistic values increase its perceived risks.[23] Other studies found no effect of egoistic values but showed that altruistic values reduce the acceptability of nuclear energy[20] and increase concern about different ecological risks[50]. In the context of climate engineering, Corner and Pidgeon[22] demonstrated a positive effect of egoistic (or self-enhancing) values on the support of climate engineering, but no effect of altruistic (or self-transcending) values. However, they did not include perceived risks or benefits in their analysis.

Based on previous findings, we expect a positive influence of egoistic values on the perceived benefits of SAI and a positive influence of altruistic values on the perceived risks of SAI. It remains an open question, whether values directly guide judgement about perceived risks and benefits or indirectly via affect. Our model allows for both pathways.

2.5. Environmental Attitudes

The assessment of environmental consequences is shaped by environmental attitudes.[18,23,49] These attitudes are often measured by the New Ecological Paradigm – NEP.[51,52] It encompasses attitudes toward the following facets: (1) balance of nature, (2) limits to growth, (3) risk of an eco-crisis, (4) anthropocentrism and (5) humans' ability to control nature.

The NEP's facets are significantly correlated with risk ratings of environmental hazards, such as global warming.[53] The NEP, as a combined measure, has strong explanatory power for the evaluation of global environmental risks[50] and the awareness of consequences of climate change[21]. In addition, respondents with higher NEP scores, i.e., a stronger environmental concern, focus more strongly on ecological impacts when evaluating environmental hazards[54] and are more willing to take pro-environmental action[55].

Environmental attitudes may have an ambiguous effect on the acceptability of new technologies like SAI that carry environmental benefits and environmental risks at the same time. SAI could reduce global warming, but may, for example, significantly alter the hydrological cycle.[2] It also manipulates nature to an extent that is often perceived as unacceptable.[6,28,56] Despite an acute concern about climate change, environmentalists might therefore remain skeptical about SAI.

Our model accounts for this ambiguity using the facets of the NEP. First, beliefs about the balance of nature, limits to growth, and the risk of an eco-crisis describe the state of nature. They might positively affect both risk and benefit perception and hence might have an ambiguous impact on acceptability. We include this set of facets as one dimension and call it 'state of nature'. Second, beliefs about anthropocentrism and humans' ability to control nature describe the right and capability of humans to control nature. They likely reduce perceived risks and increase perceived benefits of the technology and hence unambiguously increase acceptability. We include this set of facets as a second dimension and call it 'control over nature'.

Previous studies show a small positive overall effect of environmental values on the acceptability of solar radiation management,[57] in general, and SAI,[6] in particular. Studies that looked at the interdependence between determinants showed no direct effect of environmental values on risk or benefit perception. De Groot et al.[23] found that biospheric values, such as preventing pollution and protecting the environ-

ment, explain neither benefit nor risk perception of nuclear energy directly. They are linked to acceptability only via their correlation with altruistic values. Also Whitfield et al.[20] found no direct effect of environmental attitudes, measured by an aggregated NEP score, on the perception of nuclear risk or the acceptability of nuclear energy. Their model suggests a negative indirect effect via a reduction in trust. However, these models do not include affective pathways and thus cannot show whether environmental attitudes enter attitude formation via affect. We include environmental attitudes, separated into 'control over nature' and 'state of nature' into our model and allow each of them to influence both negative and positive affect and risk and benefit perception.

2.6. Risk Aversion

Acceptability of technologies involving risk should also be influenced by a person's risk aversion. Risk aversion has previously been shown to impact general risk taking behavior[58] and, more specifically, occupational choice[59] as well as migration decisions[60]. It is also related to the acceptability of field research on SAI.[6] Risk aversion may enter attitude formation either via cognitive reasoning - risk and benefit perception - or via feelings - positive or negative affect.[14] We include both possibilities in our model.

2.7. Acceptability

Aerosol injection is yet only little known and protesting or supporting behavior has not yet evolved. Hence, our model focuses on explaining the attitude toward the technology as the single outcome variable. We apply the terminology of Huijts et al.[12], who use the term acceptability to refer to the attitude toward a technology and the term acceptance to refer to behavior toward a technology.

3. METHOD

3.1. Procedure and Respondents

The survey was conducted in December 2012. Respondents are representative of the German population with respect to state of residence, age, and gender. The working sample consists of 927 cases. 52% of respondents are male. The mean age is 47 (min 18, max 81). The share of respondents with a higher education entrance certificate (52%) lies above the share in the German population (2013: 27%).[61]

3.2. Content of the Survey

A video in the survey informed respondents about climate change and stratospheric aerosol injection.[3] The video contained infographics that were accompanied by a German voice-over with the following content[4]:

> *Sunlight warms the Earth and the Earth's atmosphere. Greenhouse gases in the atmosphere, such as CO_2, ensure that a certain amount of heat remains close to the Earth's surface. This makes the Earth warm enough for humans, animals, and plants to survive.*
>
> *Since the beginning of industrialization around the year 1850, humans have emitted large amounts of greenhouse gases, for example, by burning coal, oil, and gas. These gases trap additional heat in the atmosphere and cause a gradual increase in the average global temperature.*
>
> *Since 1900, the global temperature has risen on average by approximately 0.8°C. Almost all countries agree that the increase in the average global temperature should not exceed 2°C compared to the temperature at the beginning of the industrialization. This is referred to as the 2°C goal.*
>
> *A future temperature increase between 0.9°C and 5.4°C is expected by 2100. The outcome depends especially on the amount of greenhouse gases emitted in the future. To reach the 2°C goal, the current level of emissions would have to decrease by more than half by 2050. By 2100, almost no greenhouse gases should be emitted.*
>
> *Climate change will almost certainly cause a rise in sea levels. It is very likely that both the frequency of heat waves and the number of heavy precipitation events will increase in many regions. In the future, it is likely that*

[3] Participants were not able to skip or fast forward the video. Participants, whose technical devices were not apt to show the video or play the voiceover, were screened out at the beginning of the survey. For more information on the sources for the video's content see Merk et al.[6]. The video is available in the online appendix of Merk et al.[6].

