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Informed and Uninformed Opinions on New Measures to Address Climate Change*

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Abstract:

Climate engineering (CE) and carbon capture and storage sub-seabed (CCS-S) are currently controversially debated options to address climate change. Our paper provides empirical evidence on the public perception of two different CE measures, namely, stratospheric sulphate injection (SSI) and afforestation, as well as CCS-S. Using data from a novel large-scale survey, we analyse the determinants of acceptance of these measures in Germany. We also provide experimental evidence on how additional information on these measures changes the respondents' acceptance. We show that the acceptance differs strongly between the three measures. Afforestation is strongly favoured over CCS-S and SSI. This ranking holds independent of the amount of information provided. For all three measures, we find that, on average, additional information decreases acceptance. However, the sign and the strength of the information effect strongly depend on personal characteristics, such as gender and risk attitude.

Keywords: Climate Engineering, Solar Radiation Management, Carbon Capture and Storage, Climate Change, Public Opinion, Survey

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1. Introduction

Most countries have accepted a temperature increase of 2°C above pre-industrial levels as the maximum tolerable limit for global warming. Reaching this 2°C goal, however, becomes increasingly unlikely given the current trajectories (IPCC 2014). Therefore, scientists and politicians have recently begun to consider new measures to address climate change. These measures involve large-scale interventions into the climate system and have been summarised under the term climate engineering (CE). CE encompasses two broad approaches: solar radiation management (SRM) and carbon dioxide removal (CDR) (Royal Society 2009). While SRM measures influence the temperature directly, CDR measures reduce the atmospheric concentration of CO_2. Another relatively new measure is carbon capture and storage (CCS). For CCS, CO_2 from industrial processes is captured before it enters the atmosphere and is transported to long-term storage.

The costs, benefits, and risks of these new measures, especially CE, currently are not well understood, and uncertainties remain regarding their effectiveness and side effects (Royal Society 2009; UBA 2008; Keith 2014). While research on most CE measures is still at an early stage, there are already large-scale demonstration projects on CCS. Further research on CE measures and CCS must be conducted before it can be determined whether they could become part of a portfolio to address climate change. However, in some countries even limited field research on CE and CCS is often met with widespread public protests. For instance, a small scale field experiment on ocean iron fertilisation—a CDR measure—in the South Atlantic created considerable protest among the German public. Consequently, the German Federal Ministry for the Environment called for an immediate stop of the experiment.[1] Several CCS demonstration projects in Germany faced strong opposition from both the public and local politicians (Dütschke 2010). In some instances, the explorations have been stopped entirely because of public protests.[2] These examples show that public acceptance will crucially determine the future of CE and CCS. It is an open question, however, whether the public protests have been mainly caused by a lack of information about the new measures or, the other way around, whether more information would lead to even stronger opposition. Informing the public and taking into account its concerns may thus have a strong impact on acceptance.

Our paper contributes to the literature by focusing on people's perception of these new measures to address climate change. More specifically, our paper addresses the following research questions: (1) How does the public perceive different measures? (2) How does the acceptance of the measures differ between uninformed and informed respondents? (3) How do personal characteristics influence the perception of the measures, and (4) can personal characteristics explain differences in the acceptance between uninformed and informed respondents? As will become apparent from the literature review (Section 2 below) studies exist that investigate these questions with different degrees of correspondence. However, to the best of our knowledge, no study exists that is able to compare people's perception for all three measures (SRM, CDR and CCS) within a consistent framework. This is particularly important given the potential differences in the direction and the magnitude of the effect of information between the measures.

To address these questions, we conducted a large online experiment with more than 3500 participants in Germany. Compared to other Europeans, Germans express more negative attitudes toward nuclear energy and CCS but more positive attitudes toward wind and hydroelectric energy (European

[1] http://www.bmbf.de/_media/press/Univ_Heidelberg_zu_LOHAFEX.pdf, 31.07.2015
[2] http://www.iea.org/media/workshops/2011/ccstalk/Fischer.pdf, 31.07.2015

Commission 2011). This makes Germany an especially interesting case for further analyses on other risky technologies. We elicit the perceptions of a heterogeneous set of three measures (research question 1). The first measure is stratospheric sulphate injection (SSI). It is a SRM measure where sulphate is injected at a high altitude to block part of the incoming sunlight and thus reduces the global temperature. The second measure is large-scale afforestation, a CDR measure where large areas like the Sahara and the Australian Outback are afforested. The third measure is carbon capture and storage sub-seabed (CCS-S). It is a type of CCS where CO2 is stored underneath the seabed. All measures differ with respect to their expected effectiveness, expected side effects and the uncertainty about both.

To determine the effect of additional information (research question 2), we experimentally varied the amount of information our respondents received. The control group received only basic information (BI), whereas the treatment group received full information (FI) on a measure. We also test for the effect of personal characteristics on the acceptance (research question 3) and for the interaction of the treatment effect of additional information with personal characteristics (research question 4).

The remainder of the paper is structured as follows. Section 2 surveys the previous literature and relates it to our research questions. Section 3 outlines the survey design and the data while the methodological approach is presented in Section 4. The results of our empirical analysis are described in Section 5. Section 6 discusses and concludes.

2. Literature Review

Most of the related studies have investigated the above research questions individually. For this reason our literature review presents their findings by research question.

Systematic evidence on research question (1), i.e., the measures' public perception, is still relatively scarce, and most studies focus on only one measure. The existing literature includes studies based on focus group and Delphi studies on the one hand, and more often opinion polls and surveys on the other hand (see Bellamy et al. 2012 and Scheer and Renn 2014 for a recent overview).

Among the three measures we look at, the perception of CCS is the most thoroughly researched thus far. Respondents from a broad range of countries are often either sceptical or undecided about CCS (e.g., Curry 2004; Duan 2010; Itaoka et al. 2012; Krause et al. 2014; Miller et al. 2008). The studies, however, show considerable variation, which is most likely due to different national contexts, the specific storage location or the information respondents receive. Studies on SSI report generally low levels of acceptance (Mercer et al. 2011; Merk et al. 2015; Sugiyama and Fujiwara 2012). Studies on afforestation report generally high levels of acceptance (Curry et al. 2005; Lin et al. 2012).

A few studies exist that compare attitudes across measures. Royal Society (2009) and IPSOS Mori (2010) find evidence that public attitudes differ between CDR and SRM measures, with SRM methods being less supported than CDR measures (Royal Society 2009; IPSOS Mori 2010). Similarly, Wright et al. (2014) find in a survey for Australia and New Zealand that respondents have more positive associations with CDR measures than with SSI. A direct comparison of the acceptance of the three measures has not yet been performed.

While there are a number of studies that investigate the effect of additional information (research

question 2) on the acceptance of CCS[3], there are none for SSI and afforestation. The studies on CCS find conflicting results. On the one hand, several studies find a decrease in acceptance when respondents receive more information (Ha-Duong et al. 2009; Itaoka et al. 2009; L'Orange et al. 2011). Moreover, initially neutral respondents are significantly more likely to have a negative attitude toward CCS after receiving more information (Itaoka et al. 2012). On the other hand, several studies find an increase in acceptance when respondents receive more information (Curry 2004; Curry et al. 2005; Curry et al. 2007; De Best-Waldhober et al. 2009; Itaoka et al. 2004; Shackley et al. 2005; Tokushige et al. 2007a; Tokushige et al. 2007b). Pietzner et al. (2011) show that the effect of information differs across Europe. Altogether, these studies provide little systematic evidence on the role that personal characteristics might play for the conflicting results.

