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## **Pitfalls in the communication about CO2 capture and storage**

Vries, G. de

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**Author:** Vries, Gerdien de

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# Chapter 2

## Pitfalls of Heaping Information



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The mitigation of human-induced climate change is one of the greatest environmental challenges facing the world today. Considering that climate change is largely due to carbon dioxide (i.e., CO<sub>2</sub>) emissions arising from ever-increasing energy use, the natural solution to the problem would be to increase the use of clean, sustainable energy sources (e.g., wind) and to encourage individuals, organizations, and societies to save on energy consumption. Unfortunately, this is easier said than done. Relatively few people and organizations (are willing to) engage in sustainable behavior for the purpose of mitigating climate change (Whitmarsh, 2009). A substantial increase in sustainable behavior in the near future is unlikely, among other things because of a variety of “psychological barriers” such as limited cognition about the problem and discredence of experts and authorities (Gifford, 2011). In addition to focusing on these more long-term solutions, governments all over the world are currently thinking about other, more immediate mitigation measures.

According to reports by the Intergovernmental Panel on Climate Change (IPCC, 2007) and the International Energy Agency (IEA, 2012), the large-scale implementation of CO<sub>2</sub> capture and storage (CCS) technology is a measure that would make a significant contribution to the mitigation of climate change in the short run. In a nutshell, it involves the capture of CO<sub>2</sub> in fossil fuel power plants or other major industrial processes, and the subsequent transport and long-term storage of this CO<sub>2</sub> in deep geological formations (e.g., depleted natural gas fields and saline aquifers). Despite the fact that several countries are considering the use of CCS, a recent Eurobarometer survey commissioned by the European Commission (2011, pp. 1-185) shows that the majority of the public is unfamiliar with the technology. Due to the lack of public knowledge and awareness of CCS there is plenty of opportunity for stakeholders (i.e., the proponents and opponents of CCS) to educate people on the matter and to convince them of the benefits and the risks associated with CCS.

In the current research, we focus on the relative persuasiveness of communications that consist of either highly relevant information only (e.g., the argument that the implementation of CCS has important climate benefits) or that combine highly relevant

with less relevant information. This is important to examine because persuasiveness plays a central role in the attitude formation process (e.g., Petty & Cacioppo, 1981). On the one hand, previous studies suggest that a message's persuasiveness may increase with length (i.e., the length-implies-strength heuristic; e.g., Stec & Bernstein, 1999). Thus, it might be useful to increase the length of communications about CCS by adding less relevant arguments (or perhaps even information that is irrelevant for attitude formation) to the most relevant argument in order to increase the persuasiveness of public communications. On the other hand, based on insights from research on the dilution effect (e.g., Nisbett et al., 1981), one might anticipate the added information to weaken the impact of the relevant argument. This would make public communications less instead of more persuasive. That is, although only the most relevant information should dictate people's judgments and beliefs, less relevant details can cause people to alter their judgments (Nisbett et al., 1981). The main question that we intend to answer is whether adding less relevant information to relevant information makes communications about CCS more or less persuasive than sharing merely the most relevant information.

### **The Dilution Effect**

The dilution effect has been defined as "a judgment bias in which the presence of nondiagnostic cues, when processed along with diagnostic cues, causes a judge to under-weigh the diagnostic cues" (Waller & Zimbelman, 2003, p. 254). This bias has been documented by researchers from various disciplines and across different settings. Research has revealed dilution in relation to the effects of stereotypical information on impression formation (Nisbett et al., 1981; Tetlock & Boettger, 1989) and the effects of auditing cues on financial evaluations (Ettenson, Shanteau, & Krogstad, 1987). Furthermore, the dilution effect plays a role in juror decisions (Smith, Stasson, & Hawkes, 1998) and product evaluations (Meyvis & Janiszewski, 2002). For example, Meyvis and Janiszewski (2002) found that consumers' beliefs about the speed of a computer were diluted when relevant information ("this computer has a very powerful processor") was mixed with irrelevant information ("this computer can be ordered online"). Up till now, the dilution effect has not been examined in regard to evaluations of the persuasiveness of communications.

Prior research on the dilution effect has mainly focused on the effects of adding irrelevant (i.e., nondiagnostic) information to relevant information, while less is known about the possible diluting effect of moderately relevant information (i.e., less strong than highly relevant information, but pointing in the same direction). At first sight, it might seem logical to assume that if irrelevant information dilutes the impact of relevant information, moderately relevant information has a similar effect. Indeed, this would be in line with the human tendency to average evaluations of different pieces of

information into a single evaluative judgment (i.e., the averaging bias, Lichtenstein, Earle, & Slovic, 1975). Nevertheless, Tetlock and Boettger (1989) found no dilution effect when people had to predict a student's study performance after reading relevant information as well as information that was moderately relevant for this prediction. Moreover, Meyvis and Janiszewski (2002) suggest that moderately relevant information can even strengthen the persuasiveness of highly relevant information. They showed that participants who evaluated the speed of a computer were more confident that a computer was fast when they had received both highly relevant information and three pieces of moderately relevant information than when they had only received the relevant information.