[4] The survey used the broader term solar radiation management to refer to the technology of stratospheric aerosol injection.

more areas will be affected by longer droughts and that the frequency and the intensity of tropical cyclones will increase. In addition, because oceans absorb some of the CO_2 in the atmosphere, they will become more acidic.

There are different ways to deal with climate change:

We can reduce greenhouse gas emissions or adapt to the new climate – for example, by building dikes or using more robust plants in agriculture. Another option is to reduce the global temperature by deploying solar radiation management (SRM).

Through SRM, a portion of the sunlight is reflected before it can warm the Earth. This can be achieved by, for example, spraying sulfate particles into the atmosphere at a high altitude.

A similar phenomenon is observed in nature. When large volcanoes erupt, similar particles are distributed across wide areas of the Earth's atmosphere, which cools the Earth.

The particles remain in the higher regions of the atmosphere for about two years. To prevent the Earth from heating up again, spraying would have to be continued until the cause of global warming is removed. Because the emitted CO_2 stays in the atmosphere for a very long time, SRM might have to be used for several centuries. Ocean acidification will not be halted by using SRM. However, the 2°C goal could be met regardless of future greenhouse gas emissions by deploying SRM. Currently, researchers are investigating the risks, benefits, and feasibility of SRM.

The use of SRM entails benefits as well as risks. One benefit is that global warming might be slowed more quickly compared to cutting greenhouse gas emissions. This would provide humankind with additional time to remove the cause of climate change, i.e., the high concentration of greenhouse gases in the atmosphere. Massive and irreversible changes in the climate could be stopped before too much damage is done. Furthermore, it would be possible to stop climate change even if certain countries refused to reduce their greenhouse gas emissions. Deploying SRM would be cheaper than reducing the consumption of fossil fuels.

The risks include a change in the amount of precipitation in most regions. In particular, arid regions would have to cope with even less rain. If the deployment of SRM were suddenly halted, the global temperature would rise abruptly. The speed of this temperature rise might lead to severe problems for humans and the environment. Because possible side effects would occur across international boundaries, the use of SRM might cause international conflicts. Once used, SRM might take away people's motivation to change their lifestyle and the emission of greenhouse gases would continue to increase. Furthermore, there would be the threat of other unknown and unforeseeable risks.

The aim was to present respondents with a neutrally framed and clear description of the technology. When asked whether the video was clearly understandable[5] and whether respondents thought it was

[5] "Do you think the information you just saw was clear or do you think it was unclear? completely clear (1) – completely unclear (4)".

neutral or biased in favor or against aerosol injection[6], only 7 out of 927 participants thought the video was not clearly understandable. 13% said it was biased in favor of the technology, while less than 1% perceived video as biased against SAI. 81% of respondents understood the video at least well and thought it was neutral toward aerosol injection. The video is the respondents' main source of information. Only very few indicated to have heard a lot about SAI before (3 percent), while about 19 percent had heard a little about it. The majority (78 percent) had never before heard about SAI.

The order of the questions in the survey was as follows: Risk aversion and environmental attitudes were elicited before the video. Thus, by design, their measurement cannot be influenced by domain-specific beliefs or affect. After the video, respondents were asked about their evaluation of the technology, their risk and benefit perception as well as their affective response to aerosol injection. Finally, trust, altruistic and egoistic values were elicited. We considered these variables to be distant enough from the topic of sulfate aerosol injection so that their measurement should not be influenced by domain-specific beliefs or affect.

3.3. Measures

All variables except for risk aversion were measured via several items. We performed confirmatory factor analysis on the items before estimating the path model; all items formed the expected factors. The items were included in the analysis as unweighted mean scores. Means, standard deviations and Cronbach's α as a measure for reliability are shown in Table I.

[6] "Do you think the information you just saw was biased in favor or against solar radiation management or was it neutral? - It was biased in favor of solar radiation management. - It was neutral. - It was biased against solar radiation management."

Table I: Means, standard deviations and Cronbach's α for variables in the analysis

	mean	standard deviation	Cronbach's α
Altruism	3.27	0.52	0.73
Egoism	2.18	0.65	0.79
Control over nature	1.96	0.73	0.63
State of nature	3.39	0.54	0.62
Trust	2.20	0.71	0.82
Risk aversion	5.57	2.32	-
Positive affect	1.59	0.70	0.93
Negative affect	2.36	0.84	0.88
Risk perception	3.36	0.50	0.69
Benefit perception	2.46	0.73	0.85
Acceptability	2.39	0.78	0.89

3.3.1.Risk and Benefit Perception

We measured risk and benefit perception via the respondents' ratings of five specific risks and four specific benefits. The risks and benefits were introduced and explained in the video. Risks (α=.69) were rated on a scale from `negligible' (1) to `very serious' (4). Benefits (α=.85) were rated from `very small' (1) to `very large' (4).

Risks

It changes the amount of precipitation.

It can take away people's motivation to change their lifestyle.

There is the possibility of further unknown and unforeseeable risks.

The abrupt increase of Earth's temperature in case of a sudden stop of SRM can lead to severe problems for humans and the environment.

The use of SRM could cause international conflicts.

Benefits

Global warming is slowed down more quickly than by cutting greenhouse gas emissions.

Massive and irreversible changes in the climate can be stopped before too much damage is done.

It is cheaper than reducing the consumption of fossil fuels.

Even if certain countries do not want to reduce their greenhouse gas emissions, it is possible to stop climate change.

3.3.2.Positive and Negative Affect

We measured positive and negative affect by asking respondents how strongly they felt 11 different positive and negative emotions when thinking about SAI. In line with Midden and Huijts[15], we combine worry, fear, sadness, powerlessness, anger, and annoyance into `negative affect' (α=.88) and delight, happiness, satisfaction, hopefulness, and relief into `positive affect' (α=.93). The response scale ranged from `not at all' (1) to `very strongly' (4).

3.3.3. Trust in Institutions

Trust in institutions was measured by the question `How much do you trust that … will act in the interest of the environment and the society?' We elicited trust toward the federal government, the EU, and the UN. We thus used a broad definition of general trust in good intentions for society and the environment (α=0.82). The 4-point response scale ranged from `do not trust at all' (1) to `trust completely' (4).