The influence of personal characteristics on acceptance (research question 3) has been analysed before. Studies have focused in particular on the following determinants: perceived seriousness of climate change, risk attitudes, values, and trust in institutions.

For SSI, surveys have been used to analyse the influence of several characteristics on acceptance (Mercer et al. 2011; Merk et al. 2015; Pidgeon et al. 2012; Spence et al. 2010; Sugiyama and Fujiwara 2012). These studies find that the perceived seriousness of climate change increases acceptance of SSI. In addition, Kahan et al. (2015) show that learning about CE increases the risk perception of climate change. Egoistic values generally increase the acceptance of CE measures like SSI, whereas altruism does not have a significant impact (Corner and Pidgeon 2014). An egalitarian worldview decreases the acceptance of CE (Bellamy and Hulme 2011).

In addition, the valuation of security and respondents' willingness to take risks might influence acceptance. For the latter, Merk et al. (2015) report an upward impact on acceptance of SSI. Ecological values about the relationship between humans and nature are an important factor for the acceptance of large-scale interventions like SSI. For example, the attitude that humans will eventually learn to control nature increases the acceptance of various kinds of SSI research and deployment, while a strong perception of the balance of nature being fragile decreases acceptance (Merk et al. 2015). In general, the risk perception literature also finds that perceived naturalness is an important determinant of risk perception (Slovic 2000). In the context of CE, respondents' perceived naturalness of different CE measures determines their perception (Corner et al. 2013; Corner and Pidgeon 2014; Macnaghten and Szerszynski 2013).

Beyond these general attitudes, also specific attitudes toward the technology influence the perception. The attitude that humans should not manipulate nature in the way SSI does, decreases the acceptance (Merk et al. 2015). Carr (2014) argues that also the perception of SSI as playing God might influence its acceptance, as religiousness determines the support for other technologies, e.g. nanotechnology.

Trust in institutions positively influences the acceptance of CCS as well as SSI (Terwel et al. 2009; Merk et al. 2015). Findings for other risky technologies suggest, however, that it might be less important the more knowledgeable people are about the technology (Siegrist 2000). This suggests that people rely on institutions when they know little but rely on themselves when they know more.

In addition, there are socio-demographic factors that potentially influence acceptance. Previous findings on the effect of education on acceptance are contradictory: Pidgeon et al. (2012) find a higher level of

[3] Only a few studies focus explicitly on CCS-S (Itaoka et al. 2004, 2009; Shackley et al. 2005; Tokushige et al. 2007a). The other studies cited above focus either on different types of CCS or do not define the type of CCS in more detail.

acceptance of SSI for highly educated people while Merk et al. (2015) find the reverse. Previous studies find that women tend to be more sceptical about CCS (Ha-Duong et al. 2009; Miller et al. 2007), while the results for CE measures are less clear (Pidgeon et al. 2012; Corner and Pidgeon 2014; Merk et al.2015). The gender difference might be caused by the framing and the amount of information. L'Orange et al. (2011) find lower levels of acceptance for women than for men in a basic information setting. Additional information on the monitoring of CCS has only a downward impact on men's level of acceptance, which is then similar to the impact on women.

Altogether, our study contributes to the existing literature in various ways. First, we provide insights into the perception of a heterogeneous set of new measures in Germany and compare them using a consistent framework for all three measures. Second, we are able to directly compare the levels of acceptance and their determinants across measures. Our selection of determinants is based on previous findings from the literature. In addition, we aim at providing new insights into the so far contradictory effect of education on acceptance. Education can be interpreted as a proxy of whether decisions are made intuitively or not. To address this more directly, we include the cognitive reflection text (CRT) proposed by Frederick (2005). It distinguishes intuitive from reflective decision makers and correlates with decision making. People who make more intuitive decisions are more risk-averse and more impatient than more reflective people (Frederick 2005, Oechssler et al. 2009). Additionally, more intuitive people are more susceptible to behavioural biases (Oechssler et al. 2009; Bergman et al. 2010; Hoppe and Kusterer 2011), which could be relevant in the context of processing information. Third, we analyse the effect of information on the acceptance of the three measures. Hence, we can address potential differences in the direction and the magnitude of the effect of information between the measures. Fourth, we are the first to broadly analyse the interaction of information with personal predispositions, values and attitudes. While the influence of personal characteristics on acceptance (research question 3) has been analysed before, the interaction of the treatment effect of additional information with personal characteristics (research question 4) has not yet been researched. This approach may provide insights into the reasons for the hitherto inconclusive results on the effect of information, which could be caused by differences in the survey design or the national context of previous studies.

3. Data and Survey Design

Our study uses novel data from an online survey that we conducted in August/September 2013. Respondents were randomly assigned to one of the three measures SSI, afforestation, or CCS-S. For each measure, we implemented two treatments using a between-subjects design. The two treatments differed only with respect to the amount of information that respondents received about the measure. Respondents aged 18 or above were recruited via an online panel. They were sampled using quotas for the characteristics of gender, age, and state of residence. In total, our working sample includes 3526 observations.[4] The average age was 47 years. Half of our respondents were male. Thirty-six percent of our respondents have a higher education entrance certificate. The average number of observations per treatment group is 588, ranging from 577 to 608.

[4] A total of 3909 respondents completed the survey. We dropped observations from respondents whom we identified as either speeders or straight-liners. Speeders are respondents who completed the survey in less than 9 minutes. Straight-liners are respondents who ticked the same answer within at least two blocks of questions.

The survey consisted of the following four parts. Table A-1 in the appendix reports all survey items used in our analysis and the scales on which they are measured.

In the first part, we elicited respondents' risk attitude using the scale implemented by Dohmen et al. (2011). Next, we elicited respondents' perception of the seriousness of climate change and their ecological values. The ecological values were measured by five items from the New Ecological Paradigm Scale (NEP, Dunlap et al. 2000). Before we provided respondents in the next part of the survey with information on one of the measures, we asked them about their awareness of the respective measure.

The second part contained the information treatment. Our aim was to present the information in a clear yet scientifically correct way. Unlike previous studies, we provided information using animated graphics videos. The animations explained the information graphically and were supported by verbal explanations spoken by a professional radio presenter.[5] The videos were embedded into the survey. Respondents who were not able to listen to or to play the video were excluded at the beginning of the survey. It was not possible to skip or fast-forward the video. The video first provided respondents with information on anthropogenic climate change and its likely consequences. The video then introduced mitigation, adaption and either SSI, afforestation or CCS-S as three possibilities to address climate change.[6] Afterwards, the video explained the respective measure in more detail. The video contained either basic information (BI treatment) or full information (FI treatment) on the respective measure. In the BI treatment, respondents received background information, i.e., the measure's underlying mechanisms and its impact on climate change. In the FI treatment, respondents watched the BI information video, but in addition, the video informed them about the current state of research and the potential benefits and risks of the specific measure. The information was based on peer-reviewed papers and scientific reports (taken from, e.g., Crutzen 2006, IPCC 2007; IPCC 2012; Ornstein et al. 2009; Royal Society 2009; UBA 2008). External experts checked the information for correctness and clarity. After watching the video, we asked respondents about the clarity of the video. More than 98% of the respondents across all treatments indicated that they understood the video well or very well.