Based on the above, we hypothesize that the persuasiveness of highly relevant information is diluted when irrelevant information is added (Hypothesis 2.1). Furthermore, we explore whether or not adding moderately relevant information also alters the persuasiveness of highly relevant information.

## Experiment 2.1

Experiment 2.1 examines the hypothesis that the persuasiveness of a highly relevant pro-CCS argument is diluted when irrelevant information is added (Hypothesis 2.1). It furthermore explores the effect of adding moderately relevant pro-CCS information.

## Method

**Participants and design.** Seventy-nine undergraduate students from Leiden University participated in the study. They were randomly allocated to either one of three experimental conditions (Information Relevance: highly relevant vs. highly relevant + moderately relevant vs. highly relevant + irrelevant) and received either €1 or course credits for their participation.

**Procedure.** Participants first received some general background information about energy production and CO<sub>2</sub> emissions, and a brief description of CCS. Next, participants in the 'highly relevant' condition read a pro-CCS argument that a pilot study had identified as highly relevant:<sup>2</sup>

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<sup>2</sup> The pilot study ( $N = 50$ ) was conducted in March 2011 and served to identify arguments for and against the implementation of CCS that varied in perceived relevance. The identification of irrelevant information was not part of the pilot study because this type of information was already anticipated to be quite irrelevant for the purpose of forming an opinion, due to its non-directional nature. Individuals who participated in the pilot study were not allowed to participate in the subsequent experiments.

*By implementing CCS, approximately 90 percent of the CO<sub>2</sub> emissions released by the burning of fossil fuels can be captured. This helps to combat global warming because the CO<sub>2</sub> is not released into the air.*

Participants in the 'highly relevant + moderately relevant' condition read the highly relevant pro-CCS information complemented with three pro-CCS arguments that the pilot study had identified as moderately relevant:

*A small proportion of the captured CO<sub>2</sub> can be used for the production of carbonated drinks. By implementing CCS, approximately 90 percent of the CO<sub>2</sub> emissions released by the burning of fossil fuels can be captured. This helps to combat global warming because the CO<sub>2</sub> is not released into the air. Dutch companies can qualify for European subsidies so that they do not have to finance the development of CCS completely by themselves. Also, as one of the main developers of CCS, the Netherlands can export knowledge of the technology to foreign countries.*

Participants in the 'highly relevant + irrelevant' condition read the highly relevant pro-CCS information complemented with three pieces of irrelevant information about CCS.

*In English, CCS is referred to as "CO<sub>2</sub> storage" or "CO<sub>2</sub> sequestration". In French also two terms are used, namely "CO<sub>2</sub> stockage" and "CO<sub>2</sub> séquestration". By implementing CCS, approximately 90 percent of the CO<sub>2</sub> emissions released by the burning of fossil fuels can be captured. This helps to combat global warming because the CO<sub>2</sub> is not released into the air. September last year, a conference on CCS was held in Amsterdam. A lot of information on CCS is available on the internet, for example at Wikipedia.*

After reading these communications, participants completed a questionnaire that included items to measure the persuasiveness of the communications and the perceived relevance of the different pieces of information (this measure served as the manipulation check). Finally, participants were debriefed, paid, and thanked for their participation.

## Measures

**Persuasiveness of communications.** The persuasiveness of the communications was measured with two separate questions that assessed how convincing and strong participants perceived the communications (1 = *not at all convincing/strong*; 7 = *very convincing/strong*). Responses to these questions were averaged to form an index of persuasiveness of communications ( $\alpha = .78$ ).

**Manipulation check.** To assess the adequacy of the manipulation, we asked all participants to indicate the relevance and importance of the highly relevant pro-CCS argument (i.e., CCS helps to combat global warming), the three moderately relevant pro-CCS arguments (i.e., carbonated drinks, subsidies, knowledge export), and the three pieces of irrelevant information (i.e., foreign names, conference, internet) (1 = *not at all relevant/important*; 7 = *very relevant/important*). Responses were averaged to form three separate overall indices of perceived relevance (highly relevant pro-CCS information,  $\alpha = .83$ ; moderately relevant pro-CCS information averaged across the three arguments,  $\alpha = .70$ ; irrelevant information averaged across the three pieces,  $\alpha = .76$ ).

## Results

**Manipulation check.** As intended, participants regarded the highly relevant argument in favor of CCS as significantly more relevant ( $M = 5.62$ ,  $SD = 1.07$ ) than the moderately relevant pro-CCS information ( $M = 4.20$ ,  $SD = 0.93$ ),  $t(78) = 10.41$ ,  $p < .001$ . In turn, they regarded the moderately relevant pro-CCS information as significantly more relevant than the irrelevant information ( $M = 2.48$ ,  $SD = 1.02$ ),  $t(78) = 13.69$ ,  $p < .001$ . In addition, we checked for potential between-subjects effects but did not find any ( $F_s \leq 1.13$ ,  $p_s \geq .33$ ).

