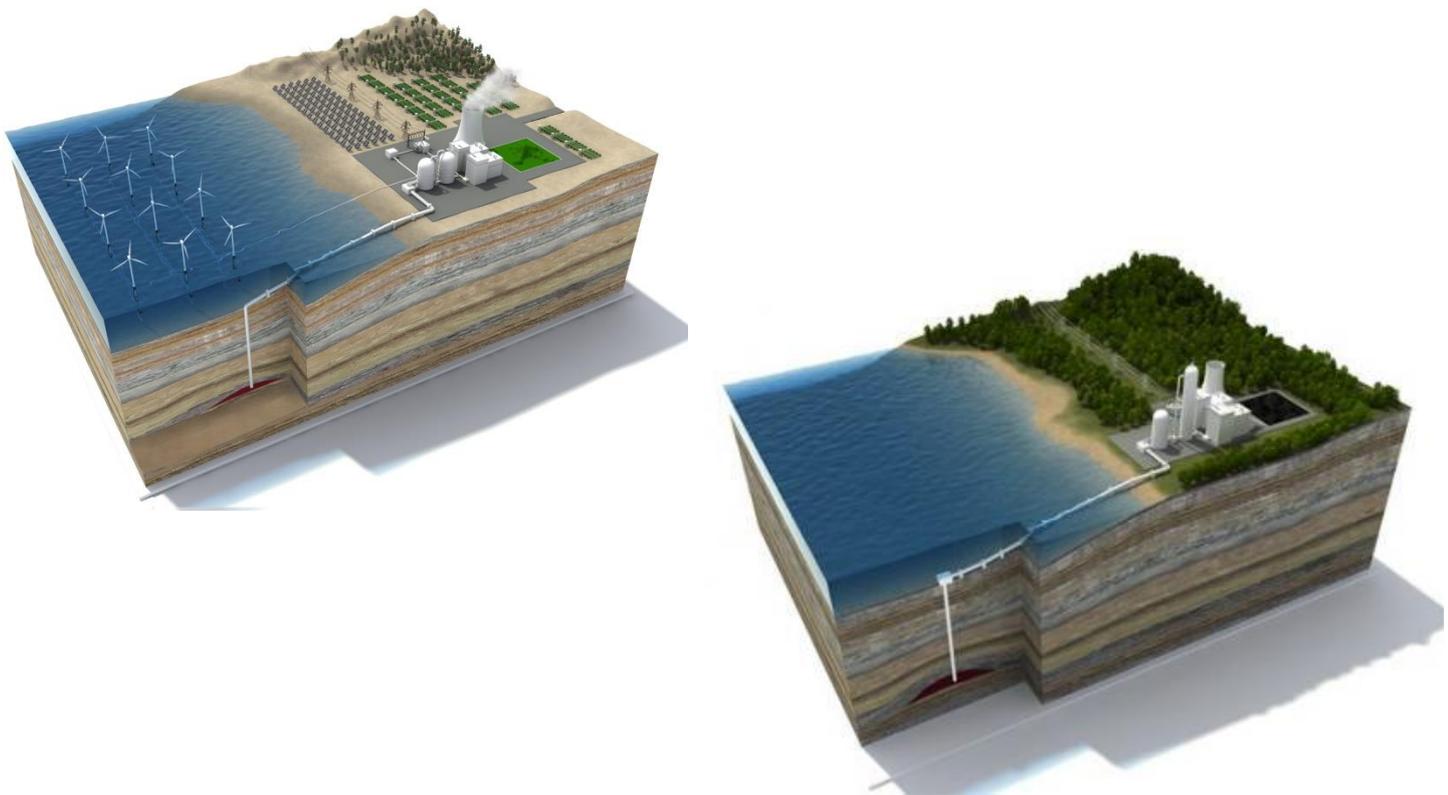# Effective framing of CO$_2$ Capture and Storage

A study into the most effective frames in risk communication on CO$_2$ Capture and Storage.

Effective framing of
CO_2 Capture and Storage

A study into the most effective factors in risk communication on CO_2 Capture and Storage.

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Master's Thesis to acquire a *Master's of Science Degree in Systems Engineering, Policy Analysis, and Management* of the

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Summary

The usage of, and research into, CO_2 capture and storage (CCS) is rising rapidly. For example, as the Dutch case of CO_2 storage under the city of Barendrecht shows, the lack of local support could possibly provide much hindrance for projects. The creation of local support could prove to be essential to stimulate the technological development of CCS.

A way to influence this local support is through communication about CCS. In this communication many choices can be made, every message created has many degrees of freedom when constructed, of which the influence on effectiveness is unknown (in the case of CCS). The theoretical concept of framing can assist in providing clarity on these influences.

Currently, considerable research is already carried out into several degrees of freedom (factors). Mostly, this research investigates factors individually, with no possibility to compare effects, and many factors are not yet studied specifically for CCS. Furthermore, many factors are studied from a more theoretical perspective, and factors are investigated that are hard to identify as actor in the debate.

Therefore the objective of this study was to "Provide insight into the factors that are *most* influential on the effectiveness of framing of risks in sociotechnical projects".

To reach this objective first a literature study was conducted to find promising factors: the most promising factors were tested empirically in a Massive Online Open Course (MOOC) from the TU Delft. The added value of this research follows from the following three facts:
- Factors were studied specifically for CCS;
- Factors were studied together to create the possibility to test interaction and effects and compare the relative strengths of effects;
- Factors were chosen from practical (policy) relevance.

From the literature analysis the following three factors were deemed to be promising candidates to influence perception on CO_2 Capture and Storage:

- The communication strategy in which the following three perspectives were identified.
  - *Calculation Strategy*: A risk is acceptable if the (monetized) advantages outweigh the (monetized) damage of the risks.
  - *Division Strategy*: A risk is acceptable if different risks are divided equally amongst a population.
  - *Acceptance Strategy*: A risk is acceptable because nothing is without risk, so not accepting means no action at all.
- The independence of the messenger.
  - Three messengers were used in this research: A scientist from a university of technology, a CEO of an oil company, and an environmental agency spokesman.
- The use of the word risk or safety in a message.

Together with the variation of positive and negative frames the implementation of factors led to a 2x2x2x3 experimental design with 25 different frames (a neutral message without a frame was also added), that were presented to the 1.360 respondents from the MOOC that completed the survey (the MOOC had a few thousand participants). These respondents were then tested for effectiveness with three methods: Test the language they used describing the CCS-discussion, a scale adopted from Petty and Cacioppo (1984) that

consisted of four Likert-scales asking the opinion of a respondent on the implementation of CCS, and a yes/no question to ask if they would support CCS implementation. Based on the literature study, hypotheses were formulated for all factors selected. These hypotheses were tested with the results of the MOOC.

The most important effect tested was the direct effect for which the following hypothesis was formulated: A positive frame leads to a more positive opinion on CCS than a negative frame. The tests resulted in the conclusion that there was no significant connection between the positive or negative frames and the opinion of respondents on CCS. In other words, the frame did not influence opinion. This conclusion held (therefore) also for almost all other expected connections and hypotheses.

An explanation for this absence of expected effects can be found in the emphasis pitfall, as presented by De Vries, Terwel and Ellemers (2015): Respondents perceive a message as more manipulative when only one side is emphasized. Also the possibility that the frames were variated not strongly enough, or not emphasized enough. The latter would lead to a respondent reading too quickly or even skipping the frame too fast, not enabling the frame to influence opinion.

Conclusions

Although the main framing effect was not in place, four effects were found that could not be explained by coincidence.

First, the only interaction effect that seemed to create an effect was the independence of the messenger. The difference between the positive and negative frame was significant when an independent messenger shared the message. Thus, *with caution,* the conclusion can be drawn that the independence of the messenger is the only effect that was strong enough to show a framing effect; none of the other factors were able to do so.

Second, a significant effect was found when analysing the usage of calculation-based language (numbers, words about height and percentages). Respondents who were shown an article containing a calculation-based strategy were found to use more calculation-based language. A calculation strategy is able to focus the discussion on calculation aspects.
From literature, some disadvantages of this strategy can also be stated: arguments used in a calculated, rational-based discussion do not incorporate all aspects of a discussion (Cuppen, Brunsting, Pesch & Feenstra, 2015), possibly ignoring a part of the intended public, and even decreasing local support. Although the public might internalize the calculation frame, it might not be beneficial for actors to use the frame when trying to improve acceptation.

Third, in the research, the values as defined by Schwartz (1992), which define a person's worldview, were tested for their influence on the opinion on CCS. The effects found lead to the conclusion that people who value the values *Power* (might), *Achievement* (achieve goals/career) and *Hedonism* (enjoyment of life) are more likely to be positive about CO_2 Capture and Storage. Respondents who scored higher on the value *Benevolence* (helping others) are more likely to be negative about CCS.

Last, a weak but significant negative correlation was found between the age of respondents and their opinions on CCS. Therefore the careful conclusion can be drawn that older people are more likely be negative about CO_2 capture and storage.

Recommendations

Based on the results of this study several recommendations were made. The three most important recommendations to increase a repetition of the research as described in this report were the following:

- Vary frames more strongly;
- Emphasize frames more (draw attention, longer frames, other medium);
- Increase the number of respondents that can be used for analysis.

Also several recommendations were made for other relevant research

- Study the effect of the different communication strategies and the variation of the words risk and safety as sole variable. Both variables are promising and further research would add to existing literature;
- Study the influence of other variables from the shortlist constructed in the literature study;
- Investigate the effect of using a MOOC on results by comparing a study in a MOOC with other remote randomized experiments.

Furthermore, to actors in the CCS debate, the advice was given to pay at least as much attention to (the independence of) the messenger as to the creation of the message, and also consider using risk communication strategies other than calculation-based approaches (especially for governments).

Acknowledgements (Dutch)

Beste lezer,

Deze thesis is de afsluiting van een proces van zo'n 8 maanden waarin ik mij ben gaan verdiepen in het onderwerp framing rond opslaan van CO_2 onder de grond, en ik voor het eerst bezig was met het uitvoeren van echt wetenschappelijk onderzoek. Daarnaast is deze thesis ook het einde van een iets meer dan 6-jarige periode waarin ik in Delft heb mogen studeren en mij heb mogen ontwikkelen op tal van andere vlakken.

Ik heb tijdens het uitvoeren van het onderzoek voor deze thesis veel geleerd. Het maken en uitzetten van de enquête heb ik ervaren als leerzaam, en daarnaast ook motiverend. Eén van de aspecten die hiervoor heeft gezorgd was het feit dat in de loop van de tijd goed zichtbaar werd dat steeds meer mensen bezig waren met het invullen van mijn vragenlijst (tot bijna **1.500** uiteindelijk), en dat deze van over de hele wereld kwamen. De figuur waarop deze respondenten geplot zijn op een wereldkaart vond ik erg leuk om te maken. Ook de fase waarin de enquête getest werd in mijn eigen omgeving en bij mijn collega's van KWINK was zowel leerzaam als leuk. Naast veel goede inhoudelijke verbeteringen was de enquête ook een aanleiding om met veel mensen in mijn naaste omgeving dieper over mijn scriptie te praten, hier zijn leuke gesprekken uit voortgevloeid. Bij dezen bedank ik graag iedereen die de enquête in de testfase heeft ingevuld hartelijk.

Nadat uit de eerste resultaten van het experiment in eerste instantie niet de conclusies kwamen die ik verwacht had was het schrijven van de definitieve scriptie soms wel enigszins een hobbel. Het heeft mij hierbij zeer geholpen om de eerste 5 maanden door te brengen bij mijn afstudeerbedrijf KWINK groep. De sfeer die bij KWINK heerste stimuleerde me om te blijven werken en de steun van collega's, en mede-afstudeerstagairs heeft eraan bijgedragen dat de hobbel goed te nemen was. In het algemeen was mijn ervaring bij KWINK een goede toevoeging op het afstudeerproces, juist ook door het meewerken aan projecten die bij KWINK liepen. Complimenten ook aan KWINK voor het feit dat jullie in staat zijn stagiairs zo snel echt onderdeel te laten worden van het team. Specifiek zou ik bij dezen graag Pauline Modderman willen bedanken voor de begeleiding vanuit KWINK, de vele uren waarin we hebben gepraat over de scriptie en al de opmerkingen die je bij stukken geplaatst hebt. Ook dank aan Annelies Dijkzeul voor het stellen van scherpe vragen en een goede inhoudelijke doorzaagsessie op een cruciaal moment in het proces.

Als laatst zou ik ook mijn afstudeercomité hartelijk willen bedanken. Al mijn begeleiders hebben op hun eigen manier en vanuit hun eigen een expertise een grote bijdrage geleverd aan dit onderzoek. Hans de Bruijn door het beschikbaar stellen en verduidelijken van de opdracht en ondersteuning op de belangrijkste momenten, ook op soms zeer korte termijn. Martijn Groenleer door zijn zeer scherp en vaak gedetailleerd constructief commentaar, maar ook altijd de mogelijkheid tot persoonlijk contact voor verduidelijking. Maarten voor de waardevolle opmerkingen over de statistische kant, een positieve ondersteuning en een grote bijdrage aan het opstellen van de enquête. Gerdien was een zeer prettige toevoeging die onverwachts ook een grote rol heeft gespeeld in mijn afstuderen. Als dat niet was gebeurd had de thesis er heel anders uit gezien. Met een zeer scherpe blik heeft Gerdien de (presentatie van) mijn methode sterk verbeterd en me gewezen op veel essentiële literatuur. Ik ben er ook nog niet helemaal uit of het volledig toevallig is dat mijn onderzoek toevallig ineens over dezelfde casus ging als haar PhD thesis.

Veel leesplezier gewenst,

Bas Vollebregt

Content

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1. Introduction

The first of December, 2009, ministers of the Dutch Government Cramer and Van der Hoeven spoke at a consultation evening in Barendrecht. They defended the plan to store CO_2 in an empty gas field beneath the neighbourhood Carnisselande. Their message was clear: *"Whether you like it or not, every research shows that it can be done safely. Safety is our first priority. Therefore it does not matter whether there are 500, or some thousands living there"* (Noordegraaf-Eelens, Van Eeten, Februari & Ferket, 2012, p. 10).

The fourth of November 2010, almost a year later, the then minister Verhagen announces that the plan to store CO_2 would not continue because of a *"lack of local support"* (Ministry of Economics, 2010, p. 1). The fact that local support played a key role was also supported by research of Brunsting et al. (2011).

Sources for this absence of local support cannot be narrowed to one source. However, when the statement above, which is representative of the attitude of the national government in the CO_2-storage project, is analysed one thing becomes clear: It is easy to dismantle the 100% safety message. Every project has risks, the risk is never zero, and this counterargument was repeated frequently amongst opponents.

Furthermore, Terwel et al. (2012), who studied the opinion of 811 residents of Barendrecht found: *"Barendrecht residents already had to put up with (risks of) several infrastructure projects in the past and may have felt 'enough is enough'."* (p. 3)

Perhaps the statement that *denied* any risks was not the most effective[1] method of communicating in this case. Maybe a method of communication that focussed more on the division of risks, such as the transfer of risks to the government or the developer Shell, could have been more effective. This solution was also proposed by Van Eeten (2010): "*Downplaying risks is not effective if the own organisation is not bearing those risks*" (p. 26).

However, knowledge as to what aspects could have been most effective in this case is still lacking. Therefore, in this research, an attempt is made to create insight into the process described above: do certain forms of risk communication work better for technical projects as CO_2 Capture and Storage (CCS)?

For the different presentations of a message the concept of *'framing'* will be used from now on, which is defined briefly as *"emphasizing different aspects of a certain issue in a message."* This definition will be explained more extensively in Paragraph 2.1.

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[1] What is seen as effectiveness in this research is explained more extensively in Paragraph 2.1, but for now the definition *"influences an opinion towards one's goal"* is sufficient.

1.1. Relevance of this research

As the previous example illustrates, (technical) solutions are often designed for societal problems. Most of these problems can be characterized as "messy" problems which have specific characteristics: Goals are uncertain; coalitions change over time and the effects of certain technological solutions designed are not well known by every player (Bots, 2007). This uncertainty makes these problems susceptible to discussion about solutions.