In the third part, we elicited respondents' acceptance of the respective measure. Next, we elicited respondents' attitude toward a measure such as 'humans should not interfere with nature in this way' or '[…] is the easy way out'. We also measured trust in various actors or institutions to act in the interest of society and the environment. Thereafter, we elicited respondents' egoistic, altruistic and security values. These values were measured using items from the Schwartz Personal Value Questionnaire (PVQ5X, Schwartz et al. 2012, Beyerlein personal communication). Next, respondents completed the cognitive reflection test (Frederik 2005). The cognitive reflection test (CRT) indicates whether a respondent is a rather intuitive (low CRT score) or a rather reflective person (high CRT score).

The fourth part contained questions on the socio-demographic characteristics of respondents. In particular, we elicited information on the respondents' gender, age, state of residence and education. A respondent with a higher education entrance certificate is coded as having a high level of education in our analysis. In addition, we elicited the respondents' religiousness.

[5] An English translation of the German script of the video is provided in appendix B.

[6] The video introduces stratospheric sulphate injection (SSI) as 'spraying sulphate particles into the atmosphere at high altitude' to reflect sunlight. When referring to the technology, both the video and the survey use the term solar radiation management or the abbreviation SRM. The video and the survey on carbon capture and storage sub-seabed (CCS-S) use the abbreviation CCS.

Respondents could refrain from answering. The option 'don't know' was included in every question.

4. Methodology

Our analysis consists of two steps. In the first step, we use a descriptive analysis to compare the respondents' perception of the different measures (research question 1) and make a first assessment of the differences in the effect of information on acceptance. In the second step, we use a regression framework to analyse the determinants of acceptance for the three different measures as well as the size of the treatment effect. We further investigate whether respondents react differently to information depending on their personal characteristics. To address research questions (2) and (3a) on the determinants of acceptance and the role of information, we estimated, separately for each measure, the following equation:

$$(I) \quad acceptance_i = \alpha + \beta info_i + \gamma X_i + \varepsilon_i.$$

To address research question (3b) on the interaction of information and personal characteristics, we estimated the following type of equation:

$$(II) \quad acceptance_i = \alpha + \beta info_i + \gamma X_i + \delta(x_i \times info_i) + \varepsilon_i.$$

The dependent variable *acceptance* measures respondent *i*'s level of acceptance of a specific measure. It takes ordered values from 0 ('strongly disagree') to 3 ('strongly agree'). The dummy variable *info* takes a value of 0 if the respondent participated in the BI treatment and 1 if she participated in the FI treatment. *X* is a vector of personal characteristics (risk attitude, perceived seriousness of climate change, values, attitudes, trust, cognitive reflection, awareness, and socio-economic characteristics. The responses for ecological values (NEP), egoistic values, altruistic values, security values, and trust are standardised indices. The characteristic awareness controls for the influence of information from sources other than ours. It is included as a dummy variable, which takes a value of 0 if a respondent had never heard about a measure before and 1 if the respondent had heard at least a little bit about the measure before. The coefficient of the interaction term δ shows how the information effect changes with a one-unit change in the personal characteristic.

Summary statistics can be found in Table A-2 in the appendix.

5. Results

5.1 Descriptive statistics

Self-reported awareness differs significantly and strongly between SSI, CCS-S and afforestation (Wilcoxon rank sum tests $p \leq 0.001$). SSI is not well known: Less than a quarter of respondents have heard at least a little bit about it (22%). In contrast, a majority of respondents have heard at least a little bit about CCS-S (52%). For afforestation, we find an even higher awareness than for CCS-S. 60% of respondents state that they have heard at least a little bit about afforestation before.

Figure 1 shows respondents' acceptance of SSI, CCS-S and afforestation in the BI treatment and FI treatment. In general, we find that the share of respondents who strongly or somewhat agree with the use of a measure is highest for afforestation, followed by CCS-S and SSI. This ranking holds irrespective of the amount of information respondents received.[7]

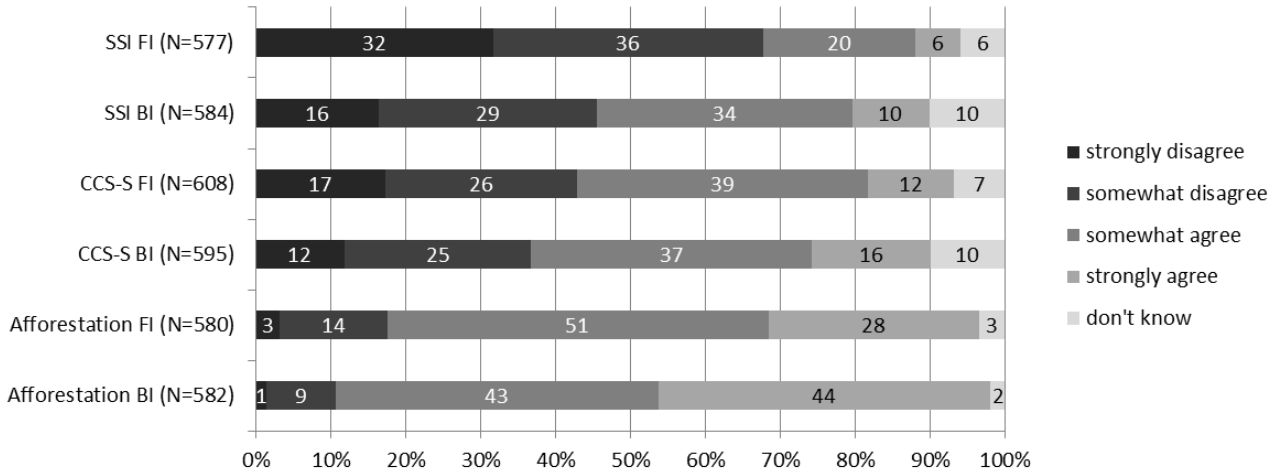

Figure 1: Acceptance of SSI, CCS-S and afforestation in the FI and BI treatments.
Note: The survey asked the following question: "We should use […] to counteract climate change." Own presentation.

Concerning the effect of information, our results show a clear picture. For each measure, we find that additional information (FI treatment) has a negative effect on acceptance (Wilcoxon rank sum tests, SSI $p < 0.001$, CCS-S $p = 0.007$, afforestation $p < 0.001$). The decrease in acceptance is weakest for CCS-S. 53% of the respondents who received only basic information on CCS-S agree that CCS-S should be used to counteract climate change. The share decreases only marginally to 51% in the FI treatment. The effect of information is strongest for SSI (44% versus 26%). For afforestation, the share of respondents who agree with using afforestation to counteract climate change is 8 percentage points lower in the FI treatment than in the BI treatment (87% versus 79%).

5.2 Regression analysis

Table 1 provides, for each measure, the results of equation (I) on the determinants of acceptance and the role of information. Table 2 provides the results of equation (II) on the interaction effects. In columns (2) to (6) of Table 2, we sequentially add interaction terms between *info* and one personal characteristic. While we ran regressions including interaction terms with all personal characteristics, Table 2 only reports coefficient estimates for interaction terms that are statistically significant for at least one measure. Tables A-3 to A-5 in the Appendix report the complete regression results. All results are based on OLS regressions.[8]

[7] In the following, we use the term 'agree' when respondents choose 'strongly agree' or 'somewhat agree' and the term 'disagree' when respondents choose 'strongly disagree' or 'somewhat disagree'.
[8] As a robustness check, we also performed ordered logit regressions. The results are very similar to the OLS results.