**Persuasiveness of communications.** We performed an analysis of variance (ANOVA) with Information Relevance as the independent variable and persuasiveness of the communications as the dependent variable, which revealed a significant between-subjects effect,  $F(2, 76) = 3.34$ ,  $p = .04$ ,  $\eta_p^2 = .08$ . We then looked at two planned contrasts to determine specific differences regarding persuasiveness between conditions. A planned contrast between the ‘highly relevant’ and the ‘highly relevant + irrelevant’ conditions showed a significant difference,  $F(1, 76) = 5.59$ ,  $p = .02$ ,  $\eta_p^2 = .07$ . Participants found the highly relevant argument more persuasive in isolation ( $M = 4.69$ ,  $SD = 0.93$ ) than when it was mixed with irrelevant information ( $M = 3.92$ ,  $SD = 1.32$ ). Furthermore, a planned contrast between the ‘highly relevant’ and ‘highly relevant + moderately relevant’ conditions did not show a significant difference,  $F(1, 76) = 0.14$ ,  $p = .71$ . Participants found the communications equally persuasive, regardless of whether these consisted of a mix of highly relevant and moderately relevant arguments in favor of CCS ( $M = 4.57$ ,  $SD = 1.13$ ) or only consisted of the highly relevant argument ( $M = 4.69$ ,  $SD = 0.93$ ). See Table 2.1 for all means and standard deviations.

**Table 2.1.**

Means (and standard deviations) for persuasiveness of communications as a function of information relevance (Experiment 2.1 and Experiment 2.2).

	Pro-CCS communications (Experiment 2.1)			Con-CCS communications (Experiment 2.2)		
	Highly relevant  ( <i>N</i> = 24)	Highly relevant + moderately relevant  ( <i>N</i> = 29)	Highly relevant + irrelevant  ( <i>N</i> = 26)	Highly relevant  ( <i>N</i> = 33)	Highly relevant + moderately relevant  ( <i>N</i> = 33)	Highly relevant + irrelevant  ( <i>N</i> = 33)
Persuasiveness communications	4.69 (0.93)	4.57 (1.13)	3.92 (1.31)	4.35 (1.24)	4.42 (0.92)	3.83 (1.18)

All in all, the results of Experiment 2.1 offer support for Hypothesis 2.1: Irrelevant information diluted the persuasiveness of a highly relevant argument in favor of CCS. Furthermore, the results show that moderately relevant pro-CCS arguments did not dilute.

## Experiment 2.2

Experiment 2.2 aims to replicate the results of Experiment 2.1, but this time we focus on information against the implementation of CCS. The fact that negative information is often processed differently (e.g., more thoroughly) and can have a stronger impact than positive information (e.g., Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001) may have implications for the magnitude of the dilution effect. Therefore, we think it is useful to examine whether or not adding irrelevant information to relevant con-CCS information has a similar effect on persuasiveness as adding irrelevant information to relevant pro-CCS information does.

## Method

**Participants and design.** Ninety-nine undergraduate students from Leiden University participated in the study. They were randomly allocated to either one of three experimental conditions (Information Relevance: highly relevant vs. highly relevant + moderately relevant vs. highly relevant + irrelevant) and received either €1 or course credits for their participation. Individuals who participated in the pilot study or in Experiment 2.1 were not allowed to participate in Experiment 2.2.

**Procedure.** As in the previous experiment, participants first received some general background information and a brief description of CCS. Next, participants in the 'highly relevant' condition read an argument against the implementation of CCS that the pilot study had identified as highly relevant:

*The different processes that CCS consists of (capture, transport, and storage) are in general industrial use for several years but the integrated chain of these processes has never been implemented before, which is why safety cannot be completely guaranteed yet.*

Participants in the 'highly relevant + moderately relevant' condition read the highly relevant argument against CCS complemented with three con-CCS arguments that the pilot study had identified as moderately relevant:

*The implementation of CCS in the Netherlands is just a drop in the ocean as long as other countries are unwilling to sign the international climate change agreement that obliges rich countries world-wide to emit 5.2 percent less greenhouse gasses between 2008 and 2012 compared to the level of 1990. The different processes that CCS consists of (capture, transport, and storage) are in general industrial use for several years but the integrated chain of these processes has never been implemented before, which is why safety cannot be completely guaranteed yet. The CO<sub>2</sub> that is stored underground cannot be used for other purposes, such as the production of carbonated drinks. The mitigation of CO<sub>2</sub> emissions is not so much the problem of the Netherlands; large, polluting countries such as China and the USA should solve the problem.*

Participants in the 'highly relevant + irrelevant' condition read the highly relevant con-CCS argument complemented with the same three pieces of irrelevant information as used in Experiment 2.1.

Participants then completed a similar questionnaire as in Experiment 2.1, which included items to measure the persuasiveness of communications ( $\alpha = .83$ ), the perceived relevance of the highly relevant information ( $\alpha = .63$ ), the perceived relevance of the moderately relevant con-CCS information ( $\alpha = .73$ ), and the perceived relevance of the irrelevant information ( $\alpha = .78$ ). Finally, participants were debriefed, paid, and thanked for their participation.

