Choice models in communication studies: the framing of communication about Carbon Capture and Storage.

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Abstract

The application of choice models in communication studies is uncommon. This is remarkable since conjoint methods can be excellent tools for examining the combined influence of factors that contribute to effective communication. Research shows that congruence is vital for effective communication messages, stressing the importance of the interactions between elements in the messages. Current studies on this topic often ignore the interactions and focus on variation within a single factor. We propose that a more inclusive application of conjoint methods in communication studies can be valuable, and provide an example of such an application.

We specifically focus on communication about Carbon Capture and Storage (CCS). The term "CCS" encompasses a combination of technologies used to capture CO2 at an electric plant or industrial source, transport it to a depleted gas field, and store it indefinitely. CCS can play a valuable role in mitigating climate change, yet public acceptance remains low. This may be attributable to poor knowledge and awareness of the technology. Properly communicating about CCS to the general public may alleviate this problem. While the content of the proposed communication is not yet clear, its existence may help by improving knowledge and awareness surrounding the issue.

Method

We examined the effect of argument content, frame and source on stated choices about persuasiveness and credibility of the argument. We also determined whether there was a change in attitude due to the choice experiment. In each choice set, respondents chose between two arguments. The arguments were presented as unlabeled alternatives that varied among three attributes: the content of the argument, the framing of the argument and the source of the argument.

We conducted an online survey with 1195 respondents. The respondents were divided into three groups. One group read exclusively pro arguments, another group read exclusively con arguments and a last group read both. Some additional questions were included that measured opinion leadership, attitude on climate change and several socio-demographic factors. The choices were analyzed first with a random coefficient conditional logit model and later with latent class models.

Results

We found that con arguments, normative arguments (i.e. arguments that appeal to personal norms), arguments from scientists and arguments that contain an extensive explanation of the

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argument are most persuasive. The change in attitude is significant and significantly differs between all experimental groups. The change was largest in the group that read only con arguments. Although the change in attitude was smaller in the group that read *both* pro and con arguments, attitude still changed in a negative direction. This provides additional support for the finding that con arguments are more persuasive.

The use of choice models has enabled us to assess several elements of a communication message conjointly. This attests to the value of choice models in communication studies. Further research should increase the number of attributes investigated in more extensive experimental designs and expand the scope beyond mere arguments; to full messages.

Keywords: communication, persuasion, credibility, choice models, carbon capture and storage, arguments, framing, source of communication, latent class analysis.

1. Introduction

Many organizations experience difficulties when communicating about controversial topics to the general public. The difficulties worsen when the topics involve hazards and risks (Slovic 1987, 1999). One such controversial topic is Carbon Capture Storage (CCS) (Singleton, Herzog, and Ansolabehere 2009), which encompasses a combination of technologies used to capture CO_2 at an electric plant or industrial source, transport it to a depleted gas field, and store it indefinitely. The large scale implementation of CCS can contribute significantly to climate change mitigation, but is often hindered by the resistance of people that live in the vicinity of storage locations (Oltra et al. 2010). A reason for this resistance is that the communication between stakeholders and residents is poorly executed (Brunsting, Best-Waldhober, et al. 2011).

Studies on communication have examined the effect of message (Cobb and Kuklinski 1997; Meyerowitz and Chaiken 1987), source (Harkins and Petty 1987; Mondak 1993), receiver (Sherman and Fazio 1982; Taber, Cann, and Kucsova 2009; Taber and Lodge 2006) and channel characteristics on the communication's persuasiveness and on the attitude towards the issue. These studies have accumulated piecemeal knowledge about communication characteristics, but tend to focus on research designs with only a few different messages (Hilton 1995). This limits their conclusions to a few particular instances of a message and ignores interaction effects between characteristics (Brashers and Jackson 1999). This is striking, because an important finding of communication studies is that persuasive communication requires congruence between its characteristics (Cesario, Grant, and Higgins 2004). For example: the persuasiveness of a source depends to some degree on the message that is communicated by that source (Cesario et al. 2004; Eagly, Wood, and Chaiken 1978). Studies should therefore examine message and source variations in a single research design.

Further, studies indicate that communicators of controversial topics should not only pay close attention the content of a message, but also to its formulation (Bickerstaff et al. 2008; Corner et al. 2011; Pidgeon, Lorenzoni, and Poortinga 2008). An example of reformulation is message framing (Meyerowitz and Chaiken 1987). Message framing is defined as changing particular words or sentences, while retaining the content of the message. The goal of framing is to change the perception of the content by using words or sentences that carry particular meanings (Chong and Druckman 2007; Druckman 2012). To find out whether the persuasiveness of a message can be attributed to its content or its frame, it is important to assess these characteristics in a single research design as well.

Although the problems of simple designs are recognized in literature (Brashers and Jackson 1999; O'Keefe 2002), methods that can deal with the combined influence of multiple communication characteristics have *not* yet been applied extensively to communication issues. An excellent tool for examining this combined influence is discrete choice experiments (DCEs). DCEs allow the assessment of multiple characteristics at once and can be used to estimate their interaction. The application of DCEs to communication issues is therefore valuable. This paper provides an example of such an application, with a focus on CCS communication.