Determinants of acceptance

Our results presented in Table 1 reveal that, for each of the three measures, the treatment variable *info* has a significantly negative effect on acceptance. This finding confirms our descriptive finding that acceptance is generally lower in the FI treatment than in the BI treatment. We find the strongest effect for SSI. The acceptance of SSI decreases by 0.29 points between the BI and FI treatments. The acceptance of CSS-S is 0.17 points lower in the FI treatment than in the BI treatment. The results are similar for afforestation: the acceptance decreases by 0.18 points between the BI and FI treatments. Thus, we find for all three measures systematic evidence that information generally reduces acceptance.

Our regression results also show that, for SSI, *awareness* is a significant determinant of acceptance. For SSI, respondents who were aware of SSI before the survey show a lower acceptance. For CCS-S and afforestation, we do not find any significant effect of awareness on acceptance. Moreover, we find that respondents' *risk attitude* has a significant effect on the acceptance of SSI and CCS-S: Risk-seeking respondents are more likely to accept the use of a measure than risk-averse respondents. The perception of the *seriousness of climate change* also determines acceptance. Respondents who perceive climate change as a more serious problem also have a higher acceptance of any measure.

Values are also important determinants of acceptance. For SSI, we find that more egoistic respondents tend to accept the measure more readily than less egoistic respondents. For CCS-S, security loving respondents show a statistically significant higher acceptance than less security loving respondents. For afforestation, respondents with higher scores on ecological values and more egoistic respondents have a significantly higher acceptance.

We also find that *attitudes* significantly affect the acceptance of all three measures. Respondents who either think that a given measure is the easy way out or that humans should not manipulate nature this way have a significantly lower acceptance. *Trust* in institutions has a significant positive effect. *Cognitive reflection* has a significant negative effect on acceptance of all three measures.

Finally, we also find that socio-demographic variables influence acceptance. For both SSI and afforestation, more religious respondents reveal a significantly higher acceptance. For SSI, women show a higher acceptance than men. In contrast, we do not find significant gender differences for the acceptance of CCS-S and afforestation. We also analysed whether the level of acceptance varies between the different states in Germany. We find that the acceptance of CCS in Schleswig-Holstein and Lower Saxony is 0.21 points lower than in the rest of Germany. These are regions that faced public protest against onshore CCS in the past. For SSI and afforestation, we do not find significant regional differences in the level of acceptance.

Table 1: OLS Regression Results Equation (I)

Acceptance	SSI	CCS-S	Afforestation
info	-0.29***	-0.17***	-0.18***
	(0.05)	(0.05)	(0.04)
awareness	-0.12**	-0.02	0.04
	(0.06)	(0.05)	(0.04)
risk attitude	0.05***	0.03**	0.02
	(0.01)	(0.01)	(0.01)
seriousness of climate change	0.13***	0.14***	0.13***
	(0.04)	(0.04)	(0.04)
Values			
ecological	-0.00	-0.09*	0.11**
	(0.05)	(0.05)	(0.04)
altruistic	-0.03	0.01	-0.02
	(0.04)	(0.04)	(0.03)
egoistic	0.11***	0.04	0.09***
	(0.04)	(0.04)	(0.03)
security	0.06	0.11***	0.07**
	(0.04)	(0.04)	(0.03)
Attitudes			
is easy way out	-0.14***	-0.14***	-0.11***
	(0.04)	(0.04)	(0.03)
not manipulate this way	-0.43***	-0.39***	-0.26***
	(0.04)	(0.04)	(0.03)
Other Factors			
trust	0.31***	0.32***	0.24***
	(0.04)	(0.04)	(0.04)
cognitive reflection	-0.09***	-0.09***	-0.04*
	(0.02)	(0.02)	(0.02)
Socio-demographics			
religiousness	0.07***	0.00	0.05**
	(0.02)	(0.02)	(0.02)
female	0.11**	0.08	-0.03
	(0.05)	(0.05)	(0.05)
high education	-0.13**	-0.10*	-0.06
	(0.05)	(0.05)	(0.05)
age	0.00	0.00	0.00*
	(0.00)	(0.00)	(0.00)
region	-0.04	-0.21***	-0.03
	(0.06)	(0.07)	(0.06)
constant	2.02***	2.22***	2.23***
	(0.18)	(0.18)	(0.16)
Observations	846	897	898
Adjusted R^2	0.4775	0.4412	0.3202

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Acceptance is measured on a scale of 0 (strongly disagree) to 3 (strongly agree).

Interaction terms

We find evidence that individuals' reactions to information depend to a certain extent on their personal characteristics (Table 2).

For SSI and afforestation, we find that the negative effect of information on acceptance is larger for *women* than for *men*; women react much more strongly to information than men do. For SSI, informing respondents about SSI decreases acceptance by 0.20 points (SSI-2: *info*), for women acceptance decreases more than for men (0.41 points in the FI treatment; sum of *info* and *female * info*). Thus, the decline in acceptance is 0.21 points higher for women than for men, and this difference is statistically significant at the 5% level. Table 2 also provides evidence that this gender difference in acceptance vanishes in the FI treatment; between the two treatments, the acceptance of women declines by 0.21 points more than that of men. For afforestation, the acceptance of men does not differ statistically significantly between the FI treatment and the BI treatment (Aff-2: *info*). The acceptance of women, in contrast, is significantly lower in the FI treatment than in the BI treatment (sum of *info* and *female * info*). Hence, for afforestation, the negative overall effect of information is mostly explained by the negative effect on women.

For SSI, we also find that the effect of information depends on respondents' *risk attitude* (SSI-3: *risk attitude * info*). Respondents who are risk-seeking react less negatively to information than do risk-averse respondents. More specifically, the effect of information increases by 0.05 points for every one-unit increase in the risk-seeking factor. A plausible explanation for the positive sign of the interaction term is that risk-averse respondents put a higher weight on the risks of SSI when being informed about its risks and benefits. We also find for SSI that the perceived *seriousness of climate change* determines the effect of information (SSI-4). Respondents who perceive climate change as a serious problem have a higher acceptance of SSI (*seriousness of climate change*), but they react more negatively to information than respondents who do not perceive climate change as a serious problem. A one-point increase in the perceived seriousness of climate change decreases the effect of information by 0.14 points (SSI-4: *seriousness of climate change * info*). A likely explanation is that respondents who consider climate change to be a serious problem are more likely to consider the use of SSI in the first place (SSI-4: *seriousness of climate change*). Only for these respondents is additional information relevant to their acceptance. Conversely, respondents who do not perceive climate change as serious are not likely to consider the use of SSI, irrespective of the amount of information they receive.

We also find, that the negative effect of information on the acceptance of SSI is less pronounced for more *egoistic* respondents (SSI-6). They might perceive the additional information on the benefits more strongly and/or the additional information on the risks and side effects less strongly than less egoistic respondents. They might, therefore, show a less negative reaction to the additional information. Finally, we find for CCS-S that more altruistic respondents react more negatively to information than less altruistic respondents (CCS-S-5).

Interaction terms between *info* and all other personal characteristics are not statistically significant determinants of the acceptance of any of the three measures. Interestingly, neither education nor cognitive reflection matter for the effect of additional information on acceptance. This finding suggests that the information provided is not understood differently depending on cognitive capacities.