## Results

**Manipulation check.** As intended (and consistent with the results of the pilot study), participants regarded the highly relevant argument against CCS as significantly more relevant ( $M = 5.56$ ,  $SD = 0.88$ ) than the moderately relevant con-CCS information ( $M = 3.75$ ,  $SD = 1.15$ ),  $t(98) = 12.54$ ,  $p < .001$ , which, in turn, was regarded as significantly more relevant than the irrelevant information ( $M = 2.73$ ,  $SD = 1.14$ ),  $t(98) = 7.82$ ,  $p < .001$ . In addition, we checked for potential between-subjects effects but did not find any ( $F_s \leq 1.98$ ,  $p_s \geq .14$ ).

**Persuasiveness of communications.** An ANOVA with Information Relevance as the independent variable and persuasiveness of communications as the dependent variable revealed a marginally significant effect,  $F(2, 96) = 2.72, p = .07, \eta_p^2 = .05$ . As in the previous experiment, we then looked at two planned contrasts to determine specific differences regarding persuasiveness between conditions. A planned contrast between the ‘highly relevant’ and ‘highly relevant + irrelevant’ conditions showed that communications were regarded as slightly less persuasive when they consisted of a mix of highly relevant con-CCS information and irrelevant information ( $M = 3.83, SD = 1.18$ ) than when they only consisted of the highly relevant con-CCS argument ( $M = 4.35, SD = 1.24$ ),  $F(1, 96) = 3.49, p = .07, \eta_p^2 = .04$ . A planned contrast between the ‘highly relevant’ and ‘highly relevant + moderately relevant’ conditions did not show any indication of the dilution effect,  $F(1, 96) = 0.08, p = .78$ . Participants regarded a mix of highly relevant and moderately relevant con-CCS information as equally persuasive ( $M = 4.42, SD = 0.92$ ) as the highly relevant con-CCS information in isolation ( $M = 4.35, SD = 1.24$ ).

In sum, the results of Experiment 2.2 offer weak support for Hypothesis 2.1 when it comes to negative information: Irrelevant information only slightly diluted the persuasiveness of highly relevant information against CCS. Furthermore, as in Experiment 2.1, the results show that moderately relevant con-CCS information did not dilute.

## Experiment 2.3

Experiment 2.3 aims to replicate the finding that irrelevant information can dilute the persuasiveness of a relevant argument. Furthermore, Experiment 2.3 extends the previous experiments in three important ways.

First, we measure participants’ belief that CCS yields benefits for the climate on earth after they have read the communications about CCS. Note that in this experiment we focus on pro-CCS information because the previous experiments show the clearest dilution effect for pro-CCS information. From an applied perspective, it is particularly relevant to measure actual beliefs as a sign of the persuasiveness of the communications (to complement the insights derived from the relatively straightforward self-report items that we used in the previous experiments). After all, CCS stakeholders determine the effectiveness of their communications by whether or not they have managed to convince people of the advantages (in the case of proponents) or disadvantages (in the case of opponents) associated with CCS. If the impact of the highly relevant argument that CCS helps to combat global warming is diluted by adding irrelevant information (Hypothesis 2.1), then the belief that the

implementation of CCS would yield important benefits for the earth's climate should thus be weaker if irrelevant information is added.

Second, we examine two possible explanations for the dilution effect, namely that it may be due to (1) a potential decrease in the perceived quality of the communications and/or (2) attention distraction as a result of adding irrelevant information to a highly relevant argument. The latter idea connects to work by Harp and Mayer (1998), which shows that details in text books may distract the reader's attention from the main text and, therefore, decrease (rather than increase) instructional effectiveness.

And third, Experiment 2.3 considers the source of communications as a potential moderator of the dilution effect. More specifically, in line with previous work on dual process models—the heuristic-systematic model (Chaiken, 1980) and the elaboration likelihood model (Petty & Cacioppo, 1986)—we suspect that irrelevant information may not dilute the persuasiveness of communications if the communication source is manifest. Especially if people are not very motivated or involved in the issue, they are more likely to engage in heuristic (peripheral) information processing than systematic (central) information processing which would involve extensive cognitive elaboration (Chaiken, 1980; Petty & Cacioppo, 1986). People tend to afford as little cognitive effort as possible in processing information (i.e., people are “cognitive misers”; Fiske & Taylor, 1991) and are therefore often inclined to base their judgments on heuristic cues (mental shortcuts that ease the cognitive load of making judgments) that may be unrelated to the specific content of communications. The identity of the source of communication is a heuristic cue that can come in handy in this regard (Pornpitakpan, 2004). Indeed, recent studies have shown that people perceive and evaluate communications about environmental issues such as climate change and CCS differently depending on the communication source (Rabinovich et al., 2012; Ter Mors et al., 2010; Terwel et al., 2009b). We think that explicit awareness of the communication source may overrule the dilution effect as the identity of the source can function as a heuristic cue when evaluating communications about CCS.