Why is this relevant? As Stoutenborough, Vedlitz, and Liu (2015) stated, the support for any policy is dependent on the *risk perception* of individuals influenced by this discussion. Every party acting in the field around risk communication of sociotechnical projects could benefit for knowledge what elements influence the effectiveness of certain forms of risk communication. In this research, an attempt is made to improve this insight. The objective of this research can, therefore, be stated as follows: *"Provide insight in the factors that are most influential on the effectiveness of framing of risks of sociotechnical projects".*

1.1.1. Knowledge gap

In existing literature, considerable research was conducted into factors influencing framing success. For an overview literature reviews by Levin, Schneider and Gaeth (1998) and Chong and Druckman (2007) give good overviews. In current literature many studies have certain characteristics:

- Only study one factor at a time. See for example: Levin and Gaeth (1988), who studied the timing of presenting frames; Druckman (2001), who investigated credibility of a messenger; Li and Chapman (2013), who tested the influence of the relative size subsets;
- Study interesting factors not focussed on sociotechnical issues, specifically CCS. For example, the studies that were already mentioned did not focus on CCS; however, some studies do take into account multiple factors, such as Fagley and Miller (1990), who studied the difference between men and women together with the area of interest and Hänggli (2011), who investigated many factors relevant for a messenger, but did not focus on a technical project;
- Studies that *do* focus on CCS mostly did not take into account multiple factors. See for example, Brunsting, de Best-Waldhober and Terwel (2013a), De Vries et al. (2015), Ter Mors, Weenig, Ellemers and Daamen (2006), and Zaal, Terwel, Ter Mors and Daamen (2014).

This knowledge gap will be discussed more extensively in the next chapter. For now, from this knowledge gap, the following aspects give this research scientific and practical relevance:

- Factors investigated in this research are studied in conjunction with other factors.
  - This way relevant interaction effects can be studied, and effects can be compared, so a statement can be made as to what factors are more important.
- Factors are studied for a specific case study: CCS.
  - As will be explained in Paragraph 1.4 the technique of CCS has the potential to influence environmental policy, and therefore, it can be relevant to study several factors specifically for this problem. Also, CCS can be used as a case to deduce conclusions on effectiveness of factors for sociotechnical problems in general. Paragraph 1.4.1 denotes the specific relevance of CCS as a case study.
- Factors were chosen based on practical relevance.
  - Factors were chosen from the perspective of an actor in the debate, so anyone acting around CCS should be able to identify and perhaps influence the factors. Insight into these factors provides practical relevance.

By investigating success factors, more insight is created into what factors are most influential regarding the effectiveness of framing. This practical relevance is on itself a contribution to scientific knowledge and, can

provide starting points for actors communicating about CCS to make their communication more effective and better understand emerging patterns in debates.

1.2. Research questions

Following from the objective the main question to be answered in this study is as follows:

"What factors determine the effectiveness of risk framing in sociotechnical projects such as CO_2 Capture and Storage?

To answer this question, the following sub-questions must be answered. Per question, the research method used is shown in parentheses.

1. What is the effectiveness of a frame, and how can this be measured? *(Literature study)*

2. What factors can influence the effectiveness of framing risks in sociotechnical projects based on existing literature? *(Literature study)*

3. What factors are most likely to be influential on framing in risk communication around sociotechnical projects, based on existing literature? *(Literature study)*

4. To what extent do tested factors influence framing success? *(Empirical quantitative research)*

Method
As already mentioned, this research will be conducted in different steps. First, a literature study was performed to find the most promising factors. These factors were then tested in an empirical study. This research made use of two surveys completed by participants of a MOOC given by the TU Delft and used CO_2 Capture and Storage as subject of the frames. The method for the literature study will be explained in Paragraph 2.1. The method for the empirical study will be described in Chapter 3.

1.3. CO_2 Capture and Storage

In this research different aspects of framing are investigated for the storage of CO_2 underground, this process is called CO_2 Capture and Storage and will be explained in this paragraph. The technology is used to reduce the amount of CO_2 in the atmosphere. This is relevant, because according to the IPCC (2013), CO_2 in the atmosphere is one of the main drivers of climate change. Because the technical complexity is not used explicitly in this research, for a more extensive explanation of CCS, Herzog, Drake and Adams (1997) can be used, or for knowledge on concrete projects CCP (2014), and for a more elaborate discussion about the controversy De Vries, Terwel and Ellemers (2014, p. 8). Briefly, CCS consists of three steps: Capture, Transport and Storage.

Capture of CO_2 is usually done at any location where considerable amounts of CO_2 are released, such as electricity production or a coal gasification plant. The CO_2 is purified, most preferably, at this location before transport.

The **transport** is achieved through pipes or with any other more regular transportation method when the CO_2 is pressurized, such as trains or trucks.

Storage will usually take place in any geographical location that can be closed relatively easily. The CO_2 is then stored there indefinitely. Not only an empty gas field (mostly used), but also active oil wells are options, even increasing oil production. An interesting option is the use of depleted saline aquifers. This option is widely investigated and is explained clearly in a presentation by Smith(2010), from the British Geological Survey.

A good overview of most recent techniques to carry out these different steps can be found in De Coninck and Benson's (2014) work. De Coninck and Benson also estimated the potential, based on recent literature: 5.000 to 25.000 GigaTonnes of CO_2, although depending heavily on technical and economic developments. Still, CCS certainly has a huge potential to influence the emission of CO_2 in the short/medium term. As a reflection on the last 10 years of research into CCS since the Intergovernmental Panel on Climate Change (IPCC) (2005) published her first paper on CCS, Gale et al. (2015) provided an excellent resource to find the latest research on CCS techniques.

1.3.1. Why CCS as a case?

The case of CCS can be seen as a sociotechnical issue. A sociotechnical problem is defined as an issue with technical complexity, as well as social complexity. In this research, the definition of sociotechnical context, based on a description of sociotechnical systems by Geels (2004) and Enserink, Hermans, Kwakkel, Thissen, and Koppenjan (2010), is used: *"An issue in a societal context that has a technical complexity and a societal complexity (with no consensus on a solution)"* . Examples are the electronic patient files (in the Netherlands), Infrastructures as (rail-)roads or electricity system and the building of windmills in any neighbourhood. Most sociotechnical projects can be characterized as messy problems, as already discussed. CCS also is a (very) messy problem.

For every solution that has to be implemented in this kind of context, there is often a requirement for implementation: Gain (local) support. Solutions need political, and thus societal support. Therefore, communication can play a big role (Brunsting et al., 2011).

In general, framing is most relevant for uncertainties, which provide room for framing (Lakoff, 2004). Uncertainty is per definition in place when dealing with risks around sociotechnical projects. Per definition, risks themselves are uncertain (Sandman, 2012), and even more important, the perception of risks is always subjective on itself (Sandman & Miller, 1991). Furthermore as stated by Olson, Birge and Linton (2014), risks always play an important role in the acceptation of technical innovation, and therefore, it is of interest to examine framing aspects in risks around technical projects when evaluating framing around these projects. This importance of risks in acceptation of technical projects was also stated by Noordegraaf-Eelens et al. (2012), who said that in every discussion dealing with risk, frames can be identified with a certain goal: Acceptation of the risk, and therefore also the technological solution itself.

In this specific study a specific sociotechnical problem was selected to test the framing variables. The following elements were considered when selecting the CCS solution as subject for this study:

- CCS has a technological complexity
- CCS has a societal complexity
- Respondents vary in their knowledge and not all have yet fully formed an opinion.

1.4. Structure

In Chapter 2 of this report, literature will be discussed that gives insight into framing, CCS, and current known success factors. Chapter 2 will end with the hypotheses that were investigated in the empirical study. This empirical study will be explained in Chapter 3 and the method will be discussed. Chapter 4 will show the results of the empirical study. Chapter 5 will combine these results into conclusions. Chapter 6 will discuss the limitations and other possibilities for improvement in this research. Chapter 7 will give recommendations for further research and some practical recommendations.

2. Theory

In this chapter first the method for the literature study that was conducted in this research is discussed in Paragraph 2.1. Some theoretical concepts and definitions are explained in Paragraph 2.2. In Paragraph 2.3 the factors that were deduced from the literature are discussed, of which a selection was chosen to test empirically. This selection of chosen factors is discussed in Paragraph 2.4, and here also hypotheses are formulated for each factor. Paragraph 2.5 concludes with an overview of all hypotheses.

2.1. Method of literature study

In this phase of the research, literature on framing is analysed structurally to answer the first three research questions.

The study can be visualized as Figure 1 shows. First, as many studies as possible were analysed to find relevant factors that influence risk communication. While analysing this literature for factors, at the same time, methods were identified to measure the effectiveness of frames. Then, from this longlist of factors, a shorter list most likely to be influential in risk communication was determined.

Figure 1: Literature study structure

Literature was found through Google Scholar and by searching for relevant criteria:

- Framing (Effects)
- Literature Review
- Priming
- Agenda setting
- Risk (Communication)
- Carbon Capture and Storage

As a starting point for the identification of relevant framing factors, the literature reviews of Levin et al. (1998), Benford and Snow (2000), and the article of Chong and Druckman (2007) were used. For CCS Framing specifically, De Vries et al. (2014) and Ashworth, Boughen, Mayhew and Millar (2015) were useful.

2.2. Definitions

2.2.1. Definition of framing

The concept of framing has always had a place in human interaction. The concept can be tracked as far back as Aristotle's essential work *Rhetoric* (4th Century BC). One of his three principles of persuasion, Pathos,[2] can be translated into *'putting the hearer into a certain frame of mind'* (Matsen, Rollinson & Sousa, 1990). It is, therefore, important to know that from this point onwards, **2400 years** researchers have been studying the best way to provide a selection of words, and have given this research several names. The *idea* behind framing is absolutely not new.

The definition of framing as used in current literature can be traced back to a more recent article, *"Frame analysis: An essay on the organization of experience"*, by Goffman (1974). Framing effects received broad attention through the quantitative study by Tversky and Kahneman in 1981. In their research, a question regarding the now famous Asian disease problem, concerning the spreading of an unknown Asian disease, with two possible strategies to combat the disease, was framed in different ways. Respondents had two options: A risky one (1/3 chance of **0 deaths**/*600 living*) and a safer one (certain **200 deaths**/*400 living*). The questions was then formulated differently per respondent: Describing the number of deaths, or the number of people saved, as shown in bold and italic above. Results showed that in a death-frame respondents were far more risk-seeking.

Although both options were exactly the same numerically, the way the question was framed, significantly changed the percentage of respondents choosing the different options. After this considerable research was conducted into framing effects. A good summary of this research can be found in Kühberger (1998), Kühberger, Schulte-Mecklenbeck and Perner (1999), and Levin et al. (1998) or for more recent research, Chong and Druckman (2007). However, despite this research into framing, an unequivocal definition of framing is still a subject of discussion. This lack of clarity is clearly identifiable in the differences in (schools of) literature concerning framing. A definition that can be used from a practical point of view is an often still used definition from Entman (1993, p. 52):

 "…to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation"

This definition is frequently contested, for example by Scheufele and Iyengar (2012), who stated that the definition is too vague to provide real conceptual clarity and has led to a large variety in types of studies into framing. However a good explanation of this issue was given by Sniderman and Theriault (2004), who stated that many narrow definitions of framing do indeed lead to research that is perhaps conceptually clear but not applicable in practice (Gamson & Modigliani, 1987).

Although this definition focusses specifically on the communicating text, it can also be expanded to other forms of communication, such as images. In every image, it is possible to emphasize certain aspects of a problem. The above definition is, therefore, useful, especially for the practical side of this research; however, a more in-depth analysis can be made to explain some psychological principles relevant for this research, elaborating on this definition. For example, in Chong and Druckman (2007), the following distinction is made into two types of framing: Internal and external.

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[2] The others being Ethos (Credibility) and Logos (The argument)

An *internal frame*, can be defined as the lens through which an individual filters reality, the perception of an individual on a certain subject. This perception is influenced by earlier received communication on a subject (initial frames). Theoretically, this internal frame can be described as a number of attributes that an individual owns, on which a subject can score a certain value. An attribute is a value, or other aspect on which a certain subject can be judged. Every attribute has a weight that describes the importance of an attribute to an individual. Summarized this can be displayed as follows (Chong and Druckman, 2007; based on Ajzen & Fishbein, 1980):

$$Perception = \sum_{i=1}^{n} score\ on\ attribute\ i * Weight\ of\ attribute\ i$$

This explanation can be made more concrete on multiple conceptual levels: A person can, for example, judge CCS on three aspects: Environmental benefits, security and cheap energy, with a different score on each attribute. These aspects are weighted. However, the judgement of environmental benefits can also consist of certain sub-aspects: Benefits to CO_2, benefits for air quality, etc.

An *external frame* can be seen as any external message arriving at an individual about a subject. This is a frame as defined by Entman (1993), as discussed earlier. To specify, an external frame has the following influence through coupling to an internal frame:
- On the weight of attributes: An external frame can emphasize (repeatedly) certain aspects in a discussion to increase the weight of this aspect in the perception and, therefore, influence perception;
- On the value on the attributes: A frame can influence the value that a subject scores on an attribute;
- On the attributes itself: Often most influential, the frame can couple a subject to certain attributes (that a receiver deems important), thus influencing the perception by adding attributes;

Many internal frames are based on a certain structure, that is often used in analysing problems. This structure follows from connected neurons in the brain; connections used often are stronger (Lakoff & Johnson, 1980). For example, a frame using the Hero/Victim/Villain structure has more chance of influencing perception, because this mechanism is a structure often used in analysing a situation. Another example is a frame expressing a contrast or contradiction, which stimulates the search for new attributes for a specific subject (Druckman, 2010; Kuklinski, Quirk, Jerit & Rich, 2001).

In this study, the concepts described above are relevant because the effectiveness of framing, as will be discussed in the next Paragraph, relates to the change of an internal frame of a person, and the frames as constructed are external frames. This study focusses on the exact point in which these perspectives collide, where the external frame is internalized or influences the internal frame.

Equivalence vs. Emphasis Framing
As already mentioned, the definition used in this research is contested by several authors. Scheufele and Iyengar (2012) made a strong argument for a more narrow definition. They identified two ways of thinking about framing. First they identify the school started with the work of Tversky and Kahneman (1981, 1984), as already mentioned (the Asian disease problem), that investigate a narrow aspect of frames that have one key element: The information provided in different frames is exactly the same. The two messages presented in experiments in this school are, therefore, logically equivalent, therefore Scheufele and Iyengar (2012) name this *Equivalence Framing,* which can be seen as a more psychological definition of framing. In this research one of the empirically tested factors: *use of the word risk vs. safety* would be part of this school of thought. This factor will be explained in Paragraph 2.4

Most framing studies are based on definitions that are broader, for example Entman's (1993) definition as used in this research. These broader definitions follow from the fact that the more experimental, equivalence framing effects cannot be easily transported to reality because of the narrow experimental settings, especially

the condition that respondents have no reason to believe their message can be framed differently (Gamson & Modigliani, 1987; Sniderman & Theriault, 2004). From this point of view, Scheufele and Iyengar (2012) identified another school of thought in framing: *Emphasis Framing*. They choose this definition because, in these studies, not only purely the presentation is varied, but also other aspects, which change the information present in different frames. Different elements are emphasized. As discussed, this emphasis can improve the transferability to reality but makes it harder to identify framing effects.

Relevant notions from literature

Many different scientific schools have studied framing, each from its own perspective. A brief summary of these schools is given in Appendix B. Here the most relevant notions from these schools of literature are noted, and the implications for this research are described.

From different schools of literature, arguments can be found why framing is specifically of interest when communicating about risks:

- Neurology: Because the principle of uncertainty is essential in the principle of risks, framing is important and applicable in these situations.
- Psychology: The perception of risk is highly dependent on how the risks are presented.

In general, messy, sociotechnical problems are relevant when discussing framing because of the following:

- Political science: Politicized issues are, per definition, susceptible to framing, because of the nature of wicked problems.

Furthermore, when discussing solutions or factors, it is important to consider more than the message itself. The factors from a more broad perspective are also important:

- Neurology: Framing does not only change perception, but can also change the issue itself for the messenger
- Public administration: Risk framing is more than formulation. It also deals with the core strategy how a communicating party looks at risks.

These notions support the fact that CCS was chosen as a case and that framing is a relevant subject, as well as directing this research to certain principles that explain several success factors. Furthermore, support for the choices made from public administration two concrete success factors were deduced:

- Using a risk communication strategy other than a calculation strategy might also be successful in risk communication.
- Successful communication about risks incorporates another value (that is emphasized).

2.2.2. Definition of a (success) factor

In this research the word factor is frequently used. In this research a factor is seen as every degree of freedom that can be varied when communicating about risks in sociotechnical problems, for this study CCS. These factors are comparable to the *input variables* for communication that McGuire (2001) defined for his communication matrix.

Four categories of degrees of freedom can be identified:

- Content factors: The substance of a message and formulation. For example the values a frame appeals to.

- Source factors: The attributes of a source sharing the message, e.g. age/sex/profession of the messenger.
- Audience factors: The attributes of the public. Age/sex/intelligence of the audience are examples.
- Contextual factors: The context in which the message is delivered. For example the medium used to deliver the frame or information that is presented before/after the frame

In all these categories both equivalence and emphasis frames can be constructed.