Table 2: OLS Regression Results Equation (II)

	SSI					CCS-S					Afforestation				
Acceptance	(SSI-2)	(SSI-3)	(SSI-4)	(SSI-5)	(SSI-6)	(CCS-S-2)	(CCS-S-3)	(CCS-S-4)	(CCS-S-5)	(CCS-S-6)	(Aff-2)	(Aff-3)	(Aff-4)	(Aff-5)	(Aff-6)
info	-0.20***	-0.55***	0.20	-0.29***	-0.30***	-0.13**	-0.08	0.14	-0.16***	-0.17***	-0.07	-0.23**	0.20	-0.18***	-0.18***
	(0.06)	(0.12)	(0.24)	(0.05)	(0.05)	(0.07)	(0.14)	(0.27)	(0.05)	(0.05)	(0.06)	(0.11)	(0.27)	(0.04)	(0.04)
female	0.22***	0.11**	0.10**	0.11**	0.11**	0.12	0.08	0.08	0.08	0.08	0.09	-0.03	-0.03	-0.03	-0.03
	(0.07)	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)	(0.05)	(0.05)	(0.05)	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)
risk attitude	0.05***	0.02	0.05***	0.05***	0.05***	0.03**	0.04*	0.03**	0.03**	0.03**	0.01	0.01	0.02	0.02	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
seriousness of climate	0.13***	0.13***	0.21***	0.13***	0.13***	0.14***	0.14***	0.18***	0.14***	0.14***	0.13***	0.13***	0.18***	0.13***	0.13***
change	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
altruistic	-0.04	-0.03	-0.04	-0.03	-0.03	0.01	0.01	0.01	0.07	0.01	-0.02	-0.02	-0.02	0.01	-0.02
	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
egoistic	0.11***	0.11***	0.11***	0.11***	0.04	0.05	0.04	0.04	0.05	0.05	0.09***	0.09***	0.09***	0.09***	0.07*
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
female * info	-0.21**					-0.08					-0.25***				
	(0.09)					(0.09)					(0.08)				
risk attitude * info		0.05**					-0.02					0.01			
		(0.02)					(0.02)					(0.02)			
seriousness of climate			-0.14**					-0.09					-0.11		
change * info			(0.07)					(0.07)					(0.07)		
altruistic * info				0.00					-0.11*					-0.06	
				(0.07)					(0.07)					(0.06)	
egoistic * info					0.13**					-0.01					0.04
					(0.07)					(0.07)					(0.06)
Other controls	All	All	All	All	All	All	All	All	All	All	All	All	All	All	All
Observations	846	846	846	846	846	897	897	897	897	897	898	898	898	898	898
Adjusted R^2	0.4801	0.4802	0.4801	0.4769	0.4798	0.4410	0.4409	0.4417	0.4427	0.4406	0.3260	0.3196	0.3221	0.3202	0.3199

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Note: Acceptance is measured on a scale of 0 (strongly disagree) to 3 (strongly agree). Other controls include: awareness, ecological values, security values, attitudes, trust, cognitive reflection, religiousness, high education, age, and region.

6. Discussion and Conclusion

This paper provides novel survey evidence for Germany on the perception of SSI, CCS-S and afforestation. These measures are currently controversially debated options to address climate change. Unlike previous surveys, we use a consistent research design for all measures and can thus directly compare the perceptions of the three measures. By examining the effect of information on perception, our paper also provides a possible projection on how acceptance might evolve in the future—as more and more information on CE and CCS-S becomes available. Finally, we also provide initial insights into how the effect of information differs across different subgroups of society.

Based on a consistent framework we are able to substantiate previous findings by allowing for a direct comparison of results across the three measures. We find that current levels of awareness differ strongly between SSI, CCS-S and afforestation. SSI is rather unknown to the public. In contrast, CCS-S and afforestation are known to slightly more than half of the respondents. Further, we find strong differences in the acceptance between the measures. Acceptance is generally highest for afforestation, followed by CCS-S and SSI (e.g., Mercer et al. 2011; Curry et al. 2005). Regarding the potential determinants of acceptance; for most determinants, we find consistent results across all measures confirming previous findings; the perception that climate change is serious increases acceptance (e.g., Mercer et al 2011). Also attitudes, e.g., that 'humans should not manipulate nature', significantly decrease acceptance (e.g., Mercer et al. 2011). We also find that trust has a positive effect on acceptance (e.g., Terwel et al. 2009).

Focusing on the so far inconclusive effect of education on acceptance, our results suggest that education has a sizeable negative effect on acceptance confirming findings of Merk et al. (2015) for SSI in Germany.

We included, novel to the literature, results of respondents' CRT to address the issue further. We find that cognitive reflection significantly decreases acceptance of all three measures, even when controlling for education and risk attitudes. More reflective decision makers are more sceptical about the measures.

Additional information significantly decreases the acceptance of all three measures—without changing their relative rankings. The difference in acceptance between the three measures is substantial before receiving full information and remains substantial after receiving full information. In particular, for SSI, we find a strong effect of information. While previous findings on the effect of additional information for CCS were mixed (e.g., Ha-Duong et al. 2009; De Best-Waldhober et al. 2009), we find a consistent negative effect of information on acceptance for the three measures analysed. Differences in the information presented, the wording of the questions, and the questionnaire design as well as the country where the survey was conducted might explained the mixed findings.

As pointed out above, results of previous findings disagree on the effect of gender on acceptance. Unlike, Ha-Duong et al. (2009) and Miller et al. (2007) we find no effect of gender on the acceptance of CCS. Also, we are unable to confirm findings of L'Orange et al. (2011) that differences depend on the amount of information provided. However, results are, again, not readily comparable; previous studies' results depend on the results of summary statistics while we obtained results from multiple regression analysis. Like Pidgeon et al. (2012) we find evidence that women show a higher acceptance of SSI. We also find that they respond particularly strongly to information. Woman have

higher acceptance than men after having received basic information. However, this gender difference in acceptance vanishes after having received full information, as woman react much more negatively to information than men. In addition, we find evidence that other personal characteristics such as risk attitude or values determine how information affects acceptance. This finding suggests that information affects subgroups of society very differently. While information lowers acceptance for some of them (i.e. less egoistic, more risk averse, those who perceive climate change as a serious problem) others are less affected by information. Communication strategies would have to take this into account. We find the strongest indication of individual-specific differences in the effect of information for SSI. Presumably, this is because the effect of information is greatest for this measure.

Overall, our results provide insights into the current perception of three hotly debated measures to address climate change. They also help to project how public opinions might evolve in the future when more information on the risks and benefits of these measures becomes available. Thus, our paper contributes to the dialog between policymakers, scientists and the general public on suitable ways to address climate change. The variability in acceptance found in our data also suggests that communication with the public should be an on-going process and that public opinions must be taken into account to ensure the legitimacy of research (Carr et al. 2013).

As other survey results, our findings must be interpreted cautiously. Corner et al. (2012) note that respondents' lack of prior knowledge of the topic creates the risk that "participants have been told what they are responding to rather than deciding for themselves how to interpret the item." We, therefore, paid specific attention to ask balanced questions without leading cues. In addition, the 'don't know' option was included in every item to signal that not answering was acceptable. The sequence of items within the questions was randomized, and we arranged the questions in a way that prevents or minimizes bias due to order effects. We also consulted with experts on survey design to ensure that our questionnaire met current quality standards.