3.3.4.Egoistic and Altruistic Values

Egoistic and altruistic values were assessed with the Schwartz Personal Value Questionnaire (PVQ5X)[62]. In the PVQ5X, persons with distinct characteristics, which stand for a specific aspect of a value, are described in one sentence. Respondents had to state their similarity with the person described on a 4-point Likert scale from `dissimilar' (1) to `similar' (4). Each value was measured by 4 items (see Table A-1 in the appendix). Egoistic values contained the aspects social power, wealth, authority, and influential

(α=.80). Altruistic values contained the aspects equality, world at peace, social justice, and helpful (α=.80). The items correspond to the items used by De Groot et al.[23].[7]

3.3.5.Environmental Attitudes

Environmental attitudes were assessed via the facets of the NEP scale. The NEP measures a pro-ecological worldview encompassing perspectives on humankind's relationship with nature and was developed and revised by Dunlap and van Liere[51] and Dunlap et al.[52]. We used 5 of the instrument's 15 items, each representing one of the NEP's 5 facets: (1) `Humans were meant to rule over the rest of nature.' for anthropocentrism, (2) `Humans will eventually learn enough about how nature works to be able to control it.' for humans' ability to control nature, (3) `The Earth is like a spaceship with very limited room and resources.' for limits to growth, (4) `The balance of nature is very delicate and easily upset.' for the perceived fragility of nature's balance, and (5) `If things continue on their present course, we will soon experience a major ecological catastrophe.' for the possibility of an eco-crisis. The response scale ranged from `strongly disagree' (1) to `strongly agree' (4).

We expected the NEP to capture two different dimensions that have distinct influences in attitude formation. A confirmatory factor analysis led to inconclusive results; the Kaiser-Meyer-Olkin-criterion, i.e., the number of eigenvalues larger than 1, supported the existence of one single factor while the scree plot suggested two distinct factors. In a one factor solution, the uniqueness of items (1) and (2), i.e., their share variance not accounted for by the factor, was relatively high (>.83). The two factor solution reduces the items' uniqueness. For the analysis, we thus use two variables to measure environmental attitudes: One variable reflects respondents' perspective of humans' relationship with nature, which we call 'control over nature' (α=.63). It is measured by items (1) and (2) on anthropocentrism and

[7] De Groot et al.[23] used an older version of the Schwartz value scale.

humans' ability to control nature. The other variable reflects the perceived state of nature (α=.63), which we call `state of nature'. It is measured by items (3) to (5) on limits to growth, the fragility of nature, and the possibility of an eco-crisis. In the literature, there is no agreement on the dimensionality of the NEP scale, but many empirical studies find multiple dimensions of the scale.[52,63] The variables we use capture different dimensions that we expected to have distinct impacts on attitude formation.

3.3.6.Risk Aversion

To assess risk aversion, respondents were asked `Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?' on an 11-point Likert-scale from `risk averse' (0) to `fully prepared to take risks' (10). This question is used in the German Socioeconomic Panel (GSOEP) and has been shown to correlate well with actual risk taking in several domains[58]. The item was reversely coded for the analysis. Thus, higher values indicate a higher level of risk aversion.

3.3.7.Acceptability

Acceptability was measured via 5 items that capture the attitude toward different types of research and deployment of aerosol injection (α=.88). Participants responded to the following items on 4-point Likert scales from `strongly disagree' (1) to `strongly agree' (4):

We should cool the Earth by using SRM.

Scientists should research SRM using theoretical models, simulations and lab experiments.

Scientists should test SRM using field trials.

SRM should be used when massive and irreversible changes in the climate system are approaching which cannot be averted otherwise.

If SRM was possible today, we should use it immediately.

3.4. ANALYSIS

We started the analysis with the initial analytical framework derived in Section 2 (compare Figure 1).[8] Table A-2 in the appendix shows the correlations between the variables. The fit statistics for the initial model delivered inconclusive results. The comparative fit index (CFI) of the initial model was 0.980, indicating a good overall fit of the model[65]. The root mean squared error of approximation (RMSEA = 0.067; 90%-CI: (0.050; 0.086)) and its probability to be below the cutoff value 0.05 (P(RMSEA ≤ .05) = 0.053) indicate a marginal passing of the close-fit test.[64] Furthermore, the standardized root mean squared residual (SRMR) of 0.015 does not indicate problems.[64] Only the likelihood ratio test was significant ($\chi^2(11) = 51.660$; $p < 0.000$). For large samples, small difference between the model and data might already cause a failure to pass the χ^2-test.[64] We thus looked at the correlation residuals, i.e., normalized covariance residuals, to check for local misfit of the model and at the modification indices to identify potential additional paths.

The correlation residual was highest for the relationship between control over nature and acceptability.[9] Also the modification index was high (MI = 18.71). From a theoretical perspective, the addition of the path is justified: Attitudes about the relationship between humans and nature could influence acceptability beyond their influence via perception and affect. In particular, the value-belief-norm theory[18,25] allows for direct effects between variables that are multiple levels apart in the causal chain. Thus, we added a path between control over nature and acceptability, which significantly improved model fit (Δ

[8] The covariances between the errors of the endogenous variables positive and negative affect and risk and benefit perception, respectively, were included in all models.[64] The covariances are not included in the results graph for better legibility.

[9] Normalized covariance residuals, i.e., correlation residuals, are used instead of standardized covariance residuals because the latter could not be calculated. This can happen with complex models. Normalized residuals return more conservative values than standardized residuals.[64]

$\chi^2(1) = 18.90$; $p < 0.000$; $\chi^2(9) = 32.765$ $p < 0.000$; CFI = 0.989; RMSEA = 0.053; 90%-CI: (0.034, 0.074); P(RMSEA ≤ .05) = 0.354; SRMR = 0.013).