2.2.3. Definition of framing Effectiveness

To explain how in this research e*ffectiveness* is defined, the Entman's (1993) definition of framing by is used, in combination with more practise-oriented literature (Lakoff, 2004; De Bruijn, 2011) and the internal/external frame definition as mentioned in Paragraph 2.1. To recap, Entman's definition is as follows (1993): "…to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to **promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation**" (p. 52)

It is important to denote that with this definition effectiveness is *not* value-free. A person or organisation framing a certain issue has a goal that he, she or it wants to achieve. Framing is used to influence the perception of the receiver towards the perception one wants to give that individual. This can be contested, but in this study the direction of De Bruijn (2011) and Lakoff (2004, 2008) will be followed.

In the case of CCS, e.g., the developing party, Shell, could want to make the perception of local residents on the implementation of CCS in Barendrecht more positive, to create support. The extent to which the frame is able to accomplish this goal can then be seen as its effectiveness. The psychological principle *how* a frame can accomplish this goal is explained in Paragraph 2.1.1 and more extensively by Druckman and Bolsen (2011), who defined how emphasis framing can influence the opinion of a public on a technological solution.

A frame can realize the influence of opinion in two ways: Directly and indirectly. For the measure of effectiveness, both ways are of interest to examine. The direct influence is straightforward: A receiver is directly influenced by the frame, and her/his perception changes. Both Lakoff (2004) and De Bruijn (2011) also discussed the indirect power of a frame, from a very practical perspective. They identified another important goal of frames which both contribute to the above goal, the two aspects they both describe are:

- A frame forces others into using the frame
- A frame sticks

Thus, the extent in which a frame is able to stick, and force receivers to use the frame when discussing the issue in the future can also be seen as a measure of effectiveness, which will be taken into account in the empirical research.

2.3. Factors from literature

2.3.1. General framing literature

A selection of studies on framing effectiveness was analysed to identify which factors could be influential on the effectiveness of framing CCS. As a result, the following longlist of factors (Table 1) was identified as raw output. The factors selected for the empirical research are already marked bold.

Framing factors	Personal characteristics (Receiver)	Personal characteristics (Messenger)
Include (more) values	Gender	Gender
Use of the word Risk vs. Safety (Attribute framed Positively/Negatively)	Age	Age
Risk communication strategies	Knowledge of technology	Emotion
3P-model: Include Person, Policy, Principles	Attitude toward technology	**Independence (credibility)**
Hero/Villain/Victim model	Attitude toward environment	
Goal framed Positively/Negatively (Gain vs. Loss)	Political orientation	
Goal (risks) framed in lives/money/feelings	Values of respondents	
Play with scale effects: Size of problem	Country	**Contextual factors**
Keep options open/be certain	Level of education	Medium
Play with denials	Holistic/Analytic processing method	Background information
Win-Win/Win-Lose/Complete story	Newspaper Reading	Number of frames shown
Ask for actions/feeling/facts	Rational/Experiential decision making method (CEST)	Frame multiple problems
Frame effects as short vs. long term	Openness to alternatives in general	
Let frame solve dilemma	Need for confirmation/Self-confidence	
	Experience with problem	
	Stubbornness	
	Level of income	
	Need for cognition	

Table 1: Longlist of factors from general framing literature

In Appendix A the different sources used to identify these factors are enumerated. For the above factors, the blue headings indicate to which category a factor belongs. The categories are the same as used in the communication matrix as defined by McGuire (2001). The factors that are not self-evident are explained below.

An exception are the factors that were selected for the empirical research, as those factors will be described in depth in Paragraph 2.4. Those factors are as follows:

- Independence of messenger
- Use of the word Risk vs. Safety (Attribute framed Positively/Negatively)
- Risk communication strategies

- Gender
- Age
- Knowledge of technology
- Attitude toward technology
- Attitude toward environment

- Political orientation
- Values of respondents
- Country
- Level of education

Include (more) values
A frame can include several values. These values are for example enumerated by Schwartz (1992) as explained more in depth in Paragraph 2.4.2. The inclusion of certain values, or including more values, can influence the perception of an individual.

3P-model: Include Person, Policy, Principles
The 3P model was presented in De Bruijn (2011, p. 54), and states that a powerful technique to reframe an unwanted frame is to use another level of discussion as your opponent. The three levels De Bruijn (2011) stated are person, policy, principles (values). A frame concerning a certain concrete policy can, for example, be dismantled by taking the discussion to another level: Values.

Hero/Villain/Victim model
Another strong communication method presented by De Bruijn (2011, p. 83) is the hero-villain-victim model. The frame is based on appointing guilt to a certain person, group, or abstract entity. Another party, likely the messenger, is put forward as the hero, thus creating sympathy for a certain vision.

Goal framed Positively/Negatively (Gain vs. Loss)
This factor is one of the three forms of equivalence framing, as described in Paragraph 2.1. For a more detailed description, an explanation is given in Appendix B.2. Briefly, this factor is the variation of emphasizing the advantages or disadvantages of a certain action or policy, such as wearing seatbelts (Levin et al., 1998).

Goal (risks) framed in lives/money/feelings
The goal framing theory can also be expanded to more specific forms of goal framing. In this variation not only negative or positive forms are chosen, but the type of gains/losses is also altered. The greatest difference is seen when monetarized benefits are altered into more vague, emotional benefits, or the other way around.

Play with scale effects: Size of problem
Most problems can be stated as part of a bigger picture, a subset in a larger set. Although the original problem, the subset, is not changed, altering the larger set can on itself affect opinions.

Keep options open/be certain
One can communicate as if all options are already fully determined and a solution is chosen, or one can say that there is possibility for change.

Play with denials
Looking at the title of the book by Lakoff (2004), this principle is appealing. When someone asks a person not to think of a pink elephant, what does that person think of? Denials are often ignored by the brains.

Win-Win/Win-Lose/Complete story

When a solution has advantages and disadvantages one can choose to tell all aspects or only several aspects. This balancing of sides can be accomplished in different gradations, as carried out by De Vries et al. (2015).

Ask for actions/feeling/facts

The way a respondent is asked to react or give an opinion can highly influence that opinion. In this factor, the variation of a question after a frame was presented is meant. When this question is focussed on feelings, for example, frames that apply to feelings are possibly more effective.

Frame effects as short vs. long term

The effects of an action or policy can be stated in the long-term or the short-term.

Let frame solve dilemma

By combining two different values using newly constructed words a dilemma can be solved by a frame. This dilemma solving makes the frame likable for many groups and possibly leads to a more powerful frame. De Bruijn (2011) used Bush as an example by referring to his *compassionate conservatism*.

Newspaper Reading

Whether a person reads a newspaper regularly indicates a certain form of engagement, which has been proven to influence framing effects in several studies.

Openness to alternatives in general

When a person is, in general, more open to alternatives, framing effects could be stronger.

Need for confirmation/self-confidence

Several studies have concluded that a person who is less self-confident is more susceptible to framing.

Experience with problem

When a person has some experience with a certain problem, the frames about that issue are processed differently, which can influence framing effects

Level of income

In some studies, level of income was proven to be an indicator for framing effectiveness.

Medium

Frames are experienced differently when they are presented in different media.

Background information

The amount of background information can influence framing effects.

Number of frames shown

When more frames are shown, the individual frames are experienced differently.

2.3.2. CCS framing literature

The influence of framing on the acceptation of CCS is a subject that is currently heavily under study (Ashworth et al., 2015, gives a good overview of research until 2015). Throughout the world, several research groups are focussing on this subject. In the Netherlands for example, research groups as a sub-part of the CATO-2 project, a national project studying the possibilities of CCS in the Netherlands (CATO, 2015) and at the University of Cambridge in the Cambridge Centre for Carbon Capture and Storage. Both also specifically have identified the public perception of CCS as a specific research theme. For this research, several aspects of these studies are specifically important: The factors studied and the methods. The methods were used to improve the method in this research and are, therefore, implicitly included in Chapter 3. For a selection of studies, the factors under study are shown below, and for literature reviews, factors of interest are denoted. The factors marked in **bold** were already found in the general framing literature analysis.

Study	Research	Results
Ashworth et al. (2006)	Researched previous knowledge/opinion	**Information was most influential on respondents who were yet undecided.**
Ashworth et al. (2010)	Meta-study of literature on CCS (Until 2010)	Factors of interest for study: **Credible source** (NGO) or high profile public figures as source Present CCS not as a single solution **Use different media**
Ashworth et al. (2013)	Meta-study of literature on CCS (Until 2013)	Factors of interest for study: Include local context **Focus on aspects other than risk mitigation** **Trustful source**
Ashworth et al. (2015)	Meta-study of literature on CCS (Until 2015)	Factors of interest for study: Stockage vs. Storage **Trustful messenger** Partner up with NGO Split up in Capture, Transport, and Storage Motivation for promotion (economic vs. environmental)
Bäckstrand et al. (2011)	Meta-study of literature on CCS. (Until 2013)	Factors of interest for study: **Country of origin** Presentation as mythical solution
Brunsting et al. (2011)	Use of a communication matrix (McGuire, 2001) to classify and relate factors from other studies.	Factors of interest for study: **Risk/Benefit focus** Repetition/length/complexity **Socio-demographic variables** And many more Therefore, the overview presented in this study is also included as an output of the literature study itself (Appendix A).
Brunsting et al. (2013a)	Empirical study on the influence of knowledge on CCS attitude.	More knowledge does not lead to a more positive attitude toward CCS. Perceptions are more influential.
Brunsting et al. (2013b)	Empirical study on the influence of visual/textual representation on the estimation of CCS depth	More precise textual descriptions lead to a better estimation of depth amongst respondents who prefer text. Visual representations do not improve estimations. No influence on CCS attitude.
Cuppen et al. (2015)	Study using earlier data towards the use of a goal-rational meta-frame vs. other types	The expectation is that the dominance of the goal-rational frame left some issues undebated and, therefore, created less support for the CCS project in Barendregt. A wider use of frames (more reflexive frames) could benefit creation of support. In addition to framing, institutional factors have to be changed to create support.

Daamen et al. (2006)	Empirical study using traditional questionnaires to test the accurateness of the opinion measure	In traditional questionnaires, especially for complex and new problems, respondents often give only pseudo-opinions, which can be influenced easily and do not give much information on the actual attitude towards a certain issue.
De Vries et al. (2014)	Empirical study on the effect of providing (moderately) irrelevant information and interaction effect with the messenger	Irrelevant information weakened the message, more influential for positive messages than negative. Effect was cancelled out when source of a message was known.
De Vries et al. (2015)	Empirical study of the influence of emphasis framing on the perceived degree an article is manipulative and also on opinion on CCS. Furthermore, interaction effects with a (in)dependent messenger are investigated.	Articles that emphasize one side were perceived as more manipulative. Emphasis framing does influence the opinion on CCS. Manipulation is perceived as more inappropriate when it is carried out by a news agency. A more positive opinion was found in the neutral article, which might be due to the neutral introduction (which was also used in this study).
Feenstra et al. (2010)	Desk research and interviews towards the events in the Barendregt CCS case.	Factors of interest for study: **Trustful messenger** Use of a factual frame (using numbers to cancel arguments) Emphasis on local benefits or context **Direct contact vs. through media**
Koot (2015)	Empirical study on the influence of risk perception, credibility of a messenger, and confidence in the ability to close an opinion on the degree of closed vs. open attitude of a respondent.	A more credible messenger makes respondents more able to achieve a closed opinion. More trust in their capability to achieve cognitive closure has a positive influence on the degree of closed attitude. The perception of risks in a project greatly influences the ability to achieve a closed attitude for respondents.
Mastop et al. (2014)	Empirical study into opinion on CCS, using ICQs	Factors of interest for study: **Age; Gender; Education level** **Difference between regions** **Values of respondents**
Seigo et al. (2011)	Empirical study into the adding of information about monitoring.	Information about the monitoring of the CCS project after implementation does not seem to reassure the respondents. The men in the study were less positive and had a lower acceptance of CCS. No difference was found in the female sample.
Ter Mors et al. (2006)	Empirical study on the influence of trustworthiness and expertise of a messenger.	A more trustworthy messenger with more perceived expertise was more convincing. Both aspects also reinforce each other, so a congruent messenger (both trustworthy and expert) has even more influence.
Terwel et al. (2011)	Literature study on recent experimental research.	Study focusses on the importance of trust and different types of trust.
Terwel & Daamen (2012)	Empirical study on the influence of the project being near respondents and the influence on the attitude towards CCS	Residents that were presented with a frame that placed the CCS **project under their municipality were more concerned about local risks**. However CCS perception is more determined by trust in a government.
Terwel & Ter Mors (2015)	Empirical study in the evaluation of compensation measures	Local government officials have other priorities than citizens when choosing compensation methods. Both groups are fairly well equipped to estimate the other group's priorities.
Zaal et al. (2014)	Empirical study in framing the compensatory measures	When a compensatory measure is framed more in values that have higher importance for people (human lives), that measure is far more likely to be accepted.

Table 2: Literature on CCS Framing analysis

For the factors mentioned in Table 2, above, the factors that are not self-evident are explained below.

Previous Opinion

When a person already has a strong opinion about a different subject, framing effects are different. Frames confirming a vision can be seen as more effective in some cases, and frames contesting a personal vision are more easily discarded.

Credible source (NGO)

See Paragraph 2.3.1

Present CCS amongst other options

When CCS is presented as an option compared to other options the effect of a message can differ.

Use different media

See Paragraph 2.3.1

Use of the word Stockage vs. Storage

As Ashworth et al. (2015) presented, the use of the word stockage instead of storage can influence the opinion of CCS.

Partner up with NGO

A company that wants to carry out a CCS-project could team up with an NGO and communicate together to create credibility.

Split up in Capture, Transport, and Storage

The three phases of CCS can be split and discussed separately, which can influence opinion (Ashworth et al., 2015).

Values incorporated

See Paragraph 2.3.1

Presentation as mythical solution

At the current global regime on climate policy (uncertainty), there is a large body of scepticism for solutions presented as miracles and silver-bullet solutions. Backstrand et al. (2011) stated that this line of communication should be evaded or at least be well thought about.

Risk/Benefit focus

See Paragraph 2.3.1

Repetition/length/complexity

A message on CCS can be varied in different directions. For example, the length can be changed by including (partly) irrelevant information (De Vries, 2014), the message can be repeated or formulated more simply or more complexly.

Use of a factual frame (using numbers to cancel arguments)

See Paragraph 2.3.1

Emphasis on local benefits

An interesting option for CCS is emphasizing local benefits amongst all other factors important in a CCS project.

Values of respondents

See Paragraph 2.3.1

Include monitoring information

Unexpectedly, Seigo et al. (2011) found that including information about monitoring (an extra safety measure) could lead to a lower support for CCS implementation.

Involvement in the CCS-project

The opinion of a respondent is highly affected by the distance a respondent has to the problem. Terwel and Daamen (2011) thoroughly investigated this idea.

Furthermore two aspects from literature on CCS framing have specific relevance for this study:

The occurrence of Pseudo-Opinions

A notion that is influential for this research is the notion that traditional questionnaires are not able to capture an opinion accurately. Daamen et al. (2006) investigated the accurateness of traditional questionnaires on the measurement of opinion. Their research suggests that many respondents answer with pseudo-opinions. A pseudo-opinion does not say much about the respondent's actual opinion on a subject. Koot (2015) expanded this research and provided insight into the factors that influence the degree a respondent was able to make a what she called a closed attitude (whereby an open attitude corresponds more to the pseudo-opinions from Daamen). Most importantly, the ability to achieve cognitive closure influenced ability to achieve a closed attitude. Koot showed that the risks present in an issue and the credibility of the source both influence this ability.

In this research, a traditional questionnaire was used, with many respondents that did not yet have much information on the implementation of CCS. Therefore, the insights Daamen et al. (2006) and Koot (2015) presented are relevant for this study. No actions were taken beforehand to cancel this effect, so the theoretical notion could help with the interpretation of results (see Chapter 6).

Pitfalls for emphasis framing

As discussed briefly above in Table 2, the study of De Vries et al. (2015) provided support for the hypothesis that a pure pro/negative-CCS frame can be perceived as being manipulative. This effect could influence the framing effects, maybe even decrease them.

In this research, emphasis frames were used, only emphasizing advantages or disadvantages. This effect could influence results. Therefore, the emphasis pitfall was considered when the results of this study were analysed.

2.3.3. Shortlist of most promising factors

From the total list, Table 1 and 2, the most promising factors most likely to influence the effectiveness of framing in a sociotechnical context were identified. The factors were selected based on the following criteria:

- Number of studies with proven effect: Specific preference for studies on technical subjects
- Possibility to generalize (the use of specific percentage-related framing factors were discarded because they could not be used in all cases)
- The expectation to have interaction effects with other effects
- Factors that were not researched specifically for CCS had a preference
- Factors that had a practical (policy) applicability were given preference
- Simplicity to measure a factor.

The full analysis and rating on all of the different criteria can be found in Appendix H.

Nine factors were selected to be most relevant to investigate, by scoring the factors on the criteria above. However, because of experimental limits, three of them were selected to test empirically. These experimental limits were the number of expected respondents, because of the needed number of cases per experimental condition, and the objective to keep the survey as short as possible.