Given the novelty of the measures analysed, the information of our respondents is mostly drawn from the video shown in the survey. While we made sure that the information in the video is regarded as complete and balanced by scientists, it must be noted, however, that the way in which information is framed might influence responses (Corner and Pidgeon 2014). Our study thus can only provide a snapshot of public acceptance obtained in a highly controlled setting at a time when strong media coverage and lively public discourse are still absent. Hence, it provides an indication for current and future acceptance based on the assumption that respondents regard the provided information as neutral. Yet, the future discourse on CE and CCS might be strongly influenced by information from the media, from NGOs or from the industry. Such information might be unbalanced and shape perceptions differently. Moreover, the effect of information on acceptance might vary over time.

Despite these limitations, which provide natural reference points for future research, our survey makes a valuable contribution to the emerging public debate on new measures to address climate change. In particular, our results suggest that only providing information, without actively involving the public, might further reduce the acceptance of CE and CCS projects --and might thus put such projects to a premature hold. Therefore, a broad public discourse, allowing for active engagement, is needed if CE and CCS should become publically accepted --and thus politically viable--options to counteract climate change (see also Corner et al. 2012).

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Appendix A

Table A-1: Survey Items

Question and items	*response scale*
Risk attitude	
Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks?	risk averse (0) - risk seeking (10)
Seriousness of climate change	strongly disagree (0) - strongly agree (3)
Global warming is a serious problem.	
Ecological values (Cronbach's α = 0.5756)	strongly disagree (0) - strongly agree (3)
The Earth is like a spaceship with very limited room and resources.	
Humans were meant to rule over the rest of nature.	
The balance of nature is very delicate and easily upset.	
Humans will eventually learn enough about how nature works to be able to control it.	
If things continue on their present course, we will soon experience a major ecological catastrophe.	
Altruistic values (Cronbach's α = 0.7224)	
She thinks it is important that every person has equal opportunities in life.	very dissimilar (0) - very similar (3)
She works to promote 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.	
Egoistic values (Cronbach's α = 0.7724)	very dissimilar (0) - very similar (3)
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.	
Security values (Cronbach's α = 0.7114)	very dissimilar (0) - very similar (3)
Her personal security is extremely important to her.	
She avoids anything that might endanger his safety.	
It is important to her to live in secure surroundings.	
Having order and stability in society is important to her.	
Awareness	
Have you ever heard about […] before or have you never heard about it before?	No, I have never heard about it Yes, I have heard a little about it. Yes, I have heard a lot about it
Acceptance	strongly disagree (0) - strongly agree (3)
We should use […] to counteract climate change.	
Attitudes	strongly disagree (0) - strongly agree (3)
[…] is the easy way out.	
Humans should not be manipulating nature in this way.	

Questions and items (continued)	*response scale*
Trust (Cronbach's α = 0.7942)	
How strongly do you trust that these groups will act in the interest of society and the environment?	strongly disagree (0) - strongly agree (3)
Federal government	
Companies involved in […] projects	
Environmental organisations	
Media	
Researchers studying at publicly funded research institutes	
United Nations	
European Union	
Cognitive reflection	
A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?	any number
If it takes 5 machines 5 minutes to make 5 widgets, how long would it take 100 machines to make 100 widgets?	
In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake?	
Religiousness	not religious at all (0)
How religious are you?	-
	very religious (3)
Education	
What is your highest degree?	7 degrees
Region	
In which Federal State do you live?	16 states

Table A-2: Summary Statistics

		SSI		*CCS-S*		*Afforestation*	
Variables	***Domain***	***mean***	***standard deviation***	***mean***	***standard deviation***	***mean***	***standard deviation***
acceptance	0 - 3	1.21	0.93	1.56	0.93	1.20	0.74
awareness	0 (have never heard); 1 (have heard at least a little bit)	0.22		0.52		0.60	
risk attitude	0 - 10	5.39	2.26	5.36	2.20	5.37	2.31
seriousness of climate change	0 - 3	2.51	0.71	2.51	0.71	2.51	0.70
ecological values	standardised index	-0.029	0.61	0.017	0.61	0.001	0.61
altruistic values	standardised index	-0.023	0.74	0.039	0.74	-0.026	0.74
egoistic values	standardised index	0.001	0.77	-0.024	0.74	0.032	0.80
security values	standardised index	-0.002	0.74	0.019	0.73	-0.025	0.73
attitudes_ easy way out	0 - 3	2.17	0.84	2.09	0.85	1.69	0.85
attitudes_not manipulate in this way	0 - 3	2.19	0.85	2.02	0.88	1.21	0.85
trust	standardised index	-0.021	0.67	-0.059	0.67	0.095	0.66
cognitive reflection test	0 - 3	0.98	1.03	1.06	1.03	1.05	1.03
religiousness	0 - 3	1.01	0.94	1.04	0.97	1.02	0.96
female	0 (Male); 1 (Female)	49%		50%		49%	
high education	0 (other); 1 (A level)	36%		35%		36%	
age	18 - 87	47	15.33	48	15.33	47	15.15
region	0 (other); 1 (Schleswig-Holstein or Lower Saxony)	14%		12%		13%	
N		1161		1203		1162	

Table A-3: OLS Regression Results for SSI

Acceptance of SSI	(SSI-1)	(SSI-2)	(SSI-3)	(SSI-4)	(SSI-5)	(SSI-6)
info	-0.29***	-0.20***	-0.55***	0.20	-0.29***	-0.30***
	(0.05)	(0.06)	(0.12)	(0.24)	(0.05)	(0.05)
awareness	-0.12**	-0.11**	-0.12**	-0.12**	-0.12**	-0.11**
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
risk attitude	0.05***	0.05***	0.02	0.05***	0.05***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
seriousness of climate	0.13***	0.13***	0.13***	0.21***	0.13***	0.13***
change	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
Values						
ecological	-0.00	-0.01	0.00	-0.01	-0.00	-0.00
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
altruistic	-0.03	-0.04	-0.03	-0.04	-0.03	-0.03
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
egoistic	0.11***	0.11***	0.11***	0.11***	0.11***	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)
security	0.06	0.06	0.06	0.06	0.06	0.06
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Attitudes						
is easy way out	-0.14***	-0.14***	-0.14***	-0.14***	-0.15***	-0.14***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
not manipulate this way	-0.43***	-0.43***	-0.43***	-0.42***	-0.43***	-0.43***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Other Factors						
trust	0.31***	0.31***	0.31***	0.31***	0.31***	0.31***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
cognitive reflection	-0.09***	-0.09***	-0.09***	-0.09***	-0.09***	-0.09***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Socio-demographics						
religiousness	0.07***	0.07***	0.07***	0.07***	0.07***	0.07***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
female	0.11**	0.22***	0.11**	0.10**	0.11**	0.11**
	(0.05)	(0.07)	(0.05)	(0.05)	(0.05)	(0.05)
high education	-0.13**	-0.13**	-0.14***	-0.13**	-0.13**	-0.14***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
age	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
region	-0.04	-0.05	-0.05	-0.04	-0.04	-0.04
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Interaction Terms						
female * info		-0.21**				
		(0.09)				
risk attitude * info			0.05**			
			(0.02)			
seriousness of climate				-0.14**		
change * info				(0.07)		
altruistic * info					0.00	
					(0.07)	
egoistic* info						0.13**
						(0.07)
constant	2.02***	1.95***	2.15***	1.82***	2.02***	2.00***
	(0.18)	(0.18)	(0.19)	(0.21)	(0.18)	(0.18)
Observations	846	846	846	846	846	846
Adjusted R^2	0.4775	0.4801	0.4802	0.4801	0.4769	0.4798

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-3: OLS regression of SSI acceptance. Note: Acceptance is measured on a scale of 0 (strongly disagree) to 3 (strongly agree). All other variables are also measured on scales of 0 to 3. Exceptions are dummy variables (info, awareness, female, high education, region), risk attitude (scale is from 0 to 10), and age. Variables for values and trust are standardised indices.