In the current research, we focus on two different sources, namely an environmental non-governmental organization (ENGO) and an oil and gas company. Both types of organizations are common sources of CCS information (Corry & Reiner, 2011) and the public probably has clear ideas about the branches in which these organizations operate. This knowledge can function as a heuristic cue that might overrule the dilution effect. The reason why we consider two types of sources is to make sure that our findings not only apply to one specific type of source. However, the presence versus absence of knowledge of the identity of the source should determine whether or not people are able to use this as a heuristic cue (independent of the specific type of

source). Therefore, we hypothesize that irrelevant information dilutes the persuasiveness of relevant information when the identity of the information source is not revealed, but this is less likely to be the case when the identity of the source is made explicit (Hypothesis 2.2).

## Method

**Participants and design.** Hundred-forty-six undergraduate students from Leiden University participated in the study. They were allocated to one of six conditions of the 2 (Information Relevance: highly relevant vs. highly relevant + irrelevant) × 3 (Source: no source vs. ENGO vs. oil and gas company) between-subjects factorial design. Participants received either €1 or course credits for their participation. Individuals who had participated in one of the previous experiments were not allowed to participate in Experiment 2.3.

**Procedure.** Participants were seated in front of a computer screen and received some general background information and a brief description of CCS. Next, they received a message announcing a website with information about CCS. A website was chosen because the internet is most often used for CCS communication (Corry & Reiner, 2011) and it offers an excellent opportunity to implement the source manipulation. Participants in the ENGO condition were informed that the communication source was World Planet; an ENGO. In reality, however, World Planet was a fictitious organization. We used a fictitious organization instead of a real ENGO to prevent possible distortion of the results due to pre-existing perceptions about an organization (cf. Aggarwal, 2004). Participants in the ENGO condition were then presented with a webpage displaying World Planet's logo in the left upper corner. Participants in the 'oil and gas company' condition were informed that the communication source was Baptiste Oil & Gas, an international company in the energy sector, and they were presented with a webpage with the company's logo. Participants in the 'no source' condition were kept uninformed about the identity of the communication source: They were presented with exactly the same webpage, but there was no logo on it.

Furthermore, the information on the webpage was manipulated. Participants in the 'highly relevant' condition read that CCS helps to combat global warming (see Experiment 2.1 for the exact description). Participants in the 'highly relevant + irrelevant' condition also read that CCS helps to combat global warming but this information was mixed with the same three pieces of irrelevant information as used in Experiments 2.1 and 2.2. In the latter condition, the highly relevant information was located either before, in the middle, or after the irrelevant information. This was done to be able to control for order effects. We did not find any order effects so we do not report on this matter any further. After participants had read the webpage, they

completed a questionnaire that included items to assess their belief that CCS has climate benefits, the perceived quality of the communications, attention distraction, and the manipulation checks. Finally, participants were debriefed, paid, and thanked for their participation.

## Measures

**Belief in the climate benefits of CCS.** Belief in the climate benefits of CCS was measured with two items: “To what extent do you believe that CCS helps to combat global warming?” and “To what extent do you think that CCS would benefit the climate on earth?” (1 = *not at all*; 7 = *very much*),  $\alpha = .74$ .

**Perceived quality of the communications.** To assess the perceived quality of the communications, we asked participants to answer two questions: “To what extent did you consider the communications to be of good quality?” and “To what extent did you consider the communications to be coherent?” (1 = *not at all*; 7 = *very much*),  $\alpha = .72$ .

**Attention distraction.** Attention distraction was measured by three items: “To what extent were you able to keep your attention on the information?”, “To what extent were you able to concentrate on the content of the information?”, and “To what extent did you find the information confusing?” (the first two items were reverse coded; 1 = *not at all*; 7 = *very much*),  $\alpha = .86$ .

**Manipulation checks.** We assessed the adequacy of the manipulation of the communications about CCS in the same way as in Experiments 2.1 and 2.2. So, again, all participants rated the relevance and importance of the highly relevant information ( $\alpha = .83$ ) and the three pieces of irrelevant information ( $\alpha = .61$ ). To check their awareness of the source, participants were asked to indicate the source of the communications.

## Preliminary Analyses

**Manipulation check of information relevance.** As in Experiments 2.1 and 2.2, paired t-tests showed that participants perceived the highly relevant information that CCS helps to combat global warming as significantly more relevant ( $M = 5.53$ ,  $SD = 1.01$ ) than the irrelevant information ( $M = 3.04$ ,  $SD = 0.94$ ),  $t(91) = 21.06$ ,  $p < .001$ .<sup>3</sup>

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<sup>3</sup> The results also showed a small contrast effect: The relevant argument was perceived to be somewhat stronger when it was mixed with irrelevant information ( $M = 5.80$ ,  $SD = 0.92$ ) compared to when it was not mixed ( $M = 5.26$ ,  $SD = 1.03$ ),  $F(1, 86) = 6.32$ ,  $p = .04$ ,  $\eta_p^2 = .07$ .