The selection of the final three factors was completed by considering the criteria mentioned above, but also specifically focussing on a combination with interesting interaction effects. Below, all nine most promising factors are shown; the factors that were selected are marked bold. Also, as discussed in Paragraph 4.1, the effects could differ per respondent based on several characteristics or other circumstantial factors. The factors controlled for are discussed in the third section of Paragraph 4.1. An overview of all factors considered promising in this research is shown in the Table 3, below.

Most promising factors	Factors to control for
Independence of messenger (credibility)	**Gender**
Use of the word Risk vs. Safety	**Age**
Risk communication strategies	**Knowledge on technology**
Age of messenger	**Attitude towards technology**
Gender of messenger	**Attitude towards environment**
Emotion of messenger	**Political orientation**
Include (more) values	**Values of respondents**
3P-model	**Country**
Hero/Villain/Victim model	**Level of education**
	Holistic/Analytic processing method
	Newspaper Reading

Table 3: Shortlist of factors

2.4. Factors tested in empirical research

2.4.1. Experimental factors and Hypotheses

Positive vs. Negative frames

Based on the general theory of framing as discussed and described in Chong and Druckmann (2007) the general hypothesis in this study is that a positive frame leads to a more positive perception of CCS. Druckman and Bolsen (2011) comprehensibly explained the mechanism behind this process.

Druckman and Bolsen (2011) demonstrated that, in an initial phase, a respondent will probably not have not motivation to form a well-informed opinion and, therefore will rely on gut instinct. Thus, frames presented have the potential to influence opinion, so emphasizing a positive or negative aspects can be effective.

> **Hypothesis 1: A Positive frame leads to a more positive opinion and more support for CCS than a negative frame.**

Independence of messenger (credibility)

Based on (amongst many others) De Vries et al. (2014), Callaghan and Schnell (2009), and Shmeuli (2008), the assumption was made that the independence of the messenger could have strong effects on the strength of framing in the context of a sociotechnical debate. A more independent messenger leads to stronger framing effects in literature. To illustrate, in this study, three types of spokesmen (research design adopted from Druckman, 2001) were used in the variations, as will be explained more in depth in Chapter 3:

- A representative of an environmental agency in the Netherlands (Dependent messenger)
- A CEO of an oil company in the Netherlands (Dependent messenger)
- An energy scientist at a university of technology in the Netherlands (Independent messenger)

The mechanism behind the difference in these actors involves the difference in processing methods of information. Several models exist that describe different thinking styles. A well-known model to describe these thinking styles is the Elaboration Likelihood Model (ELM) (Petty & Cacioppo, 1986), but also the heuristic vs. systematic approach as defined by Chaiken (1980) is a model often used. Because individual differences in preference for a thinking style are important for this research, in this study the Cognitive-Experiential Self-Theory (CEST) model was used. The CEST model describes two methods of thinking: Rational-analytic and experiential-intuitive (Epstein, 1983, 1990, 1993; Shiloh, Salton & Sharabi, 2002). In the first processing method, pros and cons are weighted and a rational decision is made.

In the second processing method, a more intuitive, unconscious decision is made. When assessing an issue, a higher credibility of a messenger can lead to more use of the more intuitive method of processing information and, therefore, increase the possibility for framing effects. A questionable messenger will force respondents more often to critically analyse a statement using the rational thinking style.

Hypothesis 2: An independent messenger leads to a stronger direct framing effect.

Risk communication strategies

As briefly explained in Paragraph 2.2.4, based on the work of Van Eeten (2010) and Noordegraaf-Eelens et al. (2012), three strategies for the explanation of risks can be used, that will be explained below more extensively (explanations adopted freely from Noordegraaf-Eelens et al., 2012):

Calculation

Risk communication strategies that are based upon the principle of calculation deal with the acquisition of knowledge. By knowing exactly the size of the risks, and communicating this risk, a messenger tries to persuade another to (not) accept the risk, by creating understanding of the size of the risk. The question that is continuously discussed is: "How big is a risk?" Therefore, the arguments that will mostly be exchanged in discussions following this strategy will concern the calculation (method) and the size of risks. As discussed earlier, risks can never be estimated precisely by definition, and therefore, discussion is always possible. The acceptance principle behind this strategy can be summarized as follows: A risk is acceptable if the (monetized) advantages outweigh the (monetized) damage of the risks.

Division

Risk communication strategies based upon the principle of division deal with the question of who takes responsibility for the risks. Not only does the division deal with the extent to which certain groups are affected by the firing of the risk, but also the handling that will occur after this risk: Will there be compensation between parties? Who will in the end suffer the losses, and who benefits from the gains? The acceptance principle behind this strategy can be summarized as follows: A risk is acceptable if different risks are divided equally amongst a population.

Acceptation

Risk communication strategies based on the principle of acceptation see the acceptance of risk as a fact of life. A risk is neither calculated nor discussed; it is just accepted. This strategy follows from a certain attitude or identity that a person wants to attain and from the fact that nothing is without risks. People accept risks because then they can keep doing certain things they like. One can argue whether this is a purely rational style of risk acceptance, but it is a style that is seen everywhere, such as not wearing a bike helmet. The principle behind this strategy can be summarized as follows: A risk is acceptable because nothing is without risk, so not accepting means no action at all.

The (psychological) mechanism behind this variable has the most to do with the principle of a frame connecting with an *underlying value* of a respondent. This concept was explained in Feldman and Zaller (1992), who described the relationship between core values and the attitude toward certain policy aspects of citizens. Chong (1996) described how amongst others politicians use this principle to couple values to concrete policies, which is of interest for the case study in this research. A study that is taken as reference for this research is Brewer and Gross (2005); their method of variation is also used as basis for this study.

All studies above vary the *values* more purely than in this research. The three strategies described above and varied in this study do not *solely* vary on a single value or other aspect. Per strategy, several conceptual elements were varied, which makes a pure identification of the source of framing effects harder.

This choice was made because of the practical applicability. The strategies mentioned above can be used in any daily application. Thus, when conclusions are drawn, any party operating in a sociotechnical debate can use these conclusions to better understand the different ways of communicating about risks. Furthermore, the value framing aspects were massively investigated, and conclusions about these aspects can be deduced from literature, as also concluded simply in De Bruijn (2011): Make a frame that incorporates the hearers' core values. However what this advice on frames implies concretely in a sociotechnical debate is not easy to deduce. What are the values of the public? How can one appeal to their core value: Courage, or freedom in a message about the risks of a technical problem? To give more practical insights, the strategies were chosen over the pure variation of core values.

For the direction of this hypothesis the articles of Van Eeten (2010, and Noordegraaf-Eelens et al. (2012) were used. Both propose that the other strategies could be more influential than the original calculation strategy. Therefore in this study their expectation was tested.

> **Hypothesis 3: The division and acceptation strategies will lead to stronger direct framing effects than the calculation strategy.**

Use of the word Risk vs. Safety

From the classical example of Tversky and Khaneman (1981), the use of other words can trigger other parts of the brain. Because safety is more associated with good feelings, perception on a subject will be more positive. This idea also corresponds to the observations from Lakoff and Johnson (1980) regarding identification patterns: When people hear language that gives them certain feelings, the totality of the message is influenced by those feelings.

More concretely in this research, this variable is varied by using the word *risk(s)* in half of the frames used, and the word *safety* in the other half. The effect expected is formulated below in Hypothesis 4.

> **Hypothesis 4: Using the word safety leads to a more positive opinion and more support for CCS than using the word risks.**

2.4.2. Factors controlled for and Hypotheses

In addition to the experimental variables varied in this study, the effects were controlled for nine personal characteristics.

Gender: Amongst others Fagley and Miller (1990, 1997), and Wang et al. (2001) proved there can be a difference in framing effects between men and women. However, for CCS, Mastop et al. (2014) found no difference. Therefore, the effects in this study were also controlled for gender.

Age: Many studies have investigated the effect that older adults are more susceptible to framing effects. A good example is Kim, Goldstein, Hasher and Zacks (2005). This suggestion follows from the fact that older adults tend to use the rational thinking style more often than younger adults. See the explanation on the CEST model, as explained earlier (Hypothesis 2). For CCS, Mastop et al. (2014) already found that older people tend to be more negative towards CCS.

Knowledge on technology: Flachaire and Hollard (2008) studied several aspects that influence the differences in framing effects amongst individuals. One of their findings was that previous knowledge of a problem drastically influenced the possibility of framing effects. This variable also can be used practically by actors acting in a sociotechnical debate, and therefore in this research also the effects were controlled for previous knowledge and a separate hypothesis is specified:

> **Hypothesis 5: Framing effects are stronger when a respondent's knowledge and opinion of CCS are less certain.**

Attitude toward technology: The general attitude toward technology can influence opinion on a specific sociotechnical solution and was, therefore, controlled for. This decision was also based on Druckman and Bolsen (2011), appointing attitude toward technology to play a central role in the forming of an opinion about a new technology. Druckman and Bolsen stated that a more sceptical attitude toward technology influences the way an opinion is formed. Here, the CEST model, as explained earlier (Hypothesis 2), also plays a role. A more sceptical attitude leads to more use of the rational thinking style, making framing harder and thus less effective.

Environmental concern: De Vries et al. (2014) showed that differences in environmental views influence the opinion of respondents on CCS: Respondents with more concerns about the environment seemed to have critical approaches on communication about CCS. Therefore, in this research this aspect is also controlled for with the same scale as used by De Vries.

This scale is a shortened version of the New Ecological Paradigm (NEP) scale, as defined by Dunlap, Liere, Mertig and Jones (2000), and asked the respondents to what extent they thought the following issues were a problem for society: Air pollution and smog; pollution of rivers, lakes and oceans; loss of rain forests and jungles; climate change; and ozone depletion.

Political orientation: From a practical point of view the influence of political orientation on the opinion on CCS, and on the framing effects, can be very relevant, mostly because political orientation can be identified relatively easy in a target audience. Also, knowledge about this aspect can make differentiation in message more effective. In this research, three stances were categorized: Liberal (left-wing), conservative (right-wing) and neutral.

Values of respondents: As discussed in Paragraph 4.2.1, the values of a respondent influence his or her susceptibility to framing effects. Additionally his or her individual values can influence his or her opinion on CCS in general. In this research the 10 values as defined by Schwartz (1992) are used:

- *Power:* The value of power in life
- *Achievement:* The value of achieving goals
- *Hedonism:* The value of enjoying life
- *Stimulation:* The value of an exciting life
- *Self-direction:* The value of freedom to choose direction
- *Universalism:* The value of wisdom and openness
- *Benevolence:* The value of helping others
- *Tradition:* The value of appreciating traditions
- *Conformity:* The value of confirming
- *Security:* The value of a safe life.

Schwartz (2012) also summarized these values in four dimensions shown in Figure 2, below:
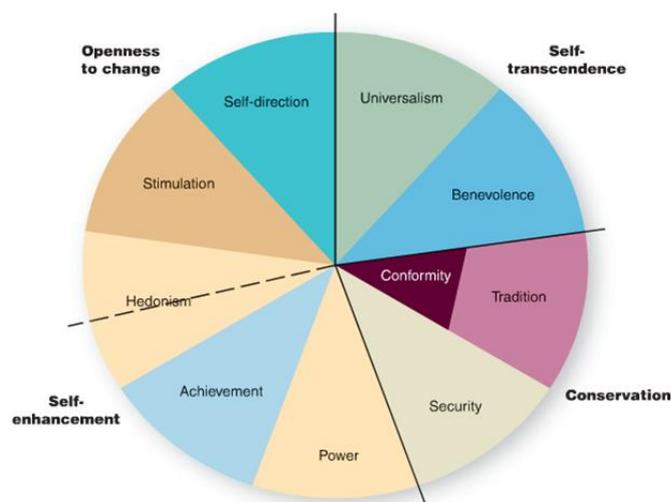
Figure 2: Schwartz value scale visualized. Adapted from FBK (2012)

This categorization provides guidelines as to how certain values can be used to create underlying scales. Mastop et al. (2014) already found indications that the self-transcendence and self-enhancement values interact with opinions regarding CCS. Mastop et al. (2014) showed that the more egoistic, self-enhancement values show a positive correlation with a more positive attitude towards CCS, and the self-transcendence values a negative correlation. Mastop et al. found no other correlations between the other values and attitude toward CCS.

The different strategies for risk communication all have certain underlying principles of risk acceptation. As Van Eeten (2010) stated it is dependent on a person which method is more effective. More specifically, the values of a person often determine which strategy is most effective. In this study, the values of a person are tested with the Schwartz (2012) values. Based on previous notions the following hypothesis is formulated:

Hypothesis 6: The values of a person have an interaction effect with the strategy framing effects.

Country: Reiner et al. (2006) showed that cultural differences influence the opinion on CCS and the formation of this opinion (influence of certain arguments) between four countries: Sweden, the US, the UK and Japan.

Therefore in this research this factor will be controlled for as well. The choice for this variable does relate closely to the possibility to carry out this test, which is given by the fact that survey respondents originated from all over the world, as will be described in Paragraph 4.1.

Level of education: Hiscox (2004) provided evidence that a lower education level could lead to more susceptibility to framing effects. Therefore, in this research, the level of education was also controlled for.

2.4.3. Language repetition Hypotheses

Brewer (2002), Chong (1996), Kinder and Sanders (1996), amongst many others, have all proven that in a successful frame, the vocabulary of the frame will also be used by the respondent. The *internal frame* of a receiver, as mentioned in Paragraph 2.1 is changed by the frame, or as Brewer and Gross (2005) stated: "*The frame is internalized.*" Also De Bruijn (2011) explicitly stated the ability to influence the receivers' language as one of the aspects that makes frames successful. In this research, this is effect is also evaluated for the different frames.

For the varied strategies and factors, specific matching words or aspects were tested to check for this effect in this research. The factors studied were the three different risk communication strategies and the use of the word risk versus safety.

For the use of the word risk versus safety the expected effect was that the word in the frame would be used more by respondents as well.

> **Hypothesis 7a: Frames using the word risk lead to a higher use of the word risk by respondents.**
> **Hypothesis 7b: Frames using the word safety lead to a higher use of the word safety by respondents.**

For the communication strategies, the expected effects were more complex and related to the mechanisms behind every communication strategy. The division communication strategy tries to trigger an acceptation pattern based on a fair or unfair division of risks. The acceptation strategy appeals to an attitude that risks can never be prevented, and the calculate strategy appeals to the assumption that the advantages outweigh the disadvantages (and can be calculated). Therefore, the following hypotheses were formulated:

> **Hypothesis 7c: The framing strategy divide leads to more use of the aspects fair/unfair.**
> **Hypothesis 7d: The framing strategy accept leads to more use of the word accept.**
> **Hypothesis 7e: The framing strategy calculate leads to more use of the word height and the use of numbers.**

2.5. Hypotheses overview

When combining the former Paragraphs into expectations for all variables included in this research the following hypotheses can be formulated:

Hypothesis 1: A positive frame leads to a more positive opinion and more support for CCS than a negative frame.

Hypothesis 2: An independent messenger leads to a stronger direct framing effect.

Hypothesis 3: The division and acceptation strategies will lead to stronger direct framing effects than the calculation strategy.

Hypothesis 4: Using the word safety leads to a more positive opinion and more support for CCS than using the word risks.

Hypothesis 5: Framing effects are stronger when a respondent's knowledge and opinion of CCS are less certain.

Hypothesis 6: The values of a person have an interaction effect with the strategy framing effects.

Hypothesis 7a: Frames using the word risk lead to a higher use of the word risk by respondents.

Hypothesis 7b: Frames using the word safety lead to a higher use of the word safety by respondents.

Hypothesis 7c: The framing strategy divide leads to more use of the aspects fair/unfair.

Hypothesis 7d: The framing strategy accept leads to more use of the word accept.

Hypothesis 7e: The framing strategy calculate leads to more use of the word height and the use of numbers.