For the new model, we again inspected the correlation residuals and the modification indices. The only remaining high residual was between state of nature and acceptability. The theoretical justification for the inclusion is similar to the justification for including control over nature. The variable's inclusion improved model fit significantly ($\Delta \chi^2(1) = 23.49$; $p < 0.000$) and the resulting model fit was very good ($\chi^2(8) = 9.28$, $p = 0.319$; CFI = 0.999; RMSEA = 0.013; 90%-CI: (0.000, 0.042); P(RMSEA ≤ .05) = 0.987; SRMR = 0.008). The resulting residual matrix did not contain any more high entries.

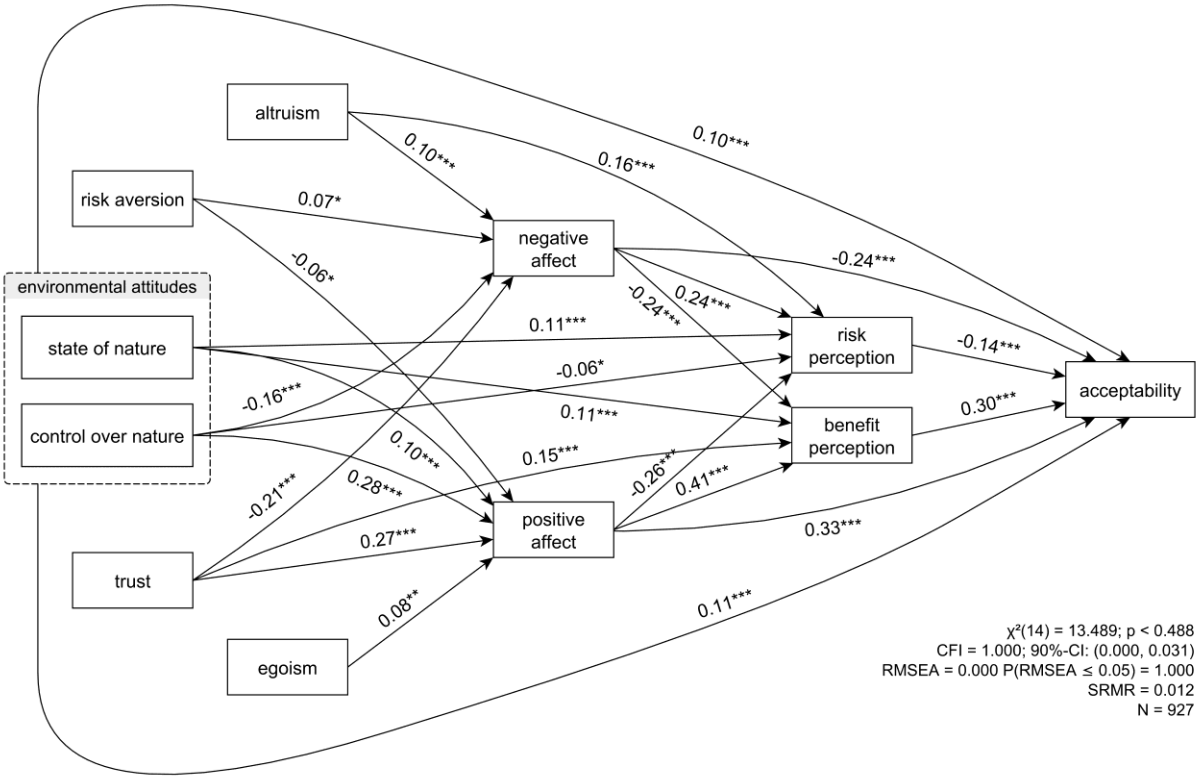
In the final step, we trimmed the model and stepwise removed the path with the highest p-value ($p > .05$). The following paths were removed: risk aversion and trust to risk perception; egoism, risk aversion, and control over nature to benefit perception; and state of nature to negative affect. The excluded paths were jointly not significant ($\Delta \chi^2(6) = 4.21$; $p = 0.648$). The resulting model (Figure 2) fitted very well ($\chi^2(14) = 13.489$, $p < 0.488$; CFI = 1.000; RMSEA = 0.000; 90%-CI: (0.000, 0.031); P(RMSEA ≤ 0.05) = 1.000; SRMR = 0.012). Furthermore, no substantial correlation residuals remained (Table A-3). The share of explained variance for acceptability was 0.66 (see Table II for explained variances of all endogenous variables).

4. RESULTS

The results from the path analysis in Figure 2 show that positive and negative affect, as well as the perception of risks and benefits have direct effects on acceptability. Furthermore, they mediate the impact of stable psychological variables on the acceptability of aerosol injection. Further direct determinants of acceptability are control over nature and state of nature; these variables' impact on acceptabil-

ity is only partly mediated by affect and risk and benefit perception. In the following, we describe the influence of the model's components in more detail.

Figure 2: Path model explaining attitude formation toward stratospheric aerosol injection



Note: standardized path coefficients; * p<.05, ** p<.01, *** p < .001

Affect is the strongest driver in attitude formation. Positive affect increases benefit and decreases risk perception, while the reverse is true for negative affect. In addition, both affect variables have a direct impact on acceptability. These results extend previous findings[17,29] by disaggregating both affect and perceived effects of the technology. However, they contrast the finding of Midden and Huijts[15] who report no impact of negative affect on the perception of benefits. Moreover, we find support for an asymmetric impact of positive and negative affect[16,17,35]: the evaluation of the technology is more

strongly influenced by positive affect (.49)[10] than by negative affect (-.34). Overall, affect has a larger influence in attitude formation than perceived risks and benefits.

Table II: Standardized total effects and share of explained variance

	dependent variables				
	Negative affect	Positive affect	Risk perception	Benefit perception	Acceptability
independent variables					
Altruism	0.10		0.19	-0.02	-0.06
Egoism		0.08	-0.02	0.03	0.04
Control over nature	-0.16	0.28	-0.17	0.15	0.30
State of nature		0.10	0.08	0.15	0.17
Trust	-0.21	0.27	-0.12	0.31	0.25
Risk aversion	0.07	-0.06	0.03	-0.04	-0.05
Negative affect			0.24	-0.23	-0.34
Positive affect			-0.26	0.41	0.49
Risk perception					-0.14
Benefit perception					0.30
R^2	0.11	0.22	0.25	0.40	0.66

Both benefit perception and risk perception influence acceptability significantly. Furthermore, benefit perception (.30) is a stronger predictor of acceptability than risk perception (-.14). This finding is consistent with previous findings on attitude formation.[23,27,29] Accounting for the affective pathway, Midden and Huijts[15] previously found no effect of risk perception on acceptability. In our data, risk perception remains a direct antecedent of acceptability despite the inclusion of affect. Our data further show that benefit and risk perception have different roles in attitude formation, both as determinants and mediating factors. Hence, they should be included as distinct concepts in the analysis of technology acceptance.