We focus on the communication of *arguments* for or against CCS. A study by Van Egmond and Hekkert (2012) identified the arguments that are used in the public debate on CCS and proposed a typology for these arguments. Broecks et al. (2013) built on this framework and identified the persuasiveness, importance and newness of a subset of these arguments. We contribute to this debate by examining the influence of argument frame and source in addition to argument content. We asked a representative sample of inhabitants of the Netherlands to choose the most persuasive and the most credible argument out of two arguments, which systemically varied on content, frame and source. Further, we take receiver characteristics into account by identifying segments of receivers. For the sake of parsimony, we limited the study to written arguments in plain text. This leads to the following research question:

What is the effect of argument content, frame, and source on the persuasiveness and credibility of arguments for or against CCS for various groups of people?

The results of this study can be used to improve communication about controversial technologies like CCS. We offer suggestions about which arguments and frames communicators should use and with which other stakeholders they can collaborate to increase the persuasiveness of communication. In the next section we discuss theory on persuasion, arguments and framing. In section 3 we present our research models. We also provide a description of the choice experiments that we use to test these models. A description of the results of the models is given in section 4. Finally, we discuss the most important conclusions and limitations of the study in sections 5 and 6.

2. Theory

We first briefly introduce Random Utility Theory (RUT) into the context of communication studies as the theoretical basis of discrete choice experiments (Carson et al. 1994). RUT specifies that the utility of individual *i* for alternative *j* is a function of attributes that are included in the choice set (V) and an error term (ε). The error term consists of attributes that are not included in the choice set, context effects, functional misspecification, and measurement error (Manski 1977).

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

Until now, RUT and DCEs have mainly been applied in the fields of marketing (Auger et al. 2003), transportation (Hensher, Stopher, and Louviere 2001) and healthcare studies (Flynn et al. 2007; Lancsar and Louviere 2008). They have not yet been applied in the field of communication. The utility of alternatives requires a particular interpretation for communication issues. Rather than using the latent construct of utility as a general assessment of value, we use utility as an indicator for persuasiveness or credibility. We specifically ask people to indicate which argument is most persuasive and most credible. We include four attributes: pro versus con arguments, argument content, frame and source. Other influences on persuasiveness are captured by the error term. In the subsequent sections we first discuss the reasons for focusing on persuasiveness and credibility. We continue with a discussion of the attributes of our choice models.

2.1 Argument persuasiveness and credibility

The selection of our dependent variables is based on theory about persuasion. We define persuasion as the use of communication to modify another person's attitude towards an object (O'Keefe 2002). To elicit the persuasiveness of communication past studies focused on the influence of the strength of the arguments that were used (Burnstein and Vinokur 1975, 1977; Johnson, Maio, and Smith-mclallen 2005; Petty and Cacioppo 1984). Argument strength is defined as the amount of favorable thoughts compared to the amount of unfavorable thoughts towards the issue (Zhao et al. 2011). The use of strong arguments is therefore conducive to persuasion. We use the perceived persuasiveness of an argument to assess argument strength.

Arguments strength matters only when arguments are also perceived as credible, which partially depends on the source of the argument (Chaiken and Maheswaran 1994; R. G. Peters, Covello, and McCallum 1997; Pornpitakpan 2004). Sources that are perceived as both trustworthy and as an expert on the issue are seen as credible (O'Keefe 2002). Otherwise, people might believe that the source willingly provides false information or that the accuracy of information suffers from the sources' knowledge deficiencies (Eagly, Wood, and Chaiken 1981). Because credibility is central to the persuasiveness of arguments that come from a distinct source, we assess argument credibility. We now continue with a discussion of the attributes: pro versus con arguments and the argument's content, frame and source.

2.2 Pro versus con arguments

Arguments support an issue (pro-arguments) or oppose an issue (con arguments) by specifying a wanted or unwanted outcome (e.g. the mitigation of climate change) and the conditions that lead to the outcome (e.g. large scale deployment of CCS in combination with renewable energy). There is substantial evidence that con arguments are more persuasive than pro arguments, because negative information attracts more attention (Cobb and Kuklinski 1997; Sen and D. Lerman 2007; Skowronski and Carlston 1987). One explanation for a higher salience of negative information is that there is less negative than positive information in the social environment. Another explanation is that people attach more value to losses rather than gains (Kahneman and Tversky 1979; Tversky and Kahneman 1981). They are inclined to prefer arguments against a proposition, just to avoid the losses associated with the change in status quo. Loss aversion can be explained by the necessity of avoiding risks or losses for human survival (Lau 1985).

2.3 Argument content

The second attribute that is used is argument content. The classification that we use for argument content is based on previous studies into CCS arguments (Broecks et al. 2013; van Egmond and Hekkert 2012). These authors distinguish between different types of arguments: the contribution of CCS to climate change mitigation (climate); the economic costs or benefits of CCS (economy); the relative advantages of CCS over other energy technologies (energy); safety issues and normative issues. Safety and normative issues are discussed in more depth, because they imply particular mechanisms for persuasion.