These hypotheses can be summarized into the following two (or actually six) conceptual models (Figure 3). In the models, the hypotheses are denoted with the letter H and their corresponding number.
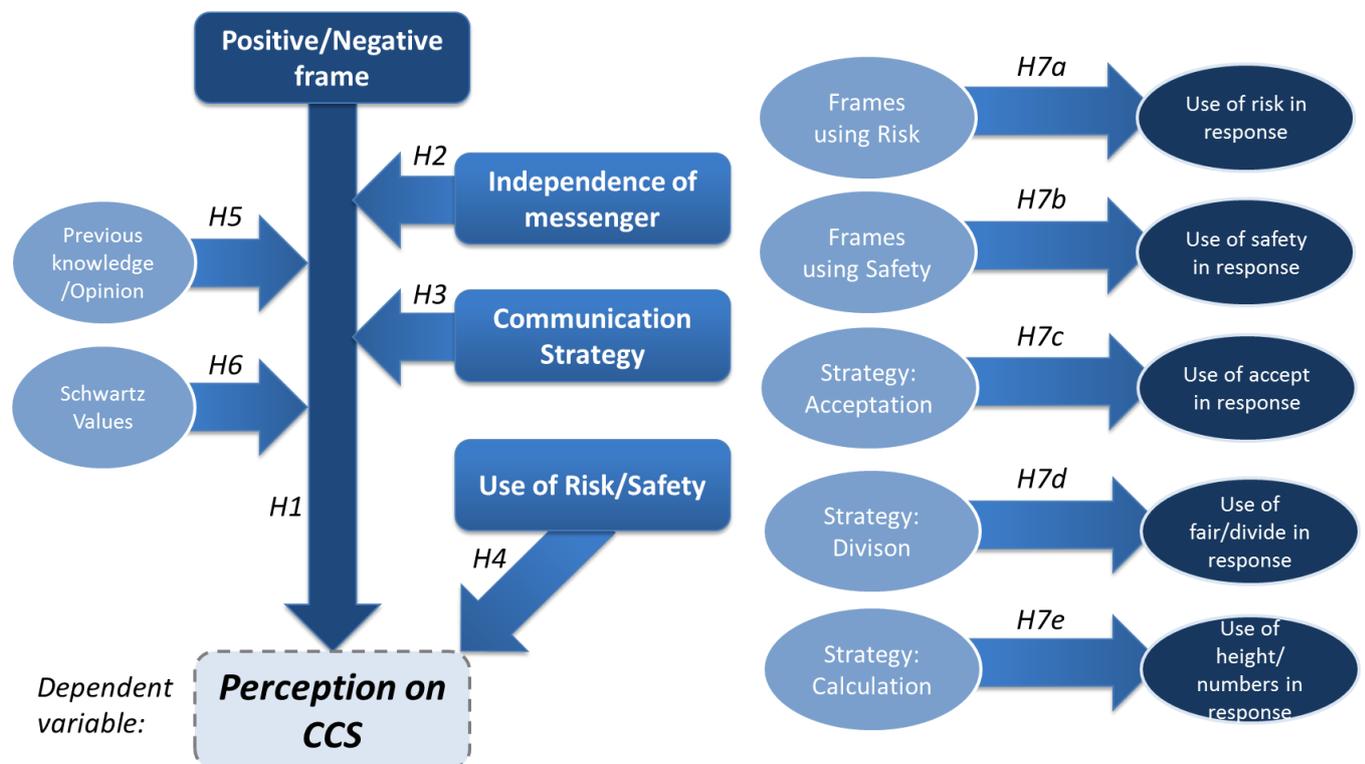
Figure 3: Conceptual models

3. Method for Empirical Research

In this chapter the method that was used for the empirical study is discussed. First in Paragraph 3.1 the participants and the design are discussed. In Paragraph 3.2 the procedure for respondents is explained. In Paragraph 3.3 the stimulus materials are presented and discussed. Paragraph 3.4, 3.5 and 3.6 explain the different measures that were used to test for the effects, first the perception on CCS, second an open question to test for repetition of language and third some manipulation checks. The chapter is concluded by showing the most important variables and their coding, as will also be used in the next chapter. The full questionnaires were included in appendix C and D.

3.1. Participants and design

This research made use of a Massive Online Open Course given by the TU Delft that started at the 20st of April 2015. Originally, a few thousand people subscribed for the MOOC. Eight hundred respondents were used in the final analysis of the results. The discordance of several respondents is discussed in Paragraph 4.1, together with some personal characteristics.

Participants were randomly distributed over the 25 experimental conditions: a 2 (Direction of article: Positive vs. Negative) x 2 (Wording: Risk vs. Safety) x 2 (Messenger: NGO vs. Scientist, Scientist vs. CEO oil company) x 3 (Risk communication strategies: Calculate vs. Divide vs. Accept) + a control group without any frame, full factorial between subjects design. Participants did not receive any reward for their contribution. The disadvantages of using a MOOC are discussed in Chapter 6.

3.2. Procedure

Respondents were not in a controlled setting when taking the two surveys. Participants completed the surveys while following the MOOC used in this study.

In the first week of the MOOC, some personal characteristics of the participants were asked in a pre-survey. The factors that were controlled for in this research, as discussed in Paragraph 4.4.2, were mostly deduced from this first survey. The specific questions used in this survey are shown in Appendix C.

Later in the MOOC, in the second week, the survey for this research was included at the end of a weekly lesson. Participants were automatically shown the questionnaire, but did have the possibility to skip it. The survey was framed as an exercise on framing that had no consequences on grades. The questions used in this survey are shown in Appendix D.

In this survey the following parts were included:

- General introduction and informed consent (as approved by Ethics Commission of TU Delft)

- Questions about personal characteristics (attitude towards technology, environmental concerns)
- An article, including a constructed frame (see next Paragraph)
- Questions about perception on CCS (see measure: Perception of CCS)
- Exercise on CCS Framing (Open questions; see measure: Use of language)
- Manipulation checks: How participants perceived the article (see measure: Manipulation checks)
- Debriefing, thank you, and an option to send feedback.

All respondents took the first and second surveys separately. It was possible for respondents to quit and return to the survey to continue.

3.3. Stimulus materials

Respondents were presented with an article about CCS. No source of the article was mentioned. The article was introduced as follows. The introduction was adopted from De Vries et al. (2014):

CO$_2$ Capture and Storage

Background

In the Netherlands, a lot of energy is used. This energy is mainly produced by fossil fuels such as oil, natural gas, and coal. During the production of energy from fossil fuels carbon dioxide (CO$_2$) is released. International agreements have been made to reduce CO$_2$ emissions. Reduction of CO$_2$ can be achieved in several ways. One of these ways is the implementation of CO$_2$ Capture and Storage technology (CCS). The capture and deep underground storage of CO$_2$ is also considered in the Netherlands.

Should the Netherlands implement it?

<Here one of the frames was inserted, or in the neutral condition left blank (and heading was removed).>

Construction of frames
Frames were created as structured as possible. As a basis, the already mentioned factors were used in a 2x2x3 experimental design. However to investigate the actual framing effects, a positive and negative frame had to be presented (See for an explanation on this necessity Paragraph 6.4). Therefore, the eventual experimental design resulted in a 2x2x2x3 set-up + 1 neutral condition, leading to a total of 25 variations of the created frame. The frames consisted of two parts: An explanation on CCS (De Vries et al., 2014), and an opinion given by John Van der Heijden, a fictitious spokesman.

The frames were created by inserting different options per small section in Excel and then selecting from every option a part for the frame. For the positive frame, this method resulted in the following scheme in Figure 4, read from top to bottom and selecting one option from each row.

Messenger Options:	According to John van der Heijden, CEO of an oil company in the Netherlands: "	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "		
Communication Strategy options:	The <Risks/Safety Number>		Division of advantages & disadvantages is fair amongst regions in the Netherlands, in other regions different civilians have the same issues with	Without
Pure Framing (Risk/Safety)	Safety of CO_2 Capture & Storage is very high with a chance of no leakage of 98%.	Risks of CO_2 Capture & Storage are very low with a chance of leakage of 2%.	Risks/Safety	Risks/Safety
Continuing			of other projects. Here the citizens benefit also from the advantages there.	issues no project could ever be carried out. Development of anything would be impossible.

Figure 4: Positive framing options

See Appendix E for an overview of all different frames that were constructed. One example is as follows:

According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "Division of advantages & disadvantages is fair amongst regions in the Netherlands, in other regions different civilians have the same issues with risks of other projects. Here the citizens benefit also from the advantages there. So CCS should be allowed in the Netherlands.''

3.4. Measure: Perception on CCS

In this research two types of methods were applied to test the effectiveness of frames: A binary choice and a scaling question.

A binary choice (Support)

In the majority of current research, the framing effects are measured with a binary choice question, specifically to test the risky choice difference as described in Paragraph 2.2. A great overview of these kinds of studies can be found in Levin et al. (1998). Some characteristics of this method were described in Rossiter, Dolnicar and Grun (2015):

- The spread is stronger, because respondents are forced to choose, which makes delicate effects more visual but can also exaggerate subtle effects.
- It is fast.

In this research, for the binary choice, three questions were used; first the respondent was asked whether he or she would implement CCS (without mentioning a role). Second, the respondent received two questions (in randomized order to control for order effects) asking whether he or she would implement CCS as a civilian or a national policy maker. This differentiation was carried out to analyse from what perspective a respondent interpreted the choice question.

Another often used method to measure perception on a subject is asking directly for this perception. A Likert-scale is, in this case, easy to use and does not force respondents to take a stand. In this research, a validated scale, from Petty and Cacioppo (1984, p. 73), following De Vries et al. (2014) is used, and respondents were presented with the following four elements that they had to score on a **7**-point scale.

I think the implementation of CCS is: (the first word mentioned labelled as 1, the second as 7)

- Unfavourable to Favourable
- Foolish to Wise
- Bad to Good
- Harmful to Beneficial

For the final variable, the four indicators were combined into one indicator. The Cronbachs alpha for this scale was *0,945*, and therefore, the scale was accepted as reliable.

3.5. Measure: Use of language (Repetition)

Two open questions on elements and frames

The hypotheses based on the repetition of language (Paragraph 2.3.3) were also tested with a dependent variable. Because the questionnaire was given in a MOOC, an exercise was included for respondents in which respondents were given a chance to elaborate on the subject CCS, to make it possible to test for repetition effects. Appendix F shows which words were tested, why and how they were tested.

The open question in this research was based on the study by Brewer and Gross (2005) into framing around school vouchers, in which respondents were also tested on their repetition of certain aspects of a frame (an equality argument for school vouchers). Based on their questions the following two questions are defined:

1. When you think of CO_2 Capture and Storage, what kind of elements do you think about? Please list as many thoughts as you have. Enter your answers in the boxes below. List only one thought in each box. Use as many boxes as you need. Please state your thoughts as concisely as possible; one word is often sufficient

2. Now think of three (or less) frames that can be used in the debate around CCS:

This frame can be used to:

	Promote CCS	Oppose CCS
Frame 1:	◯	◯
Frame 2:	◯	◯
Frame 3:	◯	◯

3.6. Measure: Manipulation checks

The respondent's perceptions on the message were tested with four elements. Respondents were asked to rate items on a 7-point scale with the following question:

In my view the text I have read (a few pages ago) was:

- *Not Manipulative to very Manipulative*
- *Short to Long*
- *Not informative at all to Very informative*
- *Objective to Subjective*

Furthermore a manipulation check was added to check which element the respondents saw as the most influential. This element was retrieved by asking the following question:

The following element was most influential on my opinion on CCS:
- *The messenger (John)*
- *The opinion of the messenger*
- *The safety/risk concerns in general*
- *The height of the risk/safety issues*
- *The division of risks amongst regions*
- *The possibility to carry out any project if there are risks/safety issues*
- *Other: _____*

3.7. Important variables

Based on the operationalization described in this chapter several variables were formed to report respondents' answers. The most important variables were labelled as shown in Table 4, and these labels will also be used when discussing results.

Variable	Label
The direction of the article, either a positive or negative oriented frame.	Direction
The messenger who communicates the frame (John van der Heijden's profession)	Independence
The use of the word safety or the use of the word risk.	Risk/Safety
The strategies for communication: Calculate, Divide, Accept	Communication Strategy
Dependent variables	
The variable depicting the combination of the four Likert scales asking for the perception on CCS	Opinion
The variable describing the binary choice whether respondents would support CCS.	Support

Table 4: Coding of important variables

4. Results

In this chapter the results of the empirical study are presented. First some general statistics are shown to describe the respondents and the data gathered in this study in Paragraph 4.1. In Paragraph 4.2 some checks are presented that were used to test whether respondents perceived the message as expected. In Paragraph 4.3 the results of the test of the hypotheses formulated in this research are discussed, and the hypotheses are discarded or confirmed. Paragraph 4.4 combines all hypotheses into a multiple regression model that was also estimated on the data. Paragraph 4.5 shows an overview of the results in the conceptual model from Chapter 2.

4.1. Descriptive statistics

In this Paragraph some general statistics of the dataset are described.

Cleansing of data and the combination surveys

Originally **1390** people responded to the survey. However, **114** respondents were removed because they did not give permission to use their input for this study. Additionally, **440** respondents had to be removed because they did not complete the survey. Therefore, **836** respondents remained to be analysed. Depending on the type of hypothesis, the **36** respondents that received no frame were excluded as well, such as when comparing different strategies, leading to a dataset of **800** respondents.

When the experimental survey was combined with the personal characteristics pre-survey, **243** respondents showed overlap, and only for these respondents was it possible to couple the datasets. Thus in this chapter, when the personal characteristics are discussed, the total dataset with **243** respondents is meant. When the framing effects without different groups based on personality characteristics were evaluated, wherever possible the experimental dataset with **836/800** respondents was used.

Personal characteristics

The average age of respondents was 39. The youngest respondent was **13**, and the oldest **73**. Of all respondents **63,5%** were males, and **34,9%** were females; **1,7%** did not specify their gender. Respondents from all over the world have completed the survey. This spread over the world is visualised in Figure 5, to the right.

Figure 5: Data on geographical map

The respondents were of mixed education. The different levels of education are shown below, in Table 5, with the corresponding percentages of respondents. The question asked for the highest level of education that was completed by the respondents. The percentages are shown in the Table below.

Level of education	Chosen
Doctorate	*10,4%*
Masters or professional degree	*46,5%*
Bachelor's degree	*28,2%*
Associate's degree	*2,1%*
Secondary / High School	*10,4%*
Junior high / junior high / middle school	*0,4%*
Elementary / primary school	*0,8%*
Other	*1,2%*

Table 5: Levels of education responses

Opinion on CCS

The general opinion about CCS in this response group was quite positive. The average of the opinion was **4,50** with a standard deviation (stdev) of **1,32**. Most respondents had a more moderate opinion. Few respondents showed an outspoken opinion. The following Figure (6) shows the opinion plotted on the certainty of this opinion. Every dot stands for a respondent's opinion.
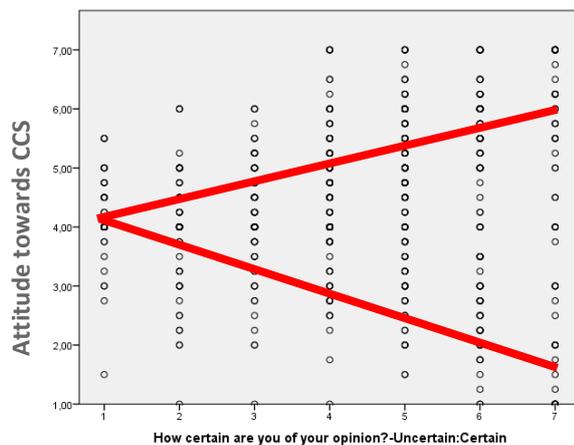
Figure 6: Scatterplot Certainty – Opinion

This figure (6) shows that a stronger opinion is, in many cases, more certain because the opinion tends to be more extreme when certainty is also higher, as illustrated above. This idea is also shown in a measured correlation between the Divergence (as defined by the difference between the average of 4 and opinion) and the certainty of opinion. This correlation was tested at **0,575 (p = 0,03, N = 800)** between the two variables (Divergence and Certainty), this can be interpreted as the idea that when a respondent is more certain of his or her opinion, this opinion is more likely to be more 'extreme'.

In addition to the opinion, the support for CCS was measured as a dichotomous variable (a *Yes/No* choice) as mentioned in Paragraph 3.2.3. This dichotomous measure was carried out over several steps, as already explained. First, a general question was asked regarding the support without specifying a role, then the

question was proposed (in randomized order) from the perspective of a local citizen and from a national policy maker's perspective.

In general, **64,6%** of the respondents supported the implementation of CCS, while **35,4%** did not support the implementation. As a local citizen the support was less, as expected: **53,5%** would accept the implementation of CCS, and **46,5%** would not accept the implementation. As a national policy maker, **63,9%** would implement CCS, and **36,1%** would not implement CCS. Respondents seemed to base their opinions more on the perspective of a national policymaker than on a local citizen. Because the respondents were mostly not involved or living near a CCS-project, this conclusion corresponds to the general expectation, and also corresponds to the findings of Terwel and Daamen (2012), who discovered that initial reactions on a CCS-project were mostly not dominated by NIMBY-like responses (Not In My BackYard). These differences are shown in Figure 7, below.
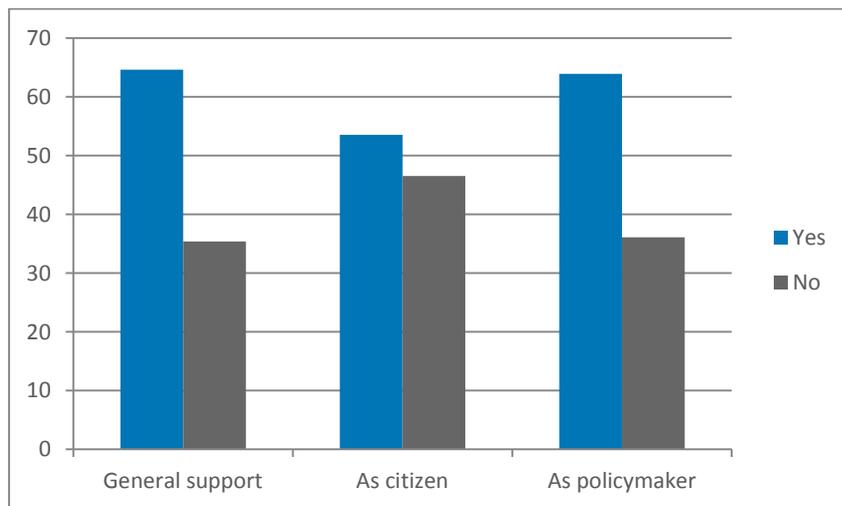
Figure 7: Division of support from perspectives

4.2. Manipulation Checks

To test if the experiment provided reliable information to confirm or disconfirm the formulated hypotheses, some assumptions about how the respondent's perceived the message were tested. These different assumptions are explained, when necessary, below.