[10] Effect sizes in parentheses are total effects (compare Table II).

Among the stable psychological variables, risk aversion has only a small total effect on acceptability (-.05). Interestingly, it influences acceptability only via increasing positive affect (-.06) and reducing negative affect (.07). It does not influence the perception of risks and benefits.

Trust in the federal government, the EU and the UN has a strong total effect on acceptability (.25). The data show that trust determines acceptability through direct influences on positive and negative affect. It also directly influences the perception of benefits but not the perception of risks. These findings confirm results of Midden and Huijts[15] and Montijn-Dorgelo and Midden[44]. In contrast to our finding, data analyzed in Huijts et al.[16] and Huijts and van Wee[17] suggested that the influence of trust is not mediated by negative affect.

Altruistic and egoistic values determine a person's focus in evaluating risks and benefits. Our data show, for the first time, that their influence on risk and benefit perception is partly mediated by affect. Altruistic and egoistic values have different impacts. Altruistic values directly increase both negative affect and risk perception. By contrast, egoistic values directly increase only positive affect, and only weakly so; they do not change risk or benefit perception directly. The direction of the total effect of values is in line with the literature – altruism reduces acceptability (-.06) and egoism increases acceptability (.04). Also previously, altruistic values were shown to increase risk perception and decrease acceptability[20,23,50] and egoistic values were shown either to have no effect[20,50] or to increase benefit perception and acceptability[22,23].

If technologies have both environmental benefits and environmental risks – such as SAI –, the effect of environmental attitudes on the acceptability of these technologies is potentially ambiguous – they might be perceived as a threat and as a solution at the same time. Therefore, our model takes a more nuanced look at the effect of environmental attitudes by splitting up the NEP into two separate factors: firstly, the perceived control over nature, which captures the belief in the human capacity to control and to rule

over nature; secondly, the perceived state of nature, which captures limits to growth, the fragility of nature, and the possibility of an eco-crisis. Overall, beliefs about the control over nature have the strongest impact among the stable psychological variables (.30), while the impact of beliefs about the state of nature (.17) is less pronounced but still high. Both environmental attitudes influence acceptability differently and have direct effects on acceptability that are not mediated by either affect or risk and benefit perception. The direct effect of control over nature (.11) accounts for one third of its total effect. The direct effect of state of nature (.10) accounts for more than half of its total effect.

The effect of control over nature on acceptability is unambiguous: It reduces negative affect and risk perception, while it increases positive affect and acceptability. It does not directly influence benefit perception. By contrast, beliefs about the state of nature have a more ambiguous impact. They intensify both risk and benefit perception, plausibly because SAI can be seen both as a cure and a threat to the environment. Its direct effect on acceptability is positive.

In sum, we show that environmental attitudes enter attitude formation. They do so directly and via both affect and risk and benefit perception. Previous studies did not find a strong impact of environmental attitudes on risk and benefit perception of nuclear power.[20,23] We also find that the impact of both NEP variables is large compared to the impact of altruistic and egoistic values. This contrasts findings for acceptability of nuclear power but mirrors findings for the perception of ecological risk[50]. Our results also highlight the benefit of taking a differentiated look at the different facets of environmental attitudes; they confirm previous results that pointed toward nuanced effects of the NEP's different facets on technology acceptance[6,53].

5. CONCLUSION

In this study, we proposed and tested a framework for attitude formation that integrates important determinants of the acceptability of new technologies which have not previously been analyzed together. In particular, we incorporate the affect hypothesis and the value-belief-norm theory to shed light on the role of affect and stable psychological variables – such as trust, values, and environmental attitudes – in forming acceptability judgements.

Our data show evidence of both affective and cognitive pathways in attitude formation. Acceptability is strongly influenced by positive and negative affect, as well as perceived risks and benefits. People are, however, more strongly guided by affect than by their perception of risks and benefits. For the first time, we show that affect is the most important mediator between stable psychological variables and acceptability.

Trust and environmental attitudes have the strongest impact on acceptability amongst the stable psychological variables. The impacts of egoistic and altruistic values, and risk aversion are relatively small. While the influence of trust, values, and risk aversion is mediated by affect and risk and benefit perception, environmental attitudes have an additional direct influence on acceptability: Up to one half of the effect of environmental attitudes on acceptability is direct. This finding is in line with the value-belief-norm theory[18,25], which allows for direct effects between variables that are multiple levels apart in the causal chain. For example, it allows values not only to influence general beliefs but also to influence attitudes directly. Previous empirical studies provided evidence in this direction, but did not check for possible mediation by affect.[20,21,66]

Our study adds to a growing literature about the importance of affect in guiding judgement.[13,14,32,67] In contrast to previous studies, we not only show the relevance of affect, but also how affect is influenced

by a person's characteristics. We show that it is in part shaped by a person's values, attitudes, trust, and risk aversion. Hence, affect, as automatic emotional reaction, seems to express a person's core values and attitudes applied to a specific situation. In this sense, it is essential to and supports rational action. Our result also speaks to literature that showed reductions in the quality of decisions when affective evaluations are impaired.[68–71]

Affect appears essential to understanding acceptability judgements of the public. In studying attitude formation, it is important to distinguish between positive and negative affect as well as between risks and benefit perception because these components have different impacts and antecedents. For technologies with both environmental risks and benefits, such as SAI, it is further useful to distinguish between different aspects of environmental attitudes. The belief in humans' ability to control nature is highly relevant and, in contrast to the perceived state of nature, has an unambiguous impact on acceptability.