**Manipulation check of communication source.** We made the a priori decision to analyze only the data of participants who had correctly indicated which source was communicating. We continued running the experiment until we had an approximately equal number of participants with correct answers to the manipulation check in each of the communication source conditions. The data used for analyses were from 30 participants in the ‘no source’ condition, 28 participants in the ENGO condition, and 34 participants in the ‘oil and gas company’ condition. We should note that especially in the last condition quite a few participants gave an incorrect answer to the source manipulation check ( $N = 40$ ). This probably has to do with the fact that the content of the relevant information (which was about the climate benefits of CCS) is incongruent with the motives oil and gas companies are assumed to act upon (e.g., de Vries, Terwel, Ellemers, & Daamen, in press). This might have been confusing to participants. However, the inclusion of these participants in the analyses did not change the pattern of results (see footnotes 4, 5 and 6).

**Comparison of ENGO and oil and gas company.** We reasoned that the presence versus absence of a source would moderate the dilution effect regardless of the specific type of source. Therefore, we made the a priori decision to look at the source contrast (source presence vs. absence) if the two sources did not produce different results concerning participants’ belief in the climate benefits associated with implementing CCS (the main dependent variable). Accordingly, as a first step in the analysis, we sought to confirm that this was the case (as indicated before, we merely considered two types of sources to increase our confidence that the results not only apply to one specific source).

Indeed, an ANOVA with the ‘highly relevant’ versus the ‘highly relevant + irrelevant’ conditions as the two levels of Information Relevance, and ENGO versus ‘oil and gas company’ condition as the two levels of the source factor revealed no significant effects ( $ps \geq .29$ ).<sup>4</sup> Means and standard deviations are presented in Table 2.2. In subsequent analyses, we thus defined a source contrast in which the ENGO condition and the ‘oil and gas company’ condition were jointly contrasted against the ‘no source’ condition.

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<sup>4</sup> A similar analysis including the responses of participants with an incorrect answer to the source manipulation check revealed a similar pattern of results: There was neither a main effect of Information Relevance ( $p = .63$ ), nor a main effect of Source ( $p = .18$ ), nor an interaction effect ( $p = .73$ ).

**Table 2.2.**

Means (and standard deviations) for belief that CCS yields climate benefits, perceived quality of the communications, and attention distraction as a function of source and information relevance.

	No source		ENGO		Oil and gas company	
	Highly relevant ( <i>N</i> = 15)	Highly relevant + irrelevant ( <i>N</i> = 15)	Highly relevant ( <i>N</i> = 13)	Highly relevant + irrelevant ( <i>N</i> = 15)	Highly relevant ( <i>N</i> = 17)	Highly relevant + irrelevant ( <i>N</i> = 17)
Belief in climate benefits of CCS	5.30 (0.68)	4.33 (1.22)	5.12 (0.98)	5.27 (0.92)	4.62 (1.50)	5.03 (1.69)
Perceived quality of the communications	4.83 (1.51)	3.83 (1.28)	5.00 (1.08)	5.10 (0.83)	4.94 (1.20)	4.56 (1.55)
Attention distraction	2.76 (1.48)	3.13 (1.45)	3.15 (1.43)	3.07 (1.37)	2.71 (0.98)	3.14 (1.40)

## Results

**Belief in the climate benefits of CCS.** We performed an ANOVA with Information Relevance and the Source contrast (i.e., the ‘no source’ condition contrasted against the two source conditions) as the independent variables, and belief in the climate benefits of CCS as the dependent variable. The analysis did not reveal a main effect of Information Relevance,  $F(1, 86) = 0.27$ ,  $p = .61$ , nor a main effect of the Source contrast,  $F(1, 86) = 0.48$ ,  $p = .49$ . However, the interaction contrast effect was significant,  $F(1, 86) = 5.10$ ,  $p = .03$ ,  $\eta_p^2 = .06$ .<sup>5</sup> See Table 2.2 for all means and standard deviations. Simple effects analysis showed that irrelevant information only diluted the persuasiveness of relevant information when the identity of the communication source was not revealed. That is, participants in the ‘no source’ condition had a stronger belief that CCS would yield climate benefits if highly relevant information was not mixed ( $M = 5.30$ ,  $SD = 0.68$ ) than when it was mixed with irrelevant information ( $M = 4.33$ ,  $SD = 1.22$ ),  $F(1, 88) = 4.58$ ,  $p = .04$ ,  $\eta_p^2 = .05$ . However, the dilution effect did not occur if participants were aware about the communication source. So, these results offer support for Hypothesis 2.2.

<sup>5</sup> A similar analysis including the responses of participants with an incorrect answer to the source manipulation check revealed a similar pattern of results: There was neither a main effect of Information Relevance ( $p = .29$ ), nor a main effect of the Source contrast ( $p = .59$ ) but again, the interaction contrast effect was significant ( $p = .04$ ,  $\eta_p^2 = .03$ ).