First, normative arguments persuade by activating personal norms (Huijts, Molin, and Steg 2012; Schwartz 1977). A normative argument emphasizes a moral obligation to perform or not perform an action. A person feels guilty when he or she violates the norm and feels pride when he or she upholds the norm (Schwartz 1977). Normative arguments can be used to persuade people to behave environmentally friendly (Bamberg and Möser 2007; Hopper and McCarlnielsen 1991) or to support or oppose nuclear energy (De Groot and Steg 2010). Second, safety arguments against controversial energy technologies like CCS are often about unknown or dreadful risks (Singleton et al. 2009; Slovic 1987, 1999). These risks can incite strong negative emotional reactions or affect (Slovic et al. 2004; Witte and Allen 2000). People rely on affect to simplify complex or uncertain situations (Slovic et al. 2007). Such situations can be created when people are asked to express their opinion about

controversial topics, such as CCS (Midden and Huijts 2009; Montijn-Dorgelo and Midden 2008; E. Peters and Slovic 1996). Dread risks can have important influences on persuasion by appealing to emotions (Slovic et al. 2007).

We selected 6 pro and 6 con arguments from among the 16 pro and 16 con arguments used by (Broecks et al. 2013). We selected the arguments that were the most persuasive or that were very persuasive for a particular group of people. We made sure that each category was represented at least once. The selection was approved by a panel of CCS experts from industry and knowledge institutes. Table 1 presents an overview of the arguments.

Arguments	**Category**
Pro	
CO_2-storage can be used in industries where no other possibilities for CO_2-reduction exist.	Climate
The development of technology for CO_2-storage contributes to employment and economic growth.	Economic - 1
The Netherlands has a better starting position because of the experience with natural gas.	Economic - 2
Gas or coal plants with CO_2-storage are a stable supplement to the varying energy supply of solar and wind.	Energy
CO_2-storage is safe. It is stored in natural gas fields where natural gas was stored for millions of years.	Safety
A waste product such as CO_2 should be cleaned up neatly.	Normative
Con	
If we use renewable energy and use energy more efficiently, we can tackle the climate problem without CO_2-storage.	Climate
The prices of houses in the direct vicinity can fall because of CO_2-storage.	Economic
The risks of CO_2-storage are not completely known.	Safety - 1
If CO_2 leaks out of an underground pipeline, the groundwater can acidify.	Safety - 2
If a lot of CO_2 leaks on a windless day, a suffocating cloud of CO_2 can be created.	Safety - 3
It is better to avoid CO_2-emmisions than to store them.	Normative

Table 1: Overview of arguments

2.4 Argument frame

The third attribute that is included is argument framing. When formulating frames we departed from the wording that was used by Broecks et al. (2013) and used those arguments as a reference frame for comparison. We rephrased these arguments in two different ways: by making the argument easier or harder; and by focusing on a different prospect.

First, we reframed the basic argument into easy and hard arguments. Easy arguments are short, focus on outcomes or symbolic meanings and omit conditions (Cobb and Kuklinski 1997). We consider two types of easy arguments: arguments that focus on outcomes and arguments that focus on symbolism. Outcome arguments can be easy to understand, although the strength of the argument can suffer from the omission of conditions (Cobb and Kuklinski 1997). Symbolic arguments focus on evoking images and persuade by inciting positive or negative emotions (Slovic et al. 2007).

Hard arguments are more complex than easy arguments (Cobb and Kuklinski 1997). We consider two types of hard arguments: arguments where conditions are added and arguments that provide an example that helps to explain the main point. Rather than appealing to emotions, hard arguments appeal to cognition by focusing on explanation and logical derivation. Yet, it should be noted that the complexity and length of the argument can also serve as a simple decision rule, where the receiver infers expertise and trustworthiness from long and complex arguments (Petty and Cacioppo

1984). To control for differences in argument length we include a control variable for the amount of words in the argument. This rules out the effect of length on persuasiveness.

Second, we reframed the prospect that the arguments refer to. Experimental evidence shows that positions are judged differently when the prospects are reversed. For example, numerical outcomes are perceived differently when they are framed as losses rather than gains (Kahneman and Tversky 1979; Tversky and Kahneman 1992). These findings are corroborated in studies that examine *message* framing rather than numerical variations (Meyerowitz and Chaiken 1987; Rothman and Salovey 1997). We changed the prospect of an argument by referring to foregone gains or losses if CCS *was not* used versus referring to gains and losses if CCS *was* used. All argument frames were written by experts on CCS communication. Appendix 1 provides an example of the way in which the arguments were reframed.

2.5 Argument source

Finally, we include argument source as the fourth attribute. We included four different types of sources that communicate about CCS in practice: energy companies, environmental NGOs, the national government and scientists (see Terwel et al. 2009; Ter Mors et al. 2010). Some evidence points out that persuasion is most effective when it is attempted by an expert source without a perceived stake in the issue (Brunsting, Upham, et al. 2011). These sources are considered trustworthy because they are willing to critique both sides of the discussion. This might imply that scientists are the most persuasive source of communication.

We also looked at collaboration between sources. A message that is produced by multiple collaborating sources is often more persuasive than messages from single sources (Harkins and Petty 1987). The effect is stronger when sources are perceived as independent and when they offer divergent perspectives. An example: Ter Mors et al. (2010) showed that a collaboration between energy companies and environmental organizations instigates trust and is conducive to persuasion. We therefore included combinations of two sources and a combination of all sources to examine the influence of collaboration between multiple types of sources. The eleven combinations were compared to a situation where no source for the argument was given.