Our study focused on social trust and underscores its relevance in attitude formation. Using a different conceptualization of trust might lead to different results. Social trust, which is based on value similarity between the trusting and trusted party, is sometimes distinguished from confidence, which is based on the perceived competence of the trusted party.[39,72] Previous studies indicated that social trust and confidence have different roles in forming judgement[27,72–74] and that confidence is more calculative and reason-based than social trust.[39] This implies that the impact of confidence might be less strongly mediated by affect than the impact of social trust. In the future, our framework could be extended to study this question.

The effects we found are likely characteristic of attitude formation toward a technology about which people have little knowledge. Only few respondents of our survey had heard about aerosol injection before and there has not yet been a broad public discourse on the topic. Once a technology becomes more mature, the relevance of the factors influencing perception might shift.[12] Additional factors likely

enter attitude formation, such as trust in industry[15,16,29,44] or the procedural and distributive fairness of implementation[12]. Moreover, particular framings of the technology might induce different perceptions[22,75] and increased familiarity might alter the relevance of affect in attitude formation. Future research should thus test our framework with more familiar technologies to evaluate the stability of the pathways indicated by our study. Furthermore, future studies might include experimental variation or longitudinal data to further substantiate causality of the relationships.

REFERENCES

1. Climate change 2014: Synthesis report. Contribution of working groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC. IPCC, Geneva; 2014.
2. Rickels W, Klepper G, Dovern J, Betz G, Brachatzek N, Cacean S, Güssow K. Large-scale intentional interventions into the climate system? Assessing the Climate Engineering Debate.: Scoping report conducted on behalf of the German Federal Ministry of Education and Research (BMBF). Kiel: Kiel Earth Institute; 2011.
3. Bellamy R, Hulme M. Beyond the tipping point: Understanding perceptions of abrupt climate change and their implications. Weather, Climate, and Society, 2011; 3(1):48–60.
4. Borick CP, Rabe B. Belief in global warming on the rebound: National survey of American public opinion on climate change. Issues in Governance Studies, 2012; 44:1–8.
5. Macnaghten P, Szerszynski B. Living the global social experiment: An analysis of public discourse on solar radiation management and its implications for governance. Global Environmental Change, 2013; 23(2):465–74.
6. Merk C, Pönitzsch G, Kniebes C, Rehdanz K, Schmidt U. Exploring public perceptions of stratospheric sulfate injection. Climatic Change, 2015; 130(2):299–312.
7. Stilgoe J, Owen R, Macnaghten P. Developing a framework for responsible innovation. Research Policy, 2013; 42(9):1568–80.
8. Schäfer S, Lawrence M, Stelzer H, Born W, Low S, Aaheim A, et al. The European transdisciplinary assessment of climate engineering (EuTRACE): Removing greenhouse gases from the atmosphere and reflecting sunlight away from Earth. Potsdam: Institute for Advanced Sustainability Studies; 2015.
9. Pidgeon NF, Parkhill K, Corner A, Vaughan NE. Deliberating stratospheric aerosols for climate geoengineering and the SPICE project. Nature Climate Change, 2013; 3(5):451–7.
10. Slovic P. Perception of risk. Science, 1987; 236(4799):280–5.
11. Carr WA, Preston CJ, Yung L, Szerszynski B, Keith DW, Mercer AM. Public engagement on solar radiation management and why it needs to happen now. Climatic Change, 2013; 121(3):567–77.
12. Huijts NMA, Molin EJE, Steg L. Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. Renewable and Sustainable Energy Reviews, 2012; 16(1):525–31.
13. Finucane ML, Alhakami A, Slovic P, Johnson SM. The affect heuristic in judgments of risks and benefits. Journal of Behavioral Decision Making, 2000; 13(1):1–17.
14. Loewenstein GF, Weber EU, Hsee CK, Welch N. Risk as feelings. Psychological Bulletin, 2001; 127(2):267–86.

15. Midden CJH, Huijts NMA. The role of trust in the affective evaluation of novel risks: The case of CO2 storage. Risk Analysis, 2009; 29(5):743–51.

16. Huijts NMA, Molin EJE, van Wee B. Hydrogen fuel station acceptance: A structural equation model based on the technology acceptance framework. Journal of Environmental Psychology, 2014; 38:153–66.

17. Huijts N, van Wee B. The evaluation of hydrogen fuel stations by citizens: The interrelated effects of socio-demographic, spatial and psychological variables. International Journal of Hydrogen Energy, 2015; 40(33):10367–81.

18. Stern PC. Toward a coherent theory of environmentally significant behavior. Journal of Social Issues, 2000; 56(3):407–24.

19. Stern PC, Kalof L, Dietz T, Guagnano GA. Values, beliefs, and proenvironmental action: Attitude formation toward emergent attitude objects. Journal of Applied Social Psychology, 1995; 25(18):1611–36.

20. Whitfield SC, Rosa EA, Dan A, Dietz T. The future of nuclear power: value orientations and risk perception. Risk Analysis, 2009; 29(3):425–37.

21. Dietz T, Dan A, Shwom R. Support for Climate Change Policy: Social Psychological and Social Structural Influences. Rural Sociology, 2007; 72(2):185–214.

22. Corner A, Pidgeon NF. Like artificial trees? The effect of framing by natural analogy on public perceptions of geoengineering. Climatic Change, 2015; 130(3):425–38.

23. De Groot JIM, Steg L, Poortinga W. Values, perceived risks and benefits, and acceptability of nuclear energy. Risk Analysis, 2013; 33(2):307–17.

24. Ajzen I. The theory of planned behavior. Organizational Behavior and Human Decision Processes, 1991; 50(2):179–211.

25. Stern PC, Dietz T, Abel T, Guagnano GA, Kalof L. A Value-Belief-Norm Theory of Support for Social Movements: The Case of Environmentalism. Human Ecology Review, 1999; 6(2):81–95.

26. Ajzen I. From intentions to actions: A theory of planned behavior. In: Kuhl J, Beckmann J (eds). Action control: From cognition to behavior (pp. 11–39). Berlin Heidelberg: Springer; 1985.