**Perceived quality of the communications.** We also performed an ANOVA with Information Relevance and the Source contrast as the independent variables, and perceived quality of the communications as the dependent variable. The analysis did not reveal a main effect of Information Relevance,  $F(1, 86) = 2.57, p = .11$ , but there was a main effect of the Source contrast,  $F(1, 86) = 3.98, p = .05, \eta_p^2 = .04$ . The interaction contrast effect was not statistically significant,  $F(1, 86) = 2.29, p = .13$ .<sup>6</sup> Simple effects analysis revealed that irrelevant information diluted the perceived quality of relevant information only when the identity of the communication source was not made explicit. Participants in the ‘no source’ condition perceived communications consisting of a mix of highly relevant and irrelevant information to be of significantly lower quality ( $M = 3.83, SD = 1.28$ ) than the communications consisting of only the highly relevant information ( $M = 4.83, SD = 1.51$ ),  $F(1, 88) = 4.65, p = .03, \eta_p^2 = .05$ . Information relevance did not affect perceptions of the quality of the communications when the source was made explicit. See Table 2.2 for means and standard deviations.

**Attention distraction.** An ANOVA with Information Relevance and the Source contrast as the independent variables and attention distraction as the dependent variable revealed no significant effects ( $F_s < 1, p_s \geq .39$ ), indicating that the dilution effect was not due to attention distraction.

## Mediation

We used Preacher and Hayes’ (2008) bootstrap approach to test whether perceived quality of the communications mediated the dilution effect observed in the ‘no source’ condition. Bootstrapping uses resampling of raw data to estimate the confidence interval (CI) of the indirect effect. We used 5000 resamples (bias corrected) and obtained a 95% confidence interval that did not include zero (lower CI =  $-1.00$ ; upper CI =  $-0.03$ ), indicating that the indirect effect was significant. This finding is consistent with the idea that the perceived quality of communications mediates the dilution effect.

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<sup>6</sup> A similar analysis including the responses of participants with an incorrect answer to the source manipulation check revealed a similar pattern of results but the main effect of Information Relevance was significant ( $p = .02, \eta_p^2 = .04$ ) and there was no main effect of the Source contrast ( $p = .12$ ). Again, the interaction contrast effect was not significant ( $p = .18$ ).

## General Discussion

The implementation of CO<sub>2</sub> capture and storage (CCS) is considered worldwide as a viable strategy to mitigate climate change. Considering that members of the general public seem to know little or nothing about the technology, there is plenty of room for both proponents and opponents to inform people about the issue, and to convince them of the advantages or the disadvantages of CCS. The current research highlights the need to think carefully about the content of public communications. Based on insights from previous research on the dilution of judgments and beliefs due to the presence of irrelevant information (e.g., Meyvis & Janiszewski, 2002; Nisbett et al., 1981), we hypothesized that adding irrelevant (i.e., nondiagnostic) information to highly relevant information would lower the persuasiveness of communications about CCS. The results supported this prediction. Importantly, we showed that irrelevant information not only diluted evaluations of the persuasiveness of communications (Experiments 2.1 and 2.2), but also actual beliefs about the issue under consideration (Experiment 2.3). Furthermore, the results showed that the dilution effect was eliminated when the information source was made explicit.

Irrelevant information weakened the impact of positive (pro-CCS) as well as negative (con-CCS) information, but the effect was less pronounced for negative information. A possible explanation for this finding might lie in the fact that negative information is typically processed relatively thoroughly—that is, more thoroughly than positive information (cf. Baumeister et al., 2001). Accordingly, people are more likely to isolate and focus on a relevant argument against CCS (as compared to a relevant argument for CCS) that is accompanied by irrelevant information. As a result, people's judgments will be based primarily on the relevant negative argument and the accompanying irrelevant information is less likely to bias their judgments. This might explain why the dilution effect was relatively weak when irrelevant details were added to relevant negative (con-CCS) information and relatively strong when irrelevant details were added to relevant positive (pro-CCS) information.

The current research also sheds some light on the psychological process associated with the dilution effect on persuasiveness of communications. Irrelevant details impaired the perceived quality of communications when they were added to a relevant argument (i.e., that CCS helps to combat global warming) and this rather than attention distraction guided the dilution effect in Experiment 2.3. We assume the same process accounts for the dilution effect on judged persuasiveness (as in Experiments 2.1 and 2.2), although we acknowledge that different psychological processes are associated with different types of judgments. For instance, dilution in judgments about persons may be caused by the use of the representativeness heuristic (Kahneman & Tversky 1972): Non-stereotypical information can weaken stereotypical judgments

about a person because it reduces the similarity between a person and a stereotype (Nisbett et al., 1981). Evaluations of products may be diluted due to other processes though, such as due to what Meyvis and Janiszewski (2002) referred to as biased hypothesis testing, a process in which people selectively search for information that supports a prior hypothesis about a product. We think that such processes do not apply here. That is, unlike this previous research, participants in our experiments were not instructed before the presentation of the information that they had to make a judgment later, and only few may have had clear ideas about the topic prior to participating in the study. This is why biased hypothesis testing is unlikely to explain the dilution effect in our research. Instead, we propose that adding irrelevant details to relevant information impairs the quality of communications and that this causes the dilution effect on both perceived and “actual” persuasiveness (i.e., beliefs). Nevertheless, further research is needed to examine the psychological processes that underlie the dilution effect in public communications in more detail.