- **When no frame was used, the article was perceived as shorter, less manipulative, and more objective.**

To test for the manipulation checks between the groups of respondents that were shown no frame, and the respondents who were shown a frame independent t-tests are used. As will be shown in tables 6 to 8 the groups that are compared do not have an equal size. Only 36 respondents were shown no frame and 800 respondents did receive a frame. This could lead to heteroscedasticity and less usability of the t-test. However the software-program used to analyse data (SPSS) corrected automatically for the unequal sample sizes by calculating the degrees of freedom based on the sample sizes, as described in Ruxton (2006).

Table 6 shows that an article without a frame was perceived as shorter. However, at a 95% confidence level, this difference is not significant. Table 7 and 8 show that respondents perceive the neutral condition (no frame shown) as more objective and less manipulative. However, at a 95% confidence level, only the objectivity was statistically significant when a one-sided t-test was conducted.

	Mean	Std.dev.	Amount (N)
No frame shown	2,03	1,38	36
Frame shown	2,29	1,36	800
	Difference	**T**	**p-value (one-sided)**
t-test	0,25	1,17	*0,121*

Table 6: Perceived article length over frame shown

	Mean	Std.dev.	Amount (N)
No frame shown	4,28	1,81	36
Frame shown	4,52	1,84	800
	Difference	**T**	**p-value (one-sided)**
t-test	0,25	0,784	*0,217*

Table 7: Perceived article manipulation over frame shown

	Mean	Std.dev.	Amount (N)
No frame shown	3,47	1,89	36
Frame shown	4,69	1,89	800
	Difference	**T**	**p-value (one-sided)**
t-test	1,22	3,77	*0,000*

Table 8: Perceived article subjectivity over frame

This analysis shows that the assumption that respondents perceive frames as manipulative and less objective is observed. The fact that the frame makes the test longer is not confirmed with a statistical test when comparing the perceptions of respondents. This could be explained by the fact that both versions of the frame were very short, only a few sentences. An average score of slightly above two supports this assumption.

- **An independent messenger was perceived as less manipulative and more objective.**

Both Tables 9 and 10 show that respondents perceived the independent messenger as more objective and less manipulative. However, at a 95% confidence level, only the perceived manipulation was statistically significant when a one-sided t-test was conducted. This is in line with the expectation, and also lines up with previous research about less biased messengers as discussed in Paragraph 2.4.1.

	Mean	Std.dev.	Amount (N)
Independent messenger (scientist)	4,43	1,88	410
Biased messenger (Oil company, NGO)	4,64	1,80	390
	Difference	T	p-value (one-sided)
t-test	0,22	1,68	*0,047*

Table 9: Perceived article manipulation over independence of messenger

	Mean	Std.dev.	Amount (N)
Independent messenger (scientist)	4,65	1,88	410
Biased messenger (Oil company, NGO)	4,72	1,91	390
	Difference	T	p-value (one-sided)
t-test	0,07	0,52	*0,303*

Table 10: Perceived article subjectivity over independence of messenger

- **The other independent variables (strategy, pure framing) have no effect on the manipulation checks (objectivity, manipulability, length and informative).**

For the strategy variable, an ANOVA test (statistical test to test for differences between more than two groups) was carried out to test for the influence on the four manipulation checks. No significant differences were found for length, objectivity, and level of information. For the perceived manipulation, a significant small difference was found between the Calculation and the Divide strategy. Therefore, when the Division strategy was used, the message was perceived as more manipulative than if the calculation strategy was used. This is shown in Table 11.

Division				P (Post Hoc test Bonferroni[3])	
Strategy	Mean	Std.dev.	N	Divide	Accept
Calculate	4,34	1,85	263	**0,043**	0,977
Divide	4,73	1,89	275	-	0,437
Accept	4,50	1,77	262	-	-
ONEWAY ANOVA: F = 3,05; p = 0,048					

Table 11: Perceived manipulation over Strategies

- **There was a high correlation between support and opinion.**

Table 12, below, clearly shows that the support variable and the opinion variable have a relation. The average between the two groups differs significantly and is also statistically significant at a confidence level of 95% when a one-sided t-test is carried out. Therefore, it can be concluded that the two dependent variables depict, to a large extent, the same underlying attitude, which was assumed in this study.

	Mean	Std.dev.	Amount (N)
Support CCS	5,18	0,94	517
Do not support CCS	3,26	0,97	283
	Difference	**T**	**p-value (one-sided)**
t-test	1,92	27,3	*0,000*

Table 12: Opinion on CSS over the Support for CCS

- **Support is lower as a local citizen than as a national policy maker.**

Because a local citizen will experience the most perceived negative aspects of CCS, when a respondent was forced to answer from this perspective, the expectation was that the attitude towards CCS would be more negative. Terwel and Daamen (2012) explained the principle behind this effect, as discussed in Paragraph 2.2.2.

As shown in Table 13 the support for CCS was indeed higher when the question was answered as a national policy maker. For the discussion on the relationship between own opinion and the other two perspectives, Paragraph 4.1 gives a more extensive analysis. An exact McNemar test[4] was conducted to compare Support from a local perspective and from a national policy maker perspective. A significant difference was found (**p = 0,026**), as was also expected from Table 13.

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[3] A Post Hoc test is used to test for individual differences after an analysis of variances. A Bonferroni test corrects for the Multiple comparisons problem, by dividing the level at which a difference is seen as significant (5% in this study) by the number of comparisons. A Bonferroni test is in general a more conservative test, correcting for Type I errors strongly (Dunn, 1961).
[4] Because the variables are paired a McNemar test was used instead of a chi-square test.

	Support CCS	
	Yes	*No*
As local citizen	53,5%	46,5%
As national policy maker	63,9%	36,1%

Table 13: Support as citizen and national policy maker (N=800)

- **Political stance has a correlation with the corresponding values.**

A political stance is mostly formulated based on worldview and principal values. Therefore, a relation was expected between different political stances and values. For each value, therefore, an ANOVA was carried out to find differences per political stance.

For most values, no statistically significant differences per political stance were found. For the following variables, differences were observed: Universalism, Tradition, and Security. The results of the relevant ANOVA's are shown below (Tables 14, 15 and 16). These analyses show that liberal (left-wing) respondents scored, on average, higher on universalism and lower on security and tradition. More conservative (right-wing) respondents scored lower on universalism. When a series of t-tests was carried out to investigate the differences between conservative and liberal respondents, the same conclusions were drawn. However, the value conformism also showed a significant difference at a 95% confidence level, as shown in the t-test report below (Table 17).

Division				P (Post Hoc test Bonferroni)		
Political stance	Mean	Std.dev.	N	Conservative	Neutral	No answer
Liberal (left-wing)	2,97	0,87	105	**0,038**	1,000	**0,043**
Conservative (right-wing)	2,38	1,06	24	-	**0,011**	1,000
Neutral	3,07	0,91	81	-	-	**0,011**
No answer	2,45	1,23	33	-	-	-
ONEWAY ANOVA: F = 5,85; p = 0,001						

Table 14: Universalism over political stances (ANOVA)

Division				P (Post Hoc test Bonferroni)		
Political stance	Mean	Std.dev.	N	Conservative	Neutral	No answer
Liberal (left-wing)	1,75	0,98	105	0,107	**0,042**	1,000
Conservative (right-wing)	2,33	1,20	24	-	1,000	1,000
Neutral	2,19	1,07	81	-	-	1,000
No answer	2,00	1,28	33	-	-	-
ONEWAY ANOVA: F = 3,40; p = 0,018						

Table 15: Security over political stances (ANOVA)

Division				P (Post Hoc test Bonferroni)		
Political stance	Mean	Std.dev.	N	Conservative	Neutral	No answer
Liberal (left-wing)	1,48	0,95	105	0,355	**0,005**	1,000
Conservative (right-wing)	1,96	1,04	24	-	1,000	1,000
Neutral	2,04	1,28	81	-	-	0,289
No answer	1,58	1,28	33	-	-	-
ONEWAY ANOVA: F = 4,332; p = 0,005						

Table 16: Tradition over political stances (ANOVA)

	Mean	Std.dev.	Amount (N)
Liberal (left-wing)	1,50	,99	105
Conservative (right-wing)	2,04	1,37	24
	Difference	T	p-value (one-sided)
t-test	0,55	2,26	*0,013*

Table 17: Conformism over political stance

- **Environmental concerns correlates with the value benevolence.**

The environmental concerns and the value of benevolence correlates by 0,137 (p = 0,032; N = 243) so a weak but significant correlation was found for these variables.

4.3. Tests of hypotheses

In Chapter 3, twelve hypotheses were defined that will be discussed in this section. Per hypothesis the statistical test used is described with the most important indicators following from the test. Relevant figures are shown to illustrate and enhance understanding. When a hypothesis is marked as *unconfirmed,* this research was not able to confirm the hypothesis. Therefore, either the data showed the opposite of the hypothesis or it was not possible to carry out the right analysis (because other effects were not significant e.g.).

Hypothesis 1: A Positive frame leads to a more positive opinion and more support for CCS than a negative frame. [Unconfirmed]

To test the difference on the opinion scale a t-test was used. The results are shown below in Table 18. As shown in Table 18 no significant difference in opinion was found for the opinion scale. This means that the average of the opinion of the group of respondents who received a positive frame was not higher than the average of opinions of respondents who received a negative frame. From this test the conclusion can be drawn that the frames had no direct effect on opinion.

	Mean	Std.dev.	Amount (N)
Positive	4,49	1,35	394
Negative	4,51	1,30	406
	Difference	**T**	**p-value (one-sided)**
t-test	0,02	0,25	*0,403*

Table 18: Opinion over Positive/Negative Frames

Also, the support variable was tested with a chi-square test; of which the results are shown in Table 19, below. As shown in this table, no significant difference was found for the positive and negative frames. This means that also for the support variable seems to have no effect.

	Support		Amount (N)
Direction	Yes	No	(=100%)
Positive	62,7%	37,3%	394
Negative	66,5%	33,5%	406
Chi^2 = 1,271; df = 1; p = 0,260			

Table 19: Support over Positive/Negative frames

Hypothesis 2: An independent messenger leads to a stronger direct framing effect. [With much caution: Confirmed]

To test the difference on the opinion scale, an ANOVA was carried out on the different interaction groups. The results are shown below in Table 20. As shown in this table, there was no difference for the independent messenger when analysing opinion on CCS.

Division				P (Post Hoc test Bonferroni)		
Independence/Direction	Mean	Std.dev.	N	Conservative	Neutral	No answer
Biased x Negative	4,56	1,32839	205	1,000	1,000	1,000
Unbiased x Negative	4,47	1,26640	201	-	1,000	1,000
Biased x Positive	4,48	1,30099	185	-	-	1,000
Unbiased x Positive	4,49	1,38793	209	-	-	-
ONEWAY ANOVA: F = 0,183; p = 0,908						

Table 20: Opinion over independent interaction (ANOVA)

For the support variable, a chi-square test was executed. A small difference was found, as shown in Table 21, but was not significant, so a first indication that an independent messenger could influence framing effects was distracted from this analysis.

Independence x Direction	Support		Amount (N)
	Yes	No	(=100%)
Biased x Negative	63,9%	36,1%	205
Unbiased x Negative	61,2%	38,8%	201
Biased x Positive	64,3%	35,7%	185
Unbiased x Positive	69,2%	30,8%	209
Chi^2 = 2,903; df = 3; p = $0,407$			

Table 21: Support over independent interaction

When a specific chi-square test was carried out to compare the unbiased groups the following results, shown in Table 22, were acquired. The tests strengthen the indication that an independent messenger creates a framing effect.

Independence x Direction	Support		Amount (N)
	Yes	No	(=100%)
Unbiased x Negative	61,2%	38,8%	201
Unbiased x Positive	69,2%	30,8%	209
Chi^2 = 2,823; df = 1; p = $0,047$			

Table 22: Support over independent interaction (chi-square test)

So although initial analysis showed no significant difference between the four groups, further analysis showed that, with caution, the following conclusion could be drawn in this study: When an independent messenger tells the message a framing effect is in place, but this is not the case when a dependent messenger is communicating. This could mean two things: The biased messenger cancels the framing effect, or framing is only possible as an unbiased messenger (although these interpretations have the same practical implications). Because the direct framing effects were not found to be significant in this study it is hard to draw hard conclusions on which explanation is most likely, based on this study, however it does point towards the second interpretation, framing only works with an independent messenger.

Hypothesis 3: The division and acceptation strategies will lead to stronger direct framing effects than the calculation strategy. [Unconfirmed]

For this hypothesis, the fact that the direct effect of the frame itself (positive/negative) is not significant lowers the possibility of finding a significant difference here as well. Still, there is a possibility that the indirect effect is present, as shown above for the independent messenger. Therefore for the opinion variable an ANOVA is carried out. As shown Table 23, no significant differences were found for the six groups. The conclusion can be drawn that the strategies do not lead to a framing effect.

Strategy x Direction			
	Mean	Std.dev.	N
Calculate x Negative	4,53	1,24	132
Divide x Negative	4,55	1,39	140
Accept x Negative	4,45	1,26	134
Calculate x Positive	4,58	1,43	131
Divide x Positive	4,44	1,41	135
Accept x Positive	4,44	1,18	128
ONEWAY ANOVA: F = 0,313; p = 0,906			

Table 23: Opinion over strategies (ANOVA)

For the support variable a chi-square test was carried out, which is shown below in Table 24. The expected effect was also not found when the support variable was used for the measurement; no significant difference was found so the hypothesis was unconfirmed.

Strategy x Direction	Support		Amount (N)
	Yes	No	(=100%)
Calculate x Negative	67,4%	32,6%	132
Divide x Negative	70,0%	30,0%	140
Accept x Negative	61,9%	38,1%	134
Calculate x Positive	62,6%	37,4%	131
Divide x Positive	61,5%	38,5%	135
Accept x Positive	64,1%	35,9%	128
Chi^2 = 3,481; df = 5; p = 0,626			

Table 24: Support over strategies

Hypothesis 4: Using the word safety leads to a more positive opinion and more support for CCS than using the word risks. [Unconfirmed]

To test the difference on the opinion scale of the usage of the word risk vs. safety a t-test was used. As shown in Table 25, no difference in opinion was found for the opinion scale. The frames using risks even seemed to score higher. This means that the expected effect cannot be confirmed, and can lead to questions if the hypothesis should even be reversed, based on the finding of De Vries et al. (2014) on the emphasis pitfall, as will be discussed in Paragraph 7.1.

	Mean	Std.dev.	Amount (N)
Risks	4,57	1,29	392
Safety	4,43	1,35	408
	Difference	T	p-value (one-sided)
t-test	0,14	1,48	*0,070*

Table 25: Opinion over Safety/Risks Frames

Besides the opinion variable, the support variable was tested with a chi-square test. As shown in Table 26, no significant difference was found for the usage of the word risk or safety on the support variable so the hypothesis was unconfirmed.

Risk/Safety usage	Support		Amount (N)
	Yes	No	(=100%)
Risks	67,3%	32,7%	392
Safety	62,0%	38,0%	408
Chi^2 = 2,491; df = 1; p = 0,114			

Table 26: Support over Safety/Risks Frames

Hypothesis 5: Framing effects are stronger when respondent's knowledge and opinion of CCS are less certain. [Unconfirmed]

To test the influence of knowledge and opinion, two new variables were formed that showed the interaction effect (Positive/Negative x Previous Knowledge and Positive/Negative x Previous Opinion). The number before knowledge or opinion denotes the score on this variable. These variables were then tested with an ANOVA. The results are shown below in Table 27 and 28.