2.6 Receiver characteristics

To identify different groups of people we include three receiver characteristics: attitude towards CCS, attitude towards climate change and opinion leadership. One important characteristic is the *attitude of the individual towards CCS*. People are inclined to favor arguments that support their attitude and counter argue arguments that are incongruent with their attitude (Taber et al. 2009; Taber and Lodge 2006). Previous studies attest to the value of attitudinal variables in explaining choice (Boxall and Adamowicz 2002; Domarchi, Tudela, and González 2008). We also assess the *attitude towards climate change.* There is some controversy among the public about the origins of climate change and about the relevance of reducing carbon dioxide emissions (Reynolds et al. 2010; Whitmarsh 2011). We therefore expect that a particular group of people is unresponsive to arguments about climate change mitigation.

These attitudes and opinions are not formed in isolation. Rather, some people actively seek advice from others to form their opinion. These people are called *opinion seekers*. Credible sources of information can facilitate decisions of opinion seekers by providing advice (Flynn, Goldsmith, and Eastman 1994). These credible sources can be *opinion leaders*. Opinion leaders communicate extensively about the issue and actively persuade people to adopt the opinion of the leader (Flynn et al. 1994). They can be peers of the opinion seeker, but also experts, such as scientists (Locock et al. 2001). Whether a person is an opinion leader or seeker can therefore have an effect on the way they interpret information from sources other than themselves.

3. Methods

3.1 Sample and data collection

The data was collected among a sample of members of a nationwide online marketing panel in the Netherlands. Quota were used to ensure that the sample would approximately represent the Dutch population of 18 years and over. The average age of the respondents was 48.18 years (S.D. 15.31) and 50.8 % of the sample was female. Further, 25.9 % of the respondents was highly educated, 40.0% had a mid-level education and 34.1% had a low-level education. The online survey was completed by 1195 respondents. The panel members received a small compensation for their participation and were assured of the anonymity of the results. A disclaimer was included at the end of the survey that mentioned that the results would be used for academic research and that each argument was not written by the source, but by the researchers.

Respondents were randomly assigned to one of three experimental groups. The first group (the pro-group) received pro-arguments (273 respondents), the second group (the con-group) received con-arguments (280 respondents) and the third group (the pro-con-group) received one pro and one con argument in each choice set (642 respondents). Each survey contained a discrete choice experiment and questions that measured receiver characteristics.

3.2 Discrete choice experiment

Each respondent received eight choice sets with two arguments. Respondents were asked to indicate which argument they found most persuasive and which argument they found most credible. The arguments, frames and sources were distributed over the choice sets using an fractional factorial orthogonal design. For the pro group and the con group 144 choice sets were used, which resulted in 18 versions for each group. For the pro-con group 288 choice sets were used, which resulted in 36 versions for this group. Respondents were randomly assigned to a group and to a version of the survey. We also randomized which argument was displayed on the right or left hand of the page. Figure 1 displays an example choice set.

Message 1	*Message 2*
Text from energy companies. "It is better to avoid CO_2-emmisions than to store them."	**Text from scientists.** "The development of technology for CO_2-storage contributes to employment and economic growth."
Which of the two messages…	
…do you think is most persuasive?	
□ Message 1	□ Message 2
… do you think is most credible?	
□ Message 1	□ Message 2
(Optional) Do you have any remarks about your choice?	

Figure 1: Example choice set.

3.3 Measurement of covariates

Before and after the choice sets respondents were asked to indicate their attitude towards CCS on four 5-point Likert items that ranged from totally disagree to totally agree and were adapted from (De Best-Waldhober et al. 2011). These items were averaged to a scale that measured attitude towards CCS. A change in attitude could thus be attributed to the DCE. The Cronbach's alpha of the attitude before the experiment was 0.83; after the experiment it increased to 0.85. To measure climate change attitude we used the average of five 5-point Likert items that were adapted from (De Best-Waldhober et al. 2011). Opinion leadership was assessed by using six 5-point Likert items that were adapted from Flynn et al. (1994). Opinion leadership is domain specific: we therefore adapted the context of these items to include sustainability. We used a confirmatory factor analysis to assess construct validity. For each construct there was only factor with an eigenvalue greater than 1. The reliability of the constructs was assessed by calculating the Cronbach's alpha. Each construct has a value that is close to 0.8, which means that reliability is sufficient. The indicators and factor loadings are displayed in table 2.