Table A-4: OLS Regression Results for CCS-S

Acceptance of CCS-S	(CCS-S-1)	(CCS-S-2)	(CCS-S-3)	(CCS-S-4)	(CCS-S-5)	(CCS-S-6)
info	-0.17***	-0.13**	-0.08	0.14	-0.16***	-0.17***
	(0.05)	(0.07)	(0.14)	(0.27)	(0.05)	(0.05)
awareness	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
risk attitude	0.03**	0.03**	0.04*	0.03**	0.03**	0.03**
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)
seriousness of climate	0.14***	0.14***	0.14***	0.18***	0.14***	0.14***
change	(0.04)	(0.04)	(0.04)	(0.06)	(0.04)	(0.04)
Values						
ecological	-0.09*	-0.09*	-0.09*	-0.09**	-0.10**	-0.09*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
altruistic	0.01	0.01	0.01	0.01	0.07	0.01
	(0.04)	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)
egoistic	0.04	0.05	0.04	0.04	0.05	0.05
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.06)
security	0.11***	0.11***	0.11***	0.10***	0.10***	0.11***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Attitudes						
is easy way out	-0.14***	-0.14***	-0.14***	-0.15***	-0.15***	-0.14***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
not manipulate this way	-0.39***	-0.39***	-0.39***	-0.39***	-0.39***	-0.39***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Other Factors						
trust	0.32***	0.32***	0.33***	0.33***	0.32***	0.32***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
cognitive reflection	-0.09***	-0.09***	-0.09***	-0.09***	-0.09***	-0.09***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Socio-demographics						
religiousness	0.00	0.00	0.00	0.00	0.00	0.00
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
female	0.08	0.12	0.08	0.08	0.08	0.08
	(0.05)	(0.07)	(0.05)	(0.05)	(0.05)	(0.05)
high education	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*	-0.10*
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
age	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
region	-0.21***	-0.21***	-0.21***	-0.21***	-0.21***	-0.21***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Interaction Terms						
female * info		-0.08				
		(0.09)				
risk attitude * info			-0.02			
			(0.02)			
seriousness of climate				-0.09		
change * info				(0.07)		
altruistic * info					-0.11*	
					(0.07)	
egoistic* info						-0.01
						(0.07)
Ccnstant	2.22***	2.20***	2.18***	2.09***	2.21***	2.22***
	(0.18)	(0.18)	(0.19)	(0.22)	(0.18)	(0.18)
Observations	897	897	897	897	897	897
Adjusted R^2	0.4412	0.4410	0.4409	0.4417	0.4427	0.4406

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-4: OLS regression of CCS acceptance. Note: Acceptance is measured on a scale of 0 (strongly disagree) to 3 (strongly agree). All other variables are also measured on scales of 0 to 3. Exceptions are dummy variables (info, awareness, female, high education, region), risk attitude (scale is from 0 to 10), and age. Variables for values and trust are standardised indices.

Table A-5: OLS Regression Results for Afforestation

Acceptance of Afforestation	(Aff-1)	(Aff-2)	(Aff-3)	(Aff-4)	(Aff-5)	(Aff-6)
info	-0.18***	-0.07	-0.23**	0.20	-0.18***	-0.18***
	(0.04)	(0.06)	(0.11)	(0.27)	(0.04)	(0.04)
awareness	0.04	0.04	0.04	0.04	0.04	0.04
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
risk attitude	0.02	0.01	0.01	0.02	0.02	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
seriousness of climate	0.13***	0.13***	0.13***	0.18***	0.13***	0.13***
change	(0.04)	(0.04)	(0.04)	(0.05)	(0.04)	(0.04)
Values						
ecological	0.11**	0.11**	0.11**	0.11**	0.11**	0.11**
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
altruistic	-0.02	-0.02	-0.02	-0.02	0.01	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)
egoistic	0.09***	0.09***	0.09***	0.09***	0.09***	0.07*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)
security	0.07**	0.06*	0.07**	0.07**	0.07**	0.07**
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Attitudes						
is easy way out	-0.11***	-0.11***	-0.11***	-0.11***	-0.11***	-0.11***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
not manipulate this way	-0.26***	-0.25***	-0.25***	-0.26***	-0.25***	-0.25***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Other Factors						
trust	0.24***	0.24***	0.24***	0.24***	0.24***	0.24***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
cognitive reflection	-0.04*	-0.05**	-0.04*	-0.04*	-0.04*	-0.04*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Socio-demographics						
religiousness	0.05**	0.05**	0.05**	0.05**	0.05**	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
female	-0.03	0.09	-0.03	-0.03	-0.03	-0.03
	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)
high education	-0.06	-0.05	-0.06	-0.06	-0.06	-0.06
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
age	0.00*	0.00*	0.00*	0.00*	0.00*	0.00*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
region	-0.03	-0.03	-0.03	-0.04	-0.03	-0.04
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Interaction Terms						
female * info		-0.25***				
		(0.08)				
risk attitude * info			0.01			
			(0.02)			
seriousness of climate				-0.11		
change * info				(0.07)		
altruistic * info					-0.06	
					(0.06)	
egoistic* info						0.04
						(0.06)
constant	2.23***	2.17***	2.26***	2.11***	2.24***	2.23***
	(0.16)	(0.17)	(0.17)	(0.19)	(0.16)	(0.16)
Observations	898	898	898	898	898	898
Adjusted R^2	0.3202	0.3260	0.3196	0.3221	0.3202	0.3199

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A-5: OLS regression of afforestation acceptance. Note: Acceptance is measured on a scale of 0 (strongly disagree) to 3 (strongly agree). All other variables are also measured on scales of 0 to 3. Exceptions are dummy variables (info, awareness, female, high education, region), risk attitude (scale is from 0 to 10), and age. Variables for values and trust are standardised indices.

Appendix B

1) Information Provided in the SSI Video:

Information provided both in the Basic and Full Information Video:

Sunlight warms the Earth and its atmosphere. Greenhouse gases in the atmosphere such as CO_2 ensure that some warmth remains close to the Earth's surface. This makes the Earth warm enough for humans, animals, and plants to live on.

Since the start of industrialisation around 1850, people have emitted a great amount of greenhouse gases by burning coal, oil, and gas. These gases trap more heat in the atmosphere and cause a gradual increase in the average global temperature.

Since 1900, the global temperature has risen by approximately 0.8°C. Almost all countries agree that the increase in the average global temperature should not exceed 2°C compared to pre-industrial levels. This is called the 2°C goal.

By 2100, a further increase in temperature between 0.9 and 5.4°C is expected. The development depends strongly on the amount of greenhouse gases emitted in the future. To reach the 2°C goal, the current level of emissions would have to be cut by more than half until 2050. By 2100, greenhouse gas emissions would have to be reduced to almost zero.