Division			
Interaction knowledge/Direction	*Mean*	*Std.dev.*	*N*
Negative x 7 knowledge	6,25	0,54	4
Negative x 6 knowledge	4,45	1,62	25
Negative x 5 knowledge	4,22	1,58	46
Negative x 4 knowledge	4,94	1,36	50
Negative x 3 knowledge	4,65	1,02	44
Negative x 2 knowledge	4,30	1,10	86
Negative x 1 knowledge	4,50	1,26	151
Positive x 1 knowledge	4,46	1,29	146
Positive x 2 knowledge	4,65	1,05	63
Positive x 3 knowledge	4,13	1,32	49
Positive x 4 knowledge	4,55	1,41	69
Positive x 5 knowledge	4,73	1,40	41
Positive x 6 knowledge	4,45	1,81	19
Positive x 7 knowledge	4,11	2,38	7
ONEWAY ANOVA: F = 1,864; p = 0,031			

Table 27: Opinion on previous knowledge (ANOVA)

Division			
Interaction Opinion/Direction	Mean	Std.dev.	N
Negative x 7 opinion	4,94	1,91	20
Negative x 6 opinion	4,27	1,58	32
Negative x 5 opinion	4,77	1,40	56
Negative x 4 opinion	4,65	1,30	53
Negative x 3 opinion	4,70	1,21	37
Negative x 2 opinion	4,21	,97	61
Negative x 1 opinion	4,44	1,20	147
Positive x 1 opinion	4,29	1,29	132
Positive x 2 opinion	4,65	,98	64
Positive x 3 opinion	4,46	,87	43
Positive x 4 opinion	4,81	1,23	60
Positive x 5 opinion	4,92	1,34	48
Positive x 6 opinion	4,05	1,95	30
Positive x 7 opinion	3,88	2,32	17
ONEWAY ANOVA: F = 4,332; p = 0,005			

Table 28: Opinion on previous opinion (ANOVA)

Because both ANOVA showed significant differences between groups a post-hoc Bonferroni was also carried out. For both variables, no groups were found that differed (almost) significantly. The hypothesis was therefore unconfirmed. This means that also when the framing effect is controlled for a more or less certain opinion no framing effects were observed.

Hypothesis 6: The values of a person have an interaction effect with the strategy framing effects.

To test for the interaction effects between strategies and the values several limitations are in place. First the direct effects have to be corrected for. When for example the value of power has a positive direct effect on the opinion of a respondent on CCS this has to be taken into account. Also the fact that original framing effects of the article are not in place lowers the chance of finding an interaction effect, because frames in general do not seem to influence opinion as expected. Third because the combined dataset exists of only 243 respondents, individual groups with a certain score on a value and a certain strategy are in some cases small. This is especially the case for outspoken categories of the values.

To test for the different strategies the dataset was divided into three different subsets, each containing the respondents that received a frame based on a certain communication strategy. In this different datasets a general linear model was estimated, containing direct effects of all values, and also the direct effect of the strategies. More importantly the interaction effects between the strategy and the values were included.

The model was not found to be significant for the acceptation and the calculation strategies, and the interaction effects were especially low. No interaction with values is therefore found in this study for the acceptation and the calculation strategies. For the Division strategy the model was found to be almost significant ($p = 0,053$). Upon further analysis this was mostly explained by the direct effects of the values. No interaction effects were found to be significant. The hypothesis was therefore unconfirmed.

Hypothesis 7a: Frames using the word risk lead to a higher use of the word risk by respondents. [Unconfirmed]

A t-test was carried out to compare the group with the risk frame to the group with the safety frame on the usage of any sentence or word containing "risk." Results are shown below in Table 30.

	Mean	Std.dev.	Amount (N)
Safety	0,20	0,51	408
Risks	0,20	0,53	392
	Difference	**T**	**p-value (one-sided)**
t-test	0,01	0,19	*0,424*

Table 29: Use of word risks over risk/safety frames

No significant difference was found so the hypothesis was unconfirmed. Based on this test the conclusion could not be drawn that respondents who received the risk-based frames used the word risk more.

Hypothesis 7b: Frames using the word safety lead to a higher use of the word safety by respondents.
[Unconfirmed]

A t-test was carried out to compare the group with the safety frame to the group with the risk frame on the usage of any sentence or word containing "safe." Results are shown below in Table 31.

	Mean	Std.dev.	Amount (N)
Safety	0,29	,60	408
Risks	0,28	,63	392
	Difference	**T**	**p-value (one-sided)**
t-test	0,01		*0,421*

Table 30: Use of word safety over risk/safety frames

No significant difference was found so the hypothesis was unconfirmed. Based on this test the conclusion could not be drawn that respondents who received the safety-based frames used the word safety more.

Hypothesis 7c: The framing strategy divide leads to more use of the aspects fair/unfair.
[Unconfirmed]

An ANOVA was carried out to compare the group with the division strategy frame to the group with the other frames on the usage of any sentence or word containing "fair," "divi," or "people." Results are shown below in Table 32.

Strategy				P (Post Hoc test Bonferroni)	
	Mean	Std.dev.	N	Divide	Accept
Calculate	,00	,06	263	0,283	1,000
Divide	,02	,13	275	-	0,659
Accept	,01	,09	262	-	-
ONEWAY ANOVA: F = 1,514; p = 0,221					

Table 31: Use of fair/divi/people over strategies (ANOVA)

No significant difference was found, so the hypothesis was unconfirmed. Based on this test the conclusion could not be drawn that respondents who received a frame with the division strategy used the aspects dealing with fairness more.

Hypothesis 7d: The framing strategy accept leads to more use of the word accept. [Unconfirmed]

An ANOVA was carried out to compare the group with the acceptation strategy frame to the groups with the other frames on the usage of any sentence or word containing "accept," or "impossible." Results are shown in Table 33.

Division				P (Post Hoc test Bonferroni)	
Strategy	Mean	Std.dev.	N	Divide	Accept
Calcute	0,02	0,12	263	1,000	1,000
Divide	0,01	0,12	275	-	1,000
Accept	0,01	0,11	262	-	-
ONEWAY ANOVA: F = 0,078; p = 0,925					

Table 32: Use of accept/impossible over strategies (ANOVA)

No significant difference was found, so the hypothesis was unconfirmed. Based on this test the conclusion could not be drawn that respondents who received a frame with the acceptation strategy used the aspects dealing with acceptation more.

Hypothesis 7e: The framing strategy calculate leads to more use of the word height/low and the use of numbers or percentages. [Confirmed]

An ANOVA was carried out to compare the group with the calculation strategy frame to the groups with the other strategies frame on the usage of any sentence or word containing "high," "low," "height," "1," "9" or "%." The results are shown below in Table 34.

Division				P (Post Hoc test Bonferroni)	
Strategy	Mean	Std.dev.	N	Divide	Accept
Calculate	0,16	0,64	263	**0,033**	**0,004**
Divide	0,07	0,43	275	-	0,449
Accept	0,04	0,27	262	-	-
ONEWAY ANOVA: F = 4,392; p = 0,013					

Table 33: Use of height-related words over strategies (ANOVA)

The ANOVA shows a difference between the different strategies when evaluating calculation-based language. Upon further investigation with a Post Hoc Bonferroni test the difference was found between the calculation strategy and the two other strategies. Therefore, the hypothesis was **confirmed**.

4.3.1. Other findings on CCS opinion.

For all personal characteristics also the direct influence on the opinion on CCS was tested. Here only the two significant effects will be discussed: Influence of values, as defined by Schwartz (1992), and the influence of age.

To test the influence on several values on the perception variable the correlations were investigated. The results of this analysis are shown below in Table 35.

		POWER	ACHIEVEMENT	HEDONISM	STIMULATION	SELFDIRECTION
Opinion	Pearson Correlation	**,160**[*]	**,196**[**]	**,244**[**]	,105	,042
	p-value	*,013*	*,002*	*,000*	*,101*	*,511*
		UNIVERSALISM	BENEVOLENCE	TRADITION	CONFORMITY	SECURITY
Opinion	Pearson Correlation	-,051	**-,142**[*]	-,072	-,002	-,007
	p-value	*,426*	*,027*	*,260*	*,980*	*,917*
**. Correlation is significant at the 0.01 level (2-tailed).						
*. Correlation is significant at the 0.05 level (2-tailed).						

Table 34: Correlation of values and perception (N = 243)

This analysis shows that people who value power, achievement and hedonism more are more likely to be positive about CO_2 Capture and Storage. Respondents who scored higher on the value benevolence were less likely to be positive about CCS. However, the correlations between these values are weak.

Mastop et al. (2014) already found indications that the self-transcendence and self-enhancement values interact with opinions regarding CCS, as explained in Paragraph 2.4.2. Mastop et al. (2014) showed that the more egoistic, self-enhancement values show a positive correlation with a more positive attitude towards CCS. These findings are in line with our findings and are supported by this research. The self-transcendence values have a negative correlation in the research of Mastop et al. This is reflected in this research, as the negative correlation of benevolence with the opinion on CCS. To fully compare the studies the classification used by Mastop et al. can also be applied to the data-set in this research. This could be carried out when a more accurate comparison is desired, it was not conducted for this thesis.

In addition to the values, one other aspect proved to have significant influence on the perception on CCS: Age of respondents. The correlation was significant at -0,202 (p = 0,002; N = 236), so a weak correlation was found. Therefore older people are more likely to be negative about CO_2 Capture and Storage, but the effect is not very strong. Stephens, Bielicki and Rand (2009) have also found this effect. In their findings especially young high educated respondents were more positive about CCS. Ha-Duong, Nadaï, and Campos (2009) have also found the same results specifically for France.

4.4. Multiple regression model

In addition to the individual tests, a multiple regression model was estimated, as this should show effects and controls for other interaction effects. In this case, many interaction effects would have (in theory) a high correlation with the original variables, which could cause multicollinearity (Farrar & Glauber, 1967). However, this multicollinearity does not lower the reliability of the estimation on prediction values of the model. Only the effects per variable may vary. As shown in Table 36, no further analysis (e.g. as mean-centring variables) is needed, because none of the regression coefficients were significant.

	Coefficient	p-value
Direction	,151	,338
Direction x Independence messenger	-,023	,616
Direction x Strategy	-,058	,311
Risk/Safety usage	-,070	,135
R²	0,004	

Table 35: Regression model for main effects on opinion

This regression model (Table 36) shows that the variables tested have no significant prediction value when predicting Opinion on CCS. Therefore, the conclusions that were drawn when testing the different hypotheses separately were enforced.

4.5. Summary of results

The previous paragraph of this chapter can be summarized in Figure 8, by marking the effects that were significantly confirmed green and the other effects red.
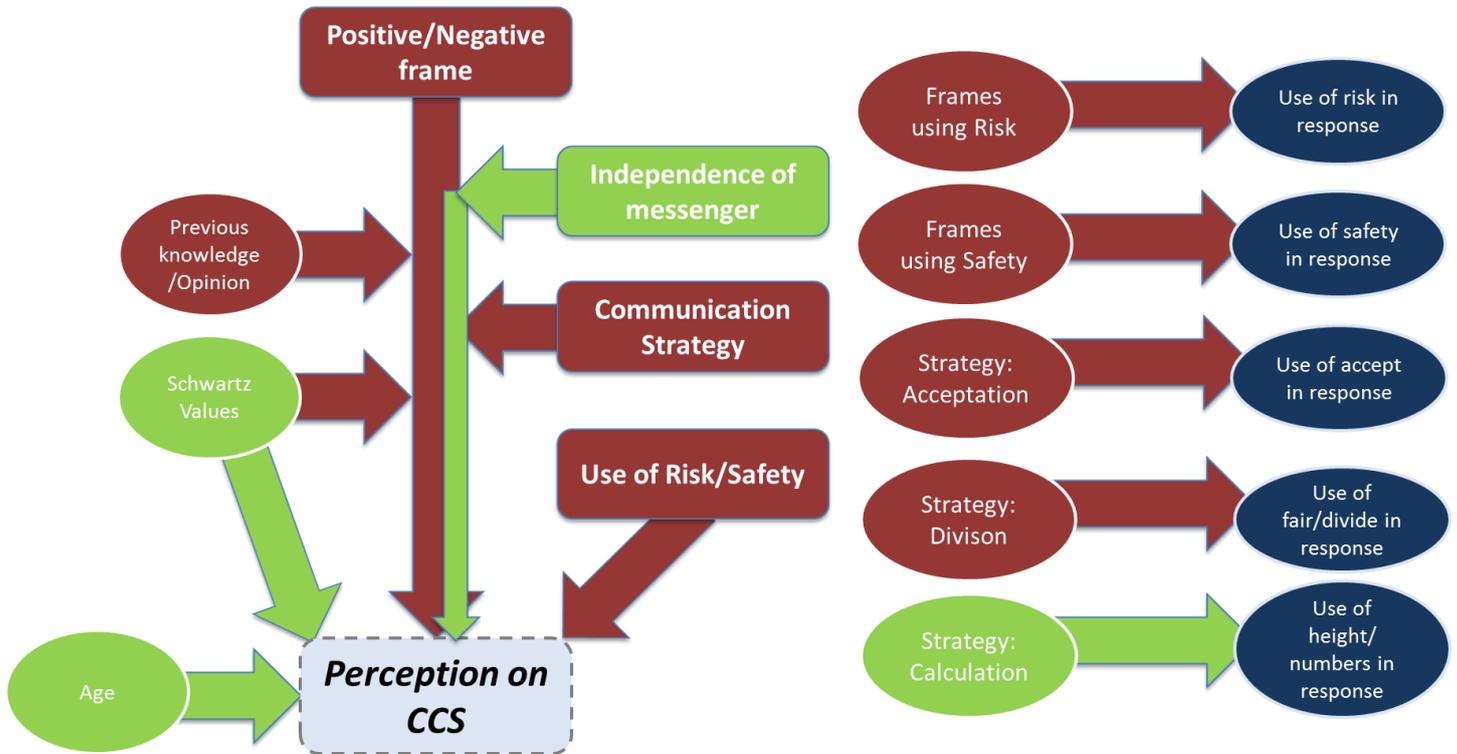

Figure 8: Confirmed hypotheses

As shown with the four green connections, four statistically significant effects were found:

- The influence of age on CCS Opinion
- The influence of certain Schwartz values on opinion
- The influence of an independent messenger on framing effects
- The effect on language use of the calculation communication strategy

5. Conclusions

The implementation of CO_2 Capture and Storage in the Netherlands is a heavy debated subject. In the different debates actors can benefit from knowledge of the influence of their specific communication messages on the opinion of their receivers. The theory of framing can help these actors understand why certain messages are more effective than others. Framing is specifically relevant when discussing risks, because uncertainty is per definition big around risks. For this thesis a study was therefore carried out to *"provide insight in the factors that are most influential on the effectiveness of framing of risks of sociotechnical projects."*

The added value of this research consisted of researching new factors for CCS, in comparison (multiple factors at once), for factors that are practical-oriented. These factored were tested by presenting around **1.400** participants of a MOOC with **25** carefully constructed different frames and asking several questions in a survey to test for their effectiveness and to control for other influences.

In this chapter the main research question of this study is answered. First in Paragraph 5.1 the research questions will be answered, second in Paragraph 5.2 other conclusions that were formulated in this research will be presented.

5.1. Answers to research questions

The main question in this research to be answered was as follows:

"What factor(s) are most influential on the effectiveness of risk framing in sociotechnical projects?

To answer this question four sub-questions were answered.

1. *What is "effectiveness" of a frame, and how can this be measured?*

In this research, effectiveness is seen as the extent to which a frame is able to influence the perception of a receiver in the desired direction. This desired direction is always subjective and depends per actor. Furthermore, a strong frame can achieve this goal, also indirectly, by being remembered longer and forcing receivers to use the frame. Therefore, both these aspects are also used as indicators for effectiveness.

2. *What factors can influence the effectiveness of framing risks in sociotechnical projects based on existing literature?*

In this research, a longlist of factors from different schools of literature was created. This longlist can be found in Paragraph 2.2.1. From this longlist a shortlist was composed consisting of nine variables of interest for an empirical study:

- **Independence of messenger (credibility)**
- **Use of the word Risk vs. Safety**
- **Risk communication strategies**
- Age of messenger
- Gender of messenger
- Emotion of messenger
- Include (more) values
- 3P-model
- Hero/Villain/Victim model

3. *What factors are most likely to be influential on framing in risk communication around sociotechnical projects, based on existing literature?*

From the factors identified for question two, three factors were selected for the empirical study in this research. These factors are marked in bold in the list above.

4. *To what extent do tested factors influence framing success?*

The empirical study provided some unexpected results. The direct framing effect (positive frames vs. negative frames) was not observed. This absence of a direct framing effect made the confirmation of many hypotheses harder. Therefore, most of the hypotheses formed regarding the most promising success factors were not confirmed and no factor(s) was found to be more effective than others. In the next chapter, some explanations of why the direct framing effects were not present will be discussed. The main question proposed in this research is, therefore, not completely answered. However some notions can be deduced from the empirical study:

- An indication was found that the independence of a messenger leads to stronger framing effects.
- A calculation-based strategy leads to more use of calculative-based language by respondents
  - o The question arises to what extent this information is useful for actors. Arguments used in a calculated, rational-based discussion do not incorporate all aspects of a discussion (Cuppen et al., 2015); possibly ignoring part of the intended public, even decreasing local support.