Concept	Mean	S.D	Indicators / Items (translated from Dutch)	Factor loadings
CCS attitude (before DCE) (α=0.83)	2,98	0,69	I am positive about CO_2-storage.	0,89
			CO_2-storage is dangerous.	0,65
			CO_2-storage is useful.	0,82
			I am against CO_2-storage.	0,90
Climate change attitude (α=0.79)	3,42	0,68	In the future the earth will become warmer.	0,66
			Global warming is caused to a large degree by human actions.	0,86
			The extent of global warming is strongly exaggerated.	0,67
			Global warming can still be slowed down by humanity.	0,66
			Something should be done about climate change.	0,84
Opinion leadership (α=0.79)	2,77	0,56	I often convince other people to adopt my opinion about sustainability.	0,78
			My opinion about sustainability is not important to other people.	0,50
			People often ask about my opinion about sustainability.	0,80
			When other people discuss sustainability, they do not ask for my advice	0,56
			People that I know base their opinion about sustainability on what I think.	0,79
			I often influence the opinion of others about sustainability.	0,89

Table 2: Descriptive statistics

3.4 Analysis

A random coefficient conditional logit model (RC)was estimated in each experimental group to rank arguments on content, frame and source for persuasiveness and credibility. The estimators indicate the 'utility' respondents assign on average to each argument, frame and source. As control variables we include the position of the argument in the choice set (left or right) and its length in words. To compare models we report the (adjusted) McFadden R^2. We also estimated latent class models to account for heterogeneity between respondents (Boxall and Adamowicz 2002; Vermunt and Magidson 2002). We used Latent Gold Choice 4.5 to identify segments of the population and to estimate the utility of argument content, frame and source for each segment. We identified the optimal solution by examining one- to five-class solutions and by using the Bayesian Information Criterion (BIC) and the McFadden R^2. The identification of segments was based on CCS attitude, climate change attitude and opinion leadership. We should note that initially a larger number of receiver characteristics was included. These were eventually excluded due to a lack of significant effects on classes. The results of the latent class models for the pro group and the con group are not reported here. The optimal BIC values support the use of a 1-class model rather than a multi-class model for these groups, although the McFadden R^2 shows large improvements.

4. Results

4.1 Attitude change

We examined whether a series of arguments had any effect on the attitude towards CCS by using a paired samples t-test. There were no significant differences between the groups before the experiment, which means that the change in attitude can be attributed to the DCE. In the pro-group respondents were slightly more favorable towards CCS after the DCE (M=3.09, S.D.=0.74), than before the DCE (M=2.99, S.D. =0.70); t=4.89, p<0.001. In the con-group respondents were slightly more negative after the DCE (M=2.83, S.D.=0.70), than before the DCE (M=3.00, S.D. =0.66); t=7.85, p<0.001. An independent samples t-test showed that attitude change indeed differs significantly between the pro and the con group (t=9.08, p<.05). An interesting result is that respondents in the pro-con group were significantly more negative after the choice experiment (M=2.88, S.D.=0.78), than before (M=2.97, S.D.=0.71); t=5.53, p<0.001. This means that con arguments are more persuasive overall. However, no significant differences were detected in the size of attitude change between the pro group and the con group.

4.2 Random coefficient conditional logit models

The results of the RC models for each group are displayed in table 3. The McFadden R^2 values are rather poor for a choice model. This might imply that there are different segments that value arguments differently. Yet, these models show interesting results. In the pro-con group the most persuasive arguments were the normative con argument (*avoid CO_2-emissions*), a safety con argument (*unknown risks*) and the climate con argument (*CO_2-storage is unnecessary*). The least persuasive arguments were a safety con argument (*risk of suffocation*), an economy pro argument (*Dutch starting position*) and an economy con argument (*housing prices*). Not surprisingly, the most persuasive arguments are con arguments. This corroborates expectations from theory about the salience of negative information (Cobb and Kuklinski 1997; Sen and D. Lerman 2007; Skowronski and Carlston 1987). This notion is also supported by the negative change in attitude that resulted from the DCE for this group.

Further, the most persuasive argument in both the pro group and the con group is a normative argument. This supports earlier studies into the impact of appeals to personal norms (Bamberg and Möser 2007; Hopper and McCarlnielsen 1991). It also confirms earlier findings about the persuasiveness of normative CCS arguments (Broecks et al. 2013). Apart from these findings, arguments about economic costs or benefits perform rather poorly and are at the bottom of the ranking in all three groups. Arguments about climate change mitigation and the relative advantage of CCS over other energy technologies make up the middle of the ranking. There is some controversy about safety arguments. Some perform rather well, others do not. Broecks et al. (2013) showed that safety arguments that discuss dread risks are persuasive only for a particular group of people, which might explain why both these arguments (*risks of suffocation* and *risks of acidification of the groundwater*) are relatively unpersuasive on average.

The persuasiveness and credibility of arguments show large similarities. We used a spearman rank order correlation to examine the relationship between the rankings of argument content for persuasiveness and credibility. The persuasiveness of arguments is indeed strongly related to the credibility of the argument (pro-con: ρ=0.90, pro: ρ=0.83, con: ρ=0.94). This supports expectations from theory on persuasion (Chaiken and Maheswaran 1994; R. G. Peters et al. 1997; Pornpitakpan 2004). Although there are some small differences, we will not discuss these in depth.