The current research has further identified an important boundary condition for the dilution effect. We found that adding moderately relevant information did not reduce the persuasiveness of communications. This finding is consistent with Tetlock and Boettger (1989) whose research also suggests that a dilution effect does not occur when moderately relevant information is added to highly relevant information. Our results differ from those of Meyvis and Janiszewski (2002) though. They found that moderately relevant information (which they referred to as “less supporting” information) strengthened the impact of relevant information. In their study, participants had to predict whether or not a computer was fast, and the information that was intended to be less supportive stated that the computer has 64 megabyte of working memory and a 32-speed CD-ROM. However, this information could have been interpreted as very relevant for computer speed, causing polarization instead of dilution. In the present study, we made sure to pilot test the relevance of the different pieces of information. All in all, based on the current results, we believe that adding information to a key message is not necessarily harmful for the persuasiveness of the message, as long as the additional information is not totally irrelevant. However, increasing the length of communications by aggregating information will also not benefit persuasiveness unless the additional information is really relevant.

We have considered the dilution effect in the context of communications about CCS, which raises the question of whether the results also apply to other environmental issues. We believe this is the case, considering that the dilution effect has already been shown to play a role across a wide range of different settings. However, we do think that the dilution effect in public communications might be stronger with respect to complex and novel issues (CCS, nanotechnology, and genetically modified foods, to

name a few) than for more familiar issues about which people have already formed a stable opinion. After all, communications about a well-known issue are less likely to change deep-rooted existing beliefs, regardless of the perceived quality of such communications. Moreover, people who have a strong opinion about an issue may focus on specific aspects of communications rather than that they look at all the information (i.e., selective exposure). For instance, they may select and pay attention to arguments that support their own views and ignore other information (e.g., Hart et al., 2009; Smith et al., 2008). Nevertheless, the dilution effect in public communications is most important to consider in the context of emerging environmental issues since the need to inform (and the possibility to convince) the public is clearest in such contexts.

Furthermore, the fact that we have used samples of undergraduate students to test our predictions raises the question of whether the results generalize to the general public. In this regard, it is important to realize that during their education, students are required and trained to discriminate between main issues and side issues. Accordingly, students are expected to be better able than less highly educated people to isolate the most relevant information and to base their judgments primarily on this information, even if their knowledge about the topic is limited. This is important because the skill to discriminate between relevant and irrelevant information may have implications for the magnitude of the dilution effect. Indeed, research shows that expert auditors are better able than non-experts to isolate and focus on the most relevant information when they are asked to judge account-related information (Ettenson et al., 1987), although they are not completely insensitive to irrelevant information (Waller & Zimbelman, 2003). In light of these findings, we believe that the use of undergraduate students provides a relatively conservative test of our hypotheses so that the dilution effect is probably stronger, rather than weaker, among members of the general public. We do not claim that our results apply to all possible populations, however. For instance, it remains to be seen whether the dilution effect also occurs among people for whom the issue of CCS is new, but directly personally relevant (e.g., people who are informed about plans for a CCS project in their own residential area). Perhaps the dilution effect impedes the effectiveness of “onsite” communications, but it might also be the case that increased personal relevance reduces the magnitude of the dilution effect. Future research is needed to examine this issue.

The findings of our research may be used by both the opponents and the proponents of CCS to increase the effectiveness of their communications. Sometimes organizations use the “scattergun approach” to public information-sharing, which is characterized by firing lots of information in the hope that people feel completely informed and will be persuaded by one of the pieces of information that sticks to them. We argue that it is

more effective to spare the details and share only the most relevant arguments to explain the organizational position than to use the scattergun approach. Not only irrelevant details should be spared, moderately relevant information should be used sparingly as well. That is, moderately relevant information does not seem beneficial for the persuasiveness of communications and, if perceived as irrelevant by the public, can in fact be harmful.<sup>7</sup>

Another concrete practical suggestion for organizations involved in CCS would be to make the organizational identity explicit, for instance by printing the name and logo of the organization on leaflets and other informational materials. After all, our findings show that awareness of the information source makes communications less sensitive to the dilution effect. We want to stress that revealing one's identity certainly not guarantees the elimination of the dilution effect though. Only those people with clear ideas about the organization (or at least about the branch in which it operates) are likely to use the identity of the organization as a heuristic cue when confronted with information. Moreover, people will not necessarily take note of the organization's name or logo. Therefore, we still advise organizations to determine the relevance of the variety of CCS information before they start communicating. This might be costly and time consuming, but could be worth the effort because only then can details be spared and the relevance be shared.

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<sup>7</sup> Of course there are several possibilities for strategic use of our findings. For example, opponents may decide to acknowledge the climate benefits associated with the implementation of CCS but at the same time put up a smoke screen of irrelevant information to obscure this pro-CCS argument and thus weaken its impact.