It is virtually certain that climate change will cause a rise in sea levels. The frequency of heat waves is very likely to increase as well as the number of heavy precipitation events in many regions. It is likely that in the future, more areas will be affected by longer droughts and that the frequency and intensity of tropical cyclones will increase. In addition, part of the emitted CO2 is absorbed by the ocean, causing ocean acidification.

There are different ways to deal with climate change:

We can reduce greenhouse gas emissions or adapt to the new climate by building dikes. Another option is to reduce the global temperature by deploying solar radiation management (SRM).

Via SRM, some sunlight is reflected before it can warm the Earth. This can be accomplished by, for example, spraying sulphate particles into the atmosphere at a high altitude.

A similar phenomenon can be observed in nature: When large volcanoes erupt, similar particles are distributed across wide areas of the Earth's atmosphere, cooling the Earth.

The particles remain in the higher regions of the atmosphere for approximately two years. To prevent the Earth from heating up again, the spraying would have to be continued until the cause of global warming is removed. Because CO2 remains in the atmosphere for a very long time, SRM might have to be used for several centuries. However, using SRM will not stop ocean acidification.

Information provided additional in the Full Information Video:

Currently, the risks, the benefits, and the feasibility of SRM are being researched.

The use of SRM entails benefits as well as risks. One of the benefits is that global warming could be slowed more quickly than by cutting greenhouse gas emissions. This would buy 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 do not want to reduce their greenhouse gas emissions. Deploying SRM would be less expensive than reducing the consumption of fossil fuels.

The risks include a change in the amount of precipitation in most regions. Arid regions in particular would have to cope with even less rain. If the deployment of SRM was suddenly stopped, the global temperature would rise abruptly. The speed of this rise in temperature would lead to severe problems for humans and the environment. Because possible side effects would be trans-boundary, the use of SSI could cause international conflicts. Once used, SRM could take away people's motivation to change their lifestyle, and greenhouse gas emissions would continue to increase. Furthermore, there would be the possibility of further unknown and unforeseeable risks arising.

2) Information Provided in the CCS-S Video

Information provided both in the Basic and Full Information Video:

Sunlight warms the Earth and its atmosphere. Greenhouse gases in the atmosphere such as CO_2 ensure that some warmth remains close to the Earth's surface. This makes the Earth warm enough for humans, animals, and plants to live on.

Since the start of industrialisation around 1850, people have emitted a great amount of greenhouse gases by burning coal, oil, and gas. These gases trap more heat in the atmosphere and cause a gradual increase in the average global temperature.

Since 1900, the global temperature has risen by approximately 0.8°C. Almost all countries agree that the increase in the average global temperature should not exceed 2°C compared to pre-industrial levels. This is called the 2°C goal.

By 2100, a further increase in temperature between 0.9 and 5.4°C is expected. The development depends strongly on the amount of greenhouse gases emitted in the future. To reach the 2°C goal, the current level of emissions would have to be cut by more than half until 2050. By 2100, greenhouse gas emissions would have to be reduced to almost zero.

It is virtually certain that climate change will cause a rise in sea levels. The frequency of heat waves is very likely to increase as well as the number of heavy precipitation events in many regions. It is likely that in the future, more areas will be affected by longer droughts and that the frequency and intensity of tropical cyclones will increase. In addition, part of the emitted CO2 is absorbed by the ocean, causing ocean acidification.

There are different ways to deal with climate change:

We can reduce greenhouse gas emissions or adapt to the new climate by building dikes. Another option is carbon capture and storage sub-seabed (CCS).

The CCS technology captures CO2 from the industrial combustion of fossil fuels. The CO2 is compressed and stored in suitable geological formations under the seabed. It is not released into the atmosphere. This process additionally uses approximately 25% of the generated energy, which increases the overall demand for fossil fuels.

On a small scale, CO2 has already been stored in the ground for approximately 30 years. CO2 is injected for the recovery of oil and gas to make this process easier. The experiences indicate a high level of storage safety.

Former oil and gas fields as well as sub-seabed saline aquifers are considered to be safe and permanently suitable deposits.

Pipelines and ships carry the compressed CO2 to the deposits.

There, it is pumped into tiny hollows of the sub-seabed deposit, where it has to be stored for several thousands of years. During this time it merges with the rock and it is rendered permanently harmless.

Information provided additional in the Full Information Video:

Scientists think further applied research on CCS would be useful. The processes, benefits and risks are already well understood.

Some expected benefits and risks of CCS are now introduced to you.

Benefits of CCS are that global warming as well as acidification of the oceans would be slowed down. Furthermore, deploying CCS would be less expensive than an energy transition from fossil fuels to renewable energies.

The risks of sub-seabed CCS include the possible leakage of CO2 from the well or from the deposits caused by increased pressure. This could lead to a local acidification, which would endanger the biodiversity of that area.

3) Information Provided in the Afforestation Video

Information provided both in the Basic and Full Information Video:

Sunlight warms the Earth and its atmosphere. Greenhouse gases in the atmosphere such as CO_2 ensure that some warmth remains close to the Earth's surface. This makes the Earth warm enough for humans, animals, and plants to live on.

Since the start of industrialisation around 1850, people have emitted a great amount of greenhouse gases by burning coal, oil, and gas. These gases trap more heat in the atmosphere and cause a gradual increase in the average global temperature.

Since 1900, the global temperature has risen by approximately 0.8°C. Almost all countries agree that the increase in the average global temperature should not exceed 2°C compared to pre-industrial levels. This is called the 2°C goal.

By 2100, a further increase in temperature between 0.9 and 5.4°C is expected. The development depends strongly on the amount of greenhouse gases emitted in the future. To reach the 2°C goal, the current level of emissions would have to be cut by more than half until 2050. By 2100, greenhouse gas emissions would have to be reduced to almost zero.

It is virtually certain that climate change will cause a rise in sea levels. The frequency of heat waves is very likely to increase as well as the number of heavy precipitation events in many regions. It is likely that in the future, more areas will be affected by longer droughts and that the frequency and intensity of tropical cyclones will increase. In addition, part of the emitted CO2 is absorbed by the ocean, causing ocean acidification.

There are different ways to deal with climate change:

We can reduce greenhouse gas emissions or adapt to the new climate by building dikes. Another option is large-scale afforestation.

Growing trees gradually absorb CO2 from the atmosphere and store it in the wood. By logging mature trees and replacing them with new ones, CO2 can be continuously absorbed from the atmosphere. To prevent the CO2 from re-entering the atmosphere, the logged trees are, for example, used as building material or buried.

To slow down climate change through afforestation, very large areas would have to be covered with trees. Suitable areas are especially tropical areas, the Sahara Desert and the Australian Outback.

Information provided additional in the Full Information Video:

Scientists agree that the local effects have already been sufficiently researched. Further research is needed on the long-term effects on natural cycles.

Some expected benefits and risks of large-scale afforestation are now being introduced to you.

Benefits of large-scale afforestation are that global warming as well as acidification of the ocean would be slowed down. In addition, the quality of soil and water would be improved.

The risks include the high water consumption for the afforestation, which could lead to regional water scarcity. For the afforestation, agricultural areas would also have to be used. The afforestation of these areas could lead to food scarcity and thus increase food prices.

Furthermore, large-scale afforestation would slow down climate change more slowly than the mitigation of greenhouse gas emissions.