The models also show some interesting results for argument frames. The most persuasive frame in the pro-con group was the conditions frame, followed by the explanation frame and the reference frame. The least persuasive frames were the foregone-losses-and-gains frame, the outcome frame

	3a: Pro & con arguments		3b: Pro arguments		3c: Con arguments	
	Persuasive	**Credible**	**Persuasive**	**Credible**	**Persuasive**	**Credible**
Argument content						
Pro: Climate	-1,010***	-0,668***	-0,465***	-0,208*		
Pro: Economy - 1	-1,013***	-0,822***	-0,559***	-0,340***		
Pro: Economy - 2	-1,126***	-0,897***	-0,497***	-0,321***		
Pro: Energy	-0,982***	-0,765***	-0,544***	-0,167		
Pro: Safety	-0,893***	-0,726***	-0,379***	-0,130		
Pro: Normative	-0,657***	-0,466***	0,00	0,00		
Con: Climate	-0,596***	-0,366***			-0,732***	-0,641***
Con: Economy	-1,050***	-0,701***			-1,152***	-0,846***
Con: Safety - 1	-0,415***	0,069			-0,232*	0,060
Con: Safety - 2	-0,929***	-0,515***			-0,980***	-0,777***
Con: Safety - 3	-1,265***	-1,085***			-1,155***	-1,070***
Con: Normative	0,00	0,00			0,00	0,00
Argument frame						
Reference	0,00	0,00	0,00	0,00	0,00	0,00
Easy: Outcome	-0,314***	-0,287***	-0,480***	-0,568***	-0,154	-0,210
Easy: Symbolism	-0,216**	-0,194**	-0,437***	-0,575***	0,089	-0,130
Hard: Conditions	0,196**	0,196**	0,053	0,012	0,328**	0,143
Hard: Explanation	0,024	-0,012	-0,237*	-0,341**	0,318**	0,077
Foregone gain / loss	-0,367***	-0,293***	-0,519***	-0,471***	-0,504***	-0,578***
Argument source						
No source	0,00	0,00	0,00	0,00	0,00	0,00
Scientists	0,158	-0,037	0,267*	0,202	0,221	0,219
National government (gov.)	-0,163	-0,324**	0,134	-0,052	0,016	-0,095
Energy Companies	-0,085	-0,233**	0,052	0,011	-0,099	0,242
Environmental NGOs	-0,101	-0,098	0,104	-0,137	0,273*	0,346**
Gov. & scientists	-0,086	-0,249**	0,269*	0,007	0,291*	0,542***
Gov. & energy companies	-0,251**	-0,319***	0,020	-0,086	0,114	0,282*
Gov. & environmental NGOs	-0,050	-0,220**	0,041	0,024	0,168	0,140
Scientists & energy companies	0,071	-0,092	0,254	0,088	0,578***	0,631***
Scientists & environmental NGOs	0,090	0,000	0,154	-0,088	0,329**	0,324**
Energy Companies & environmental NGOs	-0,067	-0,258**	0,036	-0,135	0,068	0,320**
All sources	0,023	-0,072	0,052	-0,261*	0,086	0,135
Controls						
Left vs. right	-0,170***	0,079***	-0,088**	0,142***	-0,117***	0,043
Length	-0,002	0,005	0,008	0,008	0,003	0,011
McFadden R^2	0,074	0,076	0,047	0,045	0,110	0,106
McFadden $R^2(0)$	0,080	0,077	0,050	0,049	0,112	0,106

*Table 3: Results of random coefficient conditional logit models (*p<0,05, **p<0,01, ***p<0,001)*

and the symbolism frame. Interestingly, the hard frames were more persuasive than the easy frames. This might imply that the respondents scrutinized the arguments rather carefully on average, or that the symbolisms and outcomes were not effective in appealing to emotions. Although we did not assess processing elaborateness, we did measure processing time. Respondents spent 27.5 seconds on average for each choice set (all 8 sets: M=220.37, S.D.=130.27), so it is reasonable to assume they spent sufficient time on the choice sets to read the arguments carefully.

The results for the pro and con group are rather similar to the pro-con group, although an interesting difference can be observed: examples and symbolism have more effect on the persuasiveness of con arguments and less effect on the persuasiveness of pro arguments. This might imply that con arguments invite more lively, clear or relevant symbols and examples, possibly in the form of dread risks. These risks can incite strong emotions (Slovic et al. 2004; Witte and Allen 2000). Example frames and association frames that were particularly persuasive contained terms such as poisonous chemicals or suffocating clouds and referred to oil leaks or garbage dumps. Persuasiveness is again strongly related to credibility (pro-con: ρ=0.94, pro: ρ=0.83, con: ρ=0.94), even though the differences between estimators are smaller for credibility and therefore less significant.

There are some differences between sources for persuasiveness, although the differences are rather small and rarely significant. The most persuasive sources for the pro-con group are scientists or a combination of scientists with either environmental NGOs or the national government. The other sources of a single type are far less persuasive, but they improve their persuasiveness when they collaborate with scientist or with each other. This supports the notion that collaboration between stakeholders can be of great value for communicators (Harkins and Petty 1987), although there is one exception: the collaboration between the national government and energy companies.

Interestingly, the results for the pro-con group are quite unrelated to either the pro group (ρ=0.28) or the con group (ρ=0.34), although the con and pro group are somewhat related to each other (ρ=0.64). In both the pro group and the con group sources are more persuasive in comparison to an anonymous source. Communicators are thus less persuasive when they use pro and con argument interchangeably, which might be attributed to a decrease in credibility of the source. This notion is indeed supported by results on the credibility of the sources: in the pro-con group practically every source is perceived as less credible than an anonymous source. This is not the case in either the pro group or the con group. Not surprisingly, the rank order correlations for credibility between the pro-con group and both the pro group (ρ=0.15) and the con group (ρ=0.30) are small. However, we should mention that the arguments that were used could contradict one another in some cases. In reality a communicator would combine pro and con arguments more thoughtfully.