27. Terwel BW, Harinck F, Ellemers N, Daamen, Dancker D. L. Competence-based and integrity-based trust as predictors of acceptance of carbon dioxide capture and storage (CCS). Risk Analysis, 2009; 29(8):1129–40.

28. Mercer AM, Keith DW, Sharp JD. Public understanding of solar radiation management. Environmental Research Letters, 2011; 6(4):1–9.

29. Siegrist M, Cousin M, Kastenholz H, Wiek A. Public acceptance of nanotechnology foods and food packaging: the influence of affect and trust. Appetite, 2007; 49(2):459–66.

30. Lee C, Scheufele DA, Lewenstein BV. Public attitudes toward emerging technologies: Examining the interactive effects of cognitions and affect on public attitudes toward nanotechnology. Science Communication, 2005; 27(2):240–67.

31. Slovic P, Finucane ML, Peters EM, MacGregor DG. The affect heuristic. European Journal of Operational Research, 2007; 177(3):1333–52.

32. Zajonc RB. Feeling and thinking: Preferences need no inferences. American Psychologist, 1980; 35(2):151–75.

33. Alhakami AS, Slovic P. A psychological study of the inverse relationship between perceived risk and perceived benefit. Risk Analysis, 1994; 14(6):1085–96.

34. Slovic P, Finucane ML, Peters E, MacGregor DG. Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. Risk Analysis, 2004; 24(2):311–22.

35. Peters E, Slovic P. Affective asynchrony and the measurement of the affective attitude component. Cognition and Emotion, 2007; 21(2):300–29.

36. Ajzen I. Nature and operation of attitudes. Annual Review of Psychology, 2001; 52(1):27–58.

37. Flynn J, Slovic P, Mertz CK. Decidedly different: Expert and public views of risks from a radioactive waste repository. Risk Analysis, 1993; 13(6):643–8.

38. Siegrist M, Cvetkovich G, Roth C. Salient value similarity, social trust, and risk/benefit perception. Risk Analysis, 2000; 20(3):353–62.

39. Earle TC. Trust in risk management: A model-based review of empirical research. Risk Analysis, 2010; 30(4):541–74.

40. Siegrist M. The influence of trust and perceptions of risks and benefits on the acceptance of gene technology. Risk Analysis, 2000; 20(2):195–204.

41. Barnett J, Cooper H, Senior V. Belief in public efficacy, trust, and attitudes toward modern genetic science. Risk Analysis, 2007; 27(4):921–33.

42. Siegrist M, Cvetkovich G. Perception of hazards: The role of social trust and knowledge. Risk Analysis, 2000; 20(5):713–20.

43. Visschers VHM, Siegrist M. How a nuclear power plant accident influences acceptance of nuclear power: Results of a longitudinal study before and after the Fukushima disaster. Risk Analysis, 2013; 33(2):333–47.

44. Montijn-Dorgelo FNH, Midden CJH. The role of negative associations and trust in risk perception of new hydrogen systems. Journal of Risk Research, 2008; 11(5):659–71.

45. Poortinga W, Pidgeon NF. Trust in risk regulation: cause or consequence of the acceptability of GM food? Risk Analysis, 2005; 25(1):199–209.

46. Bronfman NC, Vázquez EL, Gutiérrez VV, Cifuentes LA. Trust, acceptance and knowledge of technological and environmental hazards in Chile. Journal of Risk Research, 2008; 11(6):755–73.

47. Schwartz SH. Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. In: Zanna M. (ed). Advances in experimental social psychology (pp. 1–65, vol. 25). Orlando, FL: Academic Press; 1992.

48. De Groot JIM, Steg L. Value orientations and environmental beliefs in five countries: Validity of an instrument to measure egoistic, altruistic and biospheric value orientations. Journal of Cross-Cultural Psychology, 2007; 38(3):318–32.

49. De Groot JIM, Steg L. Value orientations to explain beliefs related to environmental significant behavior: How to measure egoistic, altruistic, and biospheric value orientations. Environment and Behavior, 2008; 40(3):330–54.

50. Slimak MW, Dietz T. Personal values, beliefs, and ecological risk perception. Risk Analysis, 2006; 26(6):1689–705.

51. Dunlap RE, van Liere KD. The "new environmental paradigm". The Journal of Environmental Education, 1978; 9(4):10–9.

52. Dunlap RE, van Liere KD, Mertig AG, Jones RE. Measuring endorsement of the new ecological paradigm: A revised NEP scale. Journal of Social Issues, 2000; 56(3):425–42.

53. Sjöberg L. Distal factors in risk perception. Journal of Risk Research, 2003; 6(3):187–211.

54. Willis HH, Dekay ML. The roles of group membership, beliefs, and norms in ecological risk perception. Risk Analysis, 2007; 27(5):1365–80.

55. Stern PC, Dietz T, Guagnano GA. The new ecological paradigm in social-psychological context. Environment and Behavior, 1995; 27(6):723–43.

56. Corner A, Parkhill K, Pidgeon NF, Vaughan NE. Messing with nature? Exploring public perceptions of geoengineering in the UK. Global Environmental Change, 2013; 23(5):938–47.

57. Pidgeon NF, Corner A, Parkhill K, Spence A, Butler C, Poortinga W. Exploring early public responses to geoengineering. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 2012; 370(1974):4176–96.

58. Dohmen T, Falk A, Huffman D, Sunde U, Schupp J, Wagner GG. Individual risk attitudes: Measurement, determinants, and behavioral consequences. Journal of the European Economic Association, 2011; 9(3):522–50.

59. Bonin H, Dohmen T, Falk A, Huffman D, Sunde U. Cross-sectional earnings risk and occupational sorting: The role of risk attitudes. Labour Economics, 2007; 14(6):926–37.

60. Jaeger DA, Dohmen T, Falk A, Huffman D, Sunde U, Bonin H. Direct evidence on risk attitudes and migration. Review of Economics and Statistics, 2010; 92(3):684–9.