Both notions can be useful when deciding how to communicate about CCS

5.2. Other conclusions

From an analysis of the influence of personal characteristics, two interesting conclusions can be drawn:

- People who value power, achievement and hedonism more, are more likely to be positive about CO_2 Capture and Storage. Respondents who scored higher on the value benevolence are less likely to be positive about CCS.
- Older people are more likely to be negative about CO_2 Capture and Storage.

Both notions can be used to better estimate the opinion on CCS, based on group characteristics.

6. Discussion/Limitations

In this study the most interesting result is that the direct framing effect was not present. Three categories of possible explanations can be formulated: The framing effect does not exist, the framing effect was not stimulated strongly enough in this study, or the effects were in place but not visible in the measurements. These three categories are discussed in the first three Paragraphs of this chapter: 6.1, 6.2 and 6.3. In Paragraph 6.4 the aspects of using a **MOOC** as a data-collection method are discussed, and in the last Paragraph 6.5 some limitations for the expansion of the results of this study are given.

6.1. Theoretical explanations

Several explanations from literature can explain the fact that the framing effects were not observed in this study. Most promising is the effect that was observed by De Vries et al. (2014): Placing emphasis on only one side of the problem may cause respondents to distrust the message and perceive it as manipulative.
In this study, this effect was observed in the manipulation check in Paragraph 4.2, and it is therefore a likely explanation that could explain the results. This assumption is supported by the fact that for the hypothesis on risk vs. safety (safety leads to more support for CCS) the observed effect is seen in the opposite direction of the hypothesis, using the word safety creates less support for CCS, which can be explained by the effect found by De Vries et al. (2014), in some way the message can be perceived as more insincere, which is, however, not observed in the manipulation checks.

As discussed in Paragraph 2.3.2 the concept of pseudo-opinions, as presented by Daamen et al. (2006) and expanded further by Koot (2015), could also give an explanation for the opinions not varying much. Respondents were forced in the survey to answer quickly and, therefore, presented their pseudo-opinion, which was, in this case, so fresh they selected the more average opinions (4 on a 7-point scale). This assumption is supported by the fact that a high peak in average opinions was seen, as discussed in Paragraph 4.1. This assumption on pseudo-opinions is also supported in another way empirically with this study, namely by the correlation between certainty and a more 'extreme' opinion as was shown in Paragraph 4.1 (Figure 7). It could have been possible to correct for this effect, however after filtering out the more average opinions not enough respondents remained in the dataset to test for the different variables.
Also expanding on this notion, the support for CCS variable was measured from three perspectives: Personal opinion, as a local citizen and as a national policy maker. The results are shown below in Table 37.

Support	Own perspective	Local citizen perspective	National policy maker perspective
Yes	64,6%	53,5%	63,9%
No	35,4%	46,5%	36,1%

Table 36: Different perspectives on CCS support

As shown in Table 37, the personal perspective aligns strongly with the perspective of a national policy maker, which leads to the assumption that, in this research, respondents did not answer the support question from their own perspective but tried to make a neutral evaluation of the decision. This neutral evaluation would lead

to more usage of the rational-analytic thinking style instead of the experiential-intuitive thinking style as described in Epstein (1983), and earlier discussed in Paragraph 2.4.1. This thinking style would give less room for framing effects. The question to measure support should, therefore, be investigated further, because apparently, the question "Do you support implementation of CCS?" has the risk of pushing respondents into a more objective analysis than was intended.

6.2. Framing effects are stimulated not strong enough

Respondents took the survey as part of a MOOC while following a week course. Many participants were full-time employees, probably with not much time (Hennis, 2014). As the survey was framed as an exercise, the temptation to complete the survey as quickly as possible was likely, so the frame was possibly not read carefully, and respondents did not absorb all information. Also, a possibility was that respondents not even read the article, but skimmed it quickly.

Furthermore, in this study, considerable attention was directed to keeping the survey as short as possible in order to maximize the number of completed surveys and to minimize the inconvenience for the respondents. This focus on a short survey was more important than usual because the MOOC contained more surveys and was meant to be pleasant to follow as well. However, this focus on a short survey also led to a very short article on framing. A possible explanation for the failure of the appearance of framing effects could be that the variation was not strong enough. A single sentence did not garner enough processing attention in the memory and was, therefore, not able to create framing effects. This effect was investigated extensively by Benson and Svenson (1993), proving a negative influence of time pressure on framing effects.
Another indication that this effect was present and could be directed to the formulation of the article was the comparison to another study that was conducted in the same MOOC. This study made use of a short movie, thus automatically placing more emphasis on the frame. This research did show significant framing effects.

Last, the variation of frames could have been too minor. When differentiating between positive and negative frames in this research an attempt was made to keep articles as alike as possible, to ensure an honest comparison. This method led to two articles not especially fluent in argumentation or persuasion. A greater variation between frames could have been able to show more framing effects.

Could this experiment be carried out without the direction in frames?
The question then of course immediately arises if this study could have been carried out without a direction in frames, because this (absence of a) direct effect influences most hypotheses. With the definition and experimental design that was chosen in this study the answer is clearly no. As discussed in Paragraph 2.2.3 the definition used for the effectiveness of framing depends on a certain goal, a certain difference between opinions and choices, and the one sending the message wants to influence a receiver towards a specific opinion or choice.

In risks, in most cases two directions are in place: one that deems the risk to be acceptable, and an oppose who deems this risk as unacceptable. These two directions were therefore also chosen in this study. Another option would have been to compare the influence of a frame with a response group that received no frame. In this study this was also carried out. This was not the main analysis in this research, because it was deemed that the difference between a group that receives a negative and a positive frame was deemed to be higher than the difference between a control group (no frame) and either a negative or positive frame. All test with the small (n=36) control group did support this assumption, as for none of the comparisons a frame differed significantly with the control group.

An option that could have been deduced from De Vries et al. (2014) would have been to test and compare with a control group that received both frames. The same argument as for the control group without any frame, a bigger effect was expected when testing for differences. When focussing not specifically on risks more options would have been appropriate, for example to place CCS amongst other options, as is done in Mastop et al. (2014) and many other studies.

6.3. Effects are not observed correctly

Initially, in this study many respondents were expected based on the number of people enrolled in the MOOC. It was anticipated that many respondents would lose focus and would stop following the MOOC over its duration, which seemed to be the case already in the second week, when the survey for this research was conducted. In total around 1390 respondents took part in the survey. This number could have been sufficient; however, some difficulties arose. The coupling of the survey to the earlier survey with personality characteristics provided an overlap of only 243 respondents. This number was too low to draw significant conclusions about many effects from the personality characteristics or the interaction with values.

Furthermore for the final dataset only 800 respondents remained. Thus, a high percentage of respondents was discarded, around **42%**. This large number of discarded respondents occurred most likely because respondents did not complete the survey fully, because the last questions were clearly not relevant for their exercise (the manipulation checks). The questions were perhaps skipped too easily. For the number of experimental conditions (25), the number of respondents was relatively low, which could influence the visibility of framing effects.

6.4. Using a **MOOC** as data-collection method

In this study the data was collected through a MOOC as given by the TU Delft. There exist several disadvantages of using the MOOC as the method of data collection. First the respondents cannot be controlled. An interesting example from this study is the fact that a respondent filled in an age of 13. This could be explained by a very young respondent, interested in framing, for example for a school project, however it could also have been a typo. The fact that the survey was deployed anonymously in a MOOC makes it impossible to control this and find out the explanation.

Second the fact that the experiment was carried out in a MOOC inevitably means that a very specific group of respondents would be acquired. A higher average education is one example. Although Kuhberger (1998) has found that experiments carried out on students can also be expanded in a lot of cases, caution has to be used when expanding results, specifically for a unique case like CCS.

Third the fact that a MOOC was used has implications for the process how respondents participated in the survey. The questionnaire was part of a weekly course. Previous research have shown that participants in general do not have a lot of time (Hennis, 2014), and every part of a weekly course can be skipped. This means that the different parts have to be designed to be attractive, and take as less time as possible.

Fourth respondents were collected from every part of the world. This aspect proved to be a challenge and a chance. The challenge would be that conclusions drawn for this response group could not easily be expanded to the population of the Netherlands as a whole. Also expansion to the general population of the world would

also not be appropriate, because several countries are highly over-represented. The chance of this worldwide population was the possibility to test for cultural differences.

Research into the effects of using a MOOC for empirical research should therefore be expanded. The (lack of) attention span and the uncontrollability of the respondents and their environment prove to be items of improvement. These items are very relevant because of the expanding use of MOOC's and their huge potential for scientific research. Potentially MOOC's could grow to be a significant pool of data for a lot of types of research.

6.5. Limitations when expanding results

Several limitations are present when results of this study are extrapolated to the total population. First, the respondents were an international-oriented group of people, which should be taken into account when focussing on a population of one nationality, for example the Netherlands.

Although no influence was found from educational level, this lack of influence can also be explained by the small number of respondents in the subset that had not acquired a bachelor's or master's degree. Therefore, expanding results to a less educated population should be conducted with caution.

Respondents in this study were not personally involved nor were living near a potential CCS location. As Terwel and Daamen (2011) showed, this can highly influence the results of the opinion measurement. Therefore, when communicating to a local public involved, or affected by, an actual CCS project not all conclusions can be directly transferred.

Caution should also be exercised when transporting framing effects to general conclusions for other subjects. Framing effects dependent much on the specific issue at stake, as shown by Fagley and Miller (1997). For example, the more independent messenger (scientist) vs. the CEO of an oil company is a specific difference in the CCS situation. From this difference, a general conclusion about the influence of a more independent messenger cannot be literally deduced. More promising is to extrapolate the conclusions in this study to problems that align more with CCS: Other sociotechnical problems in the (sustainable) energy transition.

7. Recommendations

The recommendations following from this study can be classified into three categories. In the first Paragraph 7.1 recommendations are discussed to improve a study like the one described in this report. In Paragraph 7.2 recommendations are described for other interesting research, following from additional or unsolved knowledge gaps identified in this study. In the last Paragraph 7.3 some practical notions are given to actors playing a role in the CCS debate, using the conclusions formulated in this study.

7.1. Improvements on current research

By including a second measurement of CCS opinion, better insight into the actual opinion of a respondent and the long-term influence of a frame can be acquired.

The effect as discussed in Paragraph 6.1 and shown by De Vries et al. (2014), the possible perceived manipulation when only one side of the problem is discussed (emphasis pitfall) can be prevented by elaborating both sides of a problem, perhaps emphasizing one side slightly. Also, the other effects tested in this study (independence messenger, strategies of communication, and use of the word risk/safety) can be tested with a frame showing both sides of the discussion.

As discussed in Paragraph 6.2 several improvements can be made to stimulate the differences between frames more strongly and successfully. For example, a greater variation in frames could be adopted by differentiating more. Also, a longer article could be more influential. Furthermore, attempts could be made to draw more attention to the frame: Making it more prominently visible, explicitly asking respondents to read carefully, asking whether respondents have read and understood the text fully, or focussing attention by other means (e.g. other medium).

For the combination with personal characteristics, especially the interesting concept of the Schwartz values, more respondents are needed. This higher number of respondents could have been acquired by including the personality characteristics in the same survey or increasing the number of respondents. In this study, the fact that many respondents did not complete the survey fully also can be countered easily by reordering questions, and is not expected to be a risk in most other experiments.

For the dataset that was collected with this research possible other analyses can also still be carried out. For example detailed interactions with values could be of interest and are not yet studied for this thesis.

7.2. Other research of interest

The literature study into the communication strategies provided many reasons to believe this aspect could influence framing success. Furthermore, because of the significant implications on risk communication and the absence of direct empirical research, an empirical study into this variable as sole purpose could be of great interest.

In this study no framing effect was found for the usage of the word risk or safety. Additional research, focussed solely on this variation could confirm the results found in this study (no effects are present) or prove that a framing effect does exist. Because this variable is practical, actors can actively use this knowledge and results can be useful for actors in the CCS Debate. Special attention should be paid to the emphasis pitfall as discussed earlier (De Vries et al., 2014). Does using the word safety make respondents more sceptical?

Furthermore, all other factors from the shortlist were deemed promising for influencing framing in a socio-technical problem and are, therefore, interesting to study empirically. These factors can be studied separately, but for a comparison of effects, a recommendation would be to study factors together, also to check for interaction effects.

7.3. Recommendations for the CCS debate

Because of the unexpected results in this study, no clear answers can be provided on the strength of certain framing factors. Still, some useful notions can be deduced from this research.

Any actor in the CCS debate should pay at least as much attention to the messenger as to the creation of the message. Considerable empirical evidence shows that the trust/belief in the independence of a messenger to a high degree influenced the effectiveness of framing. The results of this study also pointed in the same direction. Therefore partnering with e.g. a credible NGO could be much smarter for an oil company than hiring a communication expert. This recommendation lines up with the findings of Terwel et al. (2011), who found in their experimental study that NGO's are in general more trusted in the CCS debate at this moment.

At the moment, almost all communication from pro-CCS parties focuses on calculation-based strategy: Proving that risks are small and trying to downplay the size of the risks. When thinking about communication about CCS, also the other two strategies should be considered. For example, including the division of risks or focussing on the fatality. Van Eeten (2010*)* already said: Risks can never be fully avoided and using elements from an acceptation strategy could prove to be effective.

When looking at the public to which communication is directed, consider that old people need slightly more convincing; of course this is not always the case, but keep it in mind as pointer.

People who value power, achievement and hedonism more are more likely to be positive about CCS and respondents who score higher on the value Benevolence are less likely to be positive about CCS. Therefore try to find ways to couple frames to aspects that relate to the benevolence value, which mostly can be found in the sphere of emphasizing natural benefits. Zaal et al. (2014) stated to also express monetary compensations into values that are depicted as more important by people, *sacred* values.

Literature

Ajzen, I., & Fishbein, M. (1980*). Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Ashworth, P., Boughen, N., Mayhew, M., & Millar, F. (2010). From research to action: Now we have to move on CCS communication. *International Journal of Greenhouse Gas Control*, 4(2), 426-433.

Ashworth, P., Dowd, A. M., Rodriguez, S., Jeanneret, T., Mabon, L., & Howell, R. (2013). *Synthesis of CCS social research: Reflections and current state of play in 2013*, retrieved from: http://decarboni.se/sites/default/files/publications/115553/Synthesis-CCS-social-research.pdf

Ashworth, P., Pisarski, A., & Littleboy, A. (2006). *Social and Economic Integration Report: Understanding and incorporating stakeholder perspectives to low emission technologies in Queensland*. Centre for Low Emission Technology: Pullenvale

Ashworth, P., Wade, S., Reiner, D., & Liang, X. (2015). Developments in public communications on CCS. *International Journal of Greenhouse Gas Control*, 40, 449-458.

Bäckstrand, K., Meadowcroft, J., & Oppenheimer, M. (2011). The politics and policy of carbon capture and storage: Framing an emergent technology. *Global Environmental Change*, 21(2), 275-281.

Bai, M. (2005). The framing wars. *The New York Times Magazine*, 17, 38-45.

Barberis, N., & Huang, M. (2009). Preferences with frames: a new utility specification that allows for the framing of risks. *Journal of Economic Dynamics and Control*, 33(8), 1555-1576.

Benford, R. D. (1997). An Insider's Critique of the Social Movement Framing Perspective. *Sociological Inquiry*, 67(4), 409-430.

Benford, R. D., & Snow, D. A. (2000). Framing processes and social movements: An overview and assessment. *Annual review of sociology*, 611-639.

Bernstein, L. M., Chapman, G. B., & Elstein, A. S. (1999). Framing effects in choices between multioutcome life-expectancy lotteries. *Medical Decision Making*, 19(3), 324-338.

Bloomfield, A. N. (2006). Group size and the framing effect. *Memory & cognition*, 34(4), 929-937.

Bolsen, T., Druckman, J. N., & Cook, F. L. (2014). How frames can undermine support for scientific adaptations: Politicization and the status-quo bias. *Public opinion quarterly*, 78(1), 1-26.

Bots, P. W. (2007). Design in socio-technical system development: three angles in a common framework. *Journal of Design Research*, 5(3), 382-396.

Brewer, P. R. (2002). Framing, value words, and citizens' explanations of their issue opinions. *Political Communication*, 19(3), 303-316.

Brewer, P. R., & Gross, K. (2005). Values, framing, and citizens' thoughts about policy issues: Effects on content and quantity. *Political Psychology*, 929-948.

Brunsting, S., de Best-Waldhober, M., & Terwel, B. W. (2013a). 'I Reject