The credibility of sources is strongly related to their persuasiveness (pro-con: ρ=0.84, pro: ρ=0.38, con: ρ=0.74), which supports expectations from theory (Chaiken and Maheswaran 1994; R. G. Peters et al. 1997; Pornpitakpan 2004). The estimators for credibility are more strongly differentiated and overall more significant. This implies that sources influence the credibility of the argument more directly than its persuasiveness. Some differences for the type of source can be observed between the pro-group and the con-group. Scientists and the national government are far less credible and less persuasive when they use con arguments rather than pro arguments. The pattern is reversed for environmental NGOs and combinations of NGOs with others. This implies that scientists and national governments are more effective at persuading people to support CCS and that environmental NGOs are more effective at persuading people to oppose CCS. Sadly, we cannot determine whether this is a general pattern for pro and con arguments or whether it is specific to the CCS context.

	Table 4: Pro & con arguments	Persuasiveness				Credibility			
		Estimator		Sig.[4]		Estimator		Sig.[4]	
		Class1	Class2	Attr.	Class	Class1	Class2	Attr.	Class
	Class Intercept	0,00	4,695			0,00	1,849		
Content	Pro: Climate	-0,445	-2,617	***	***	0,041	-1,935	***	***
	Pro: Economy - 1	-0,299	-2,727	***	***	-0,115	-1,932	***	***
	Pro: Economy - 2	-0,466	-2,686	***	***	-0,086	-2,184	***	***
	Pro: Energy	-0,527	-2,181	***	***	-0,014	-1,922	***	***
	Pro: Safety	-0,183	-2,521	***	***	0,153	-2,167	***	***
	Pro: Normative	-0,058	-2,253	***	***	0,010	-1,325	***	***
	Con: Climate	-0,645	-1,178	***		-0,356	-0,715	***	
	Con: Economy	-1,244	-1,397	***		-0,773	-1,019	***	
	Con: Safety - 1	-0,379	-0,842	***		0,224	-0,229		
	Con: Safety - 2	-0,866	-1,755	***	**	-0,424	-0,995	***	
	Con: Safety - 3	-1,234	-2,012	***	**	-1,064	-1,604	***	
	Con: Normative	0.00	0.00			0.00	0.00		
Frame	Reference	0.00	0.00			0.00	0.00		
	Easy: Outcome	-0,364	-0,547	***		-0,244	-0,512	***	
	Easy: Symbolism	-0,212	-0,278	*		-0,202	-0,246	*	
	Hard: Conditions	0,496	-0,186	***	**	0,452	-0,067	**	*
	Hard: Explanation	0,026	-0,053			-0,027	-0,091		
	Foregone gain / loss	-0,393	-0,668	***		-0,211	-0,600	***	
Source	No source	0.00	0.00			0.00	0.00		
	Scientists	0,150	0,197			-0,123	0,049		
	National government (gov.)	-0,055	-0,501	*		-0,300	-0,464	***	
	Energy Companies	-0,070	0,041			-0,398	-0,081	*	
	Environmental NGOs	-0,053	-0,127			-0,212	0,122		
	Gov. & scientists	-0,140	0,113			-0,313	-0,271	*	
	Gov. & energy companies	-0,294	-0,256			-0,337	-0,481	**	
	Gov. & environmental NGOs	-0,002	-0,253			-0,252	-0,331	*	
	Scientists & energy companies	-0,110	0,561	*	**	-0,220	-0,003		
	Scientists & environmental NGOs	0,127	-0,142			-0,036	-0,056		
	Energy companies & environmental NGOs	-0,231	0,160			-0,549	-0,124	***	
	All sources	0,033	-0,036			-0,118	-0,104		
Controls	Left vs. right	-0,223	-0,142	***		0,100	0,075	**	
	Length	-0,003	0,001			-0,001	0,011		
Receiver	CCS attitude (before DCE)	0.00	-2,415		***	0.00	-1,688		***
	Climate change attitude	-	-			0.00	0,914		***
	Opinion leadership	0.00	0,774		***	-	-		
Class size		58,35	41,65			51,82	48,18		
R^2		0,24				0,23			

*Table 4: Results of latent class models (*p<0,05, **p<0,01, ***p<0,001)*

[4] We report the significance value of the attribute (attr.) and the significance value for the difference between classes (class).

4.3 Latent class models

The results of the latent class models for the pro-con group are displayed in table 4. The McFadden R^2 values show a marked improvement from the main effects models. For persuasiveness there are two classes that are similar in size (class 1=58,35% and class 2=41,65%). The classes differ significantly on two receiver characteristics: CCS attitude and opinion leadership. Class 2 is significantly more negative about CCS than class 1 (class 1: M=3.37, class 2: M=2.55) and the members of class 2 show a higher opinion leadership on average (class 1: M=2.75, class 2: M=2.90). The difference in CCS attitude is reflected in the persuasiveness of arguments for the classes. For class 2 all pro arguments are significantly less persuasive and some con arguments are significantly more persuasive. This is line with our expectations. Most importantly though, it supports the notion that attitude is an important predictor of choice (Boxall and Adamowicz 2002; Domarchi et al. 2008).