61. Destatis. Educational attainment of the population in Germany [Internet]. Wiesbaden: Statistisches Bundesamt; 2015 [cited 2016 Sep 22]. Available from: https://www.destatis.de/EN/FactsFigures/SocietyState/EducationResearchCulture/EducationalLevel/Tables/EducationalAttainmentPopulationGermany.html.

62. Schwartz SH, Cieciuch J, Vecchione M, Davidov E, Fischer R, Beierlein C, et al. Refining the theory of basic individual values. Journal of Personality and Social Psychology, 2012; 103(4):663–88.

63. Hawcroft LJ, Milfont TL. The use (and abuse) of the new environmental paradigm scale over the last 30 years: A meta-analysis. Journal of Environmental Psychology, 2010; 30(2):143–58.

64. Kline RB. Principles and practice of structural equation modeling. New York: Guilford publications; 2015.

65. Acock AC. Discovering structural equation modeling using Stata. College Station, Texas: Stata Press; 2013.

66. Steg L, Dreijerink L, Abrahamse W. Factors influencing the acceptability of energy policies: A test of VBN theory. Journal of Environmental Psychology, 2005; 25(4):415–25.

67. Lerner JS, Li Y, Valdesolo P, Kassam KS. Emotion and decision making. Annual Review of Psychology, 2015; 66(1):799–823.

68. Wilson TD, Schooler JW. Thinking too much: Introspection can reduce the quality of preferences and decisions. Journal of Personality and Social Psychology, 1991; 60(2):181–92.

69. Wilson TD, Lisle DJ, Schooler JW, Hodges SD, Klaaren KJ, LaFleur SJ. Introspecting about reasons can reduce post-choice satisfaction. Personality and Social Psychology Bulletin, 1993; 19(3):331–9.

70. Damasio AR. Descartes' error. New York: Putnam; 1994.

71. Bechara A, Damasio H, Tranel D, Damasio AR. Deciding advantageously before knowing the advantageous strategy. Science, 1997; 275(5304):1293–5.

72. Earle TC, Siegrist M. Morality Information, Performance Information, and the Distinction Between Trust and Confidence. Journal of Applied Social Psychology, 2006; 36(2):383–416.

73. Poortinga W, Pidgeon NF. Exploring the Dimensionality of Trust in Risk Regulation. Risk Analysis, 2003; 23(5):961–72.

74. Allum N. An empirical test of competing theories of hazard-related trust: the case of GM food. Risk Analysis, 2007; 27(4):935–46.

75. Sütterlin B, Siegrist M. Public perception of solar radiation management: The impact of information and evoked affect. Journal of Risk Research, 2016:1–16.

APPENDIX

Table A-1: Items measuring egoism and altruism from Schwartz et al.[62] and items measuring environmental attitudes from Dunlap et al.[52]

In the following we describe different people. Please state for each case how similar or dissimilar the described person is to you.	dissimilar (1) - similar (4)
Egoism (α=.79)	
She wants people to do what she says.	
Being wealthy is important to her.	
It is important to her to be the one who tells the others what to do.	
It is important to her to be the most influential person in any group.	
Altruism (α=.73)	
She thinks it is important that every person in the world have equal opportunities in life.	
She works to promote harmony and peace among diverse groups	
Protecting society's weak and vulnerable members is important to her.	
Caring for the well-being of people she is close to is important to her.	
Please tell us whether you agree or disagree with the following statements.	strongly disagree (1) - strongly agree (4)
State of nature (α=.62)	
The Earth is like a spaceship with very limited room and resources.	
The balance of nature is very delicate and easily upset.	
If things continue on their present course, we will soon experience a major ecological catastrophe.	
Control over nature (α=.63)	
Humans were meant to rule over the rest of nature.	
Humans will eventually learn enough about how nature works to be able to control it.	

Table A-2: Correlation matrix of all variables in the analysis

	Altruism	Egoism	Control over nature	State of nature	Trust	Risk aversion	Positive affect	Negative affect	Benefit perception	Risk perception
Altruism	1.00									
Egoism	-0.06	1.00								
Control over nature	-0.04	0.25***	1.00							
State of nature	0.21***	-0.01	-0.12***	1.00						
Trust	0.03	0.22***	0.23***	0.02	1.00					
Risk aversion	-0.01	-0.16***	-0.11**	0.01	-0.10**	1.00				
Positive affect	-0.01	0.21***	0.35***	0.06	0.36***	-0.13***	1.00			
Negative affect	0.11***	-0.08**	-0.22***	0.09**	-0.25***	0.11***	-0.38***	1.00		
Benefit perception	-0.02	0.13***	0.22***	0.11***	0.36***	-0.09***	0.56***	-0.42***	1.00	
Risk perception	0.22***	-0.09**	-0.22***	0.16***	-0.14***	0.07*	-0.37***	0.38***	-0.21***	1.00
Acceptability	-0.05	0.17***	0.36***	0.09**	0.38***	-0.13***	0.68***	-0.56***	0.65***	-0.43***

Note: * p<.05, ** p<.01, *** p < .001

Table A-3: Correlation residuals of the final model (Figure 2)

	Altruism	Egoism	Control o. nature	State of nature	Trust	Risk aversion	Positive affect	Negative affect	Benefit perc.	Risk perc.	Accept-ability
Altruism	0.00										
Egoism	0.00	0.00									
Control over nature	0.00	0.00	0.00								
State of nature	0.00	0.00	0.00	0.00							
Trust	0.00	0.00	0.00	0.00	0.00						
Risk aversion	0.00	0.00	0.00	0.00	0.00	0.00					
Positive affect	-0.83	-0.15	0.00	-0.45	0.00	0.00	-0.08				
Negative affect	0.26	0.56	0.00	1.66	0.00	0.00	0.12	0.04			
Benefit perception	-0.79	-0.55	0.22	-0.57	0.03	0.05	-0.11	0.21	-0.11		
Risk perception	0.25	0.40	0.01	0.52	0.56	0.07	-0.11	0.19	-0.03	0.12	
Acceptability	-0.61	-0.41	0.06	-0.78	1.26	-0.45	-0.11	0.20	-0.14	-0.06	-0.15