The results for credibility can also be separated between two classes that are similar in size (class 1=51,82% and class 2=48,18%). The classes differ on CCS attitude (class 1: M=3.33, class 2: M=2.70) and climate change attitude (class 1: M=3.37, class 2: M=3.62). The classes are otherwise rather similar to the classes for the persuasiveness model. Yet, arguments about climate change and arguments from environmental NGOs are seen as slightly more credible for the second class. This result can be expected from the more positive view towards climate change mitigation of class 2.

For argument frames there is a difference between classes for the persuasiveness and credibility of the conditions frame. In both models this frame is significantly less persuasive for class 2 than for class 1. The same pattern holds for the explanations frame, although the differences are not significant here. For argument source there is an interesting difference between classes for the persuasiveness model: class 2 finds distinct sources overall less persuasive than an anonymous source, although only a few differences are significant. This is in line with theoretical expectations: opinion leaders attach less value to the opinions of others (Flynn et al. 1994; Locock et al. 2001).

5. Conclusion

Communication studies have often resorted to relatively simple research designs. The conclusions that could be drawn from these studies are necessarily limited, because only a few instances of a message are examined. This shortcoming is recognized by several authors (Brashers and Jackson 1999; O'Keefe 2002), but the field lacked methods that allow multiple communication characteristics to be assessed at once. Our study demonstrates that choice models could fill this gap as they have proven highly valuable.

We were able to assess the persuasiveness and credibility of argument frames and sources in addition to argument content. We thereby contribute to literature on CCS by furthering the understanding of CCS arguments (Broecks et al. 2013; van Egmond and Hekkert 2012). We identified how the persuasiveness and credibility of arguments changes when the argument is reframed or when the source changes. It has also given us some insight into message congruence by comparing the credibility and persuasiveness between different sets of pro or con arguments. Although the findings are specific to the context of CCS, some of the patterns can be readily translated to other controversial topics, such as nuclear energy or shale gas.

Some of these patterns were already demonstrated in the general communication literature, such as the higher salience of con arguments (Cobb and Kuklinski 1997; Sen and D. Lerman 2007; Skowronski and Carlston 1987); the connection between persuasiveness and credibility (Chaiken and Maheswaran 1994; R. G. Peters et al. 1997; Pornpitakpan 2004); the persuasive effect of appeals to norms (Bamberg and Möser 2007; De Groot and Steg 2010; Hopper and McCarlnielsen 1991); the effect of source collaboration (Harkins and Petty 1987) and the influence of prior attitudes on persuasion and choice (Boxall and Adamowicz 2002; Domarchi et al. 2008; Taber et al. 2009; Taber

and Lodge 2006). Yet, the effect of argument content, frame and source cannot be entirely separated from its context: controversial topics and CCS in specific. We have shown how these concepts and patterns translate to the CCS context and what their relative impact is.

6. Discussion

This study is not the first study that applied choice models to communication issues. Broecks et al. (2013) showed that choice models are valuable for the assessment of a large set of arguments. We have built upon this earlier study by showing their value for the estimation of different *kinds* of communication characteristics. Future studies should explore the possibilities of assessing an even wider range of characteristics and expand the scope to full messages. The limited scope of our study might have implications for its results. The focus on short messages in the form of arguments necessarily limits conclusions about framing and source effects. For example: it is not unthinkable that the higher persuasiveness of hard frames lessens when messages cross a length threshold. Although we accounted for argument length, the messages were still rather short.

The fit of the models that were estimated was initially rather poor. Latent class models are a valuable tool to increase the explanatory power of choice models. Besides enabling the identification of segments of receivers, it can also provide some implications for receiver characteristics. The segments that we identified were based on CCS attitude, attitude towards climate change and opinion leadership. Other characteristics could be used to further classify the segments. This question can be explored in future studies.

Finally, we provide some suggestions for communication about CCS and controversial topics in general that might help to prevent problems that result from poorly executed communication. Our results once again point out that normative arguments are the most persuasive arguments. It is therefore advisable to focus on appeals to personal norms in a communicated message. These appeals and other arguments should use explanation and examples to present the argument, because these frames are generally most persuasive. It is also advisable that communicators collaborate, especially with scientists. These collaborations add credibility to the communicator and increase the persuasiveness of the message. It should also be noted that the receiver's attitude towards the issue will largely influence how the message is perceived. This means that the effects of communication are somewhat dependent on previous experiences with the topic.

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Appendix 1: Example of the framing of arguments.

Example: A pro economic argument	Frame
The development of technology for CO_2-storage contributes to employment and economic growth.	Reference
CO_2-storage is good for the economy.	Easy: Outcome
Germany is the frontrunner with solar and wind energy. The Netherlands can still be the frontrunner with CO_2-storage and earn a lot of money.	Easy: Symbolism
The development of technology for CO_2-storage attracts firms. For this reason CO_2-storage contributes to employment and economic growth.	Hard: Conditions
The harbor of Rotterdam would like to earn money with CO_2-storage. This harbor is of critical importance for the Dutch economy.	Hard: Example
Without the development of technology for CO_2-storage there will be less employment and economic growth.	Foregone gains/losses

Appendix 1: Overview of argument frames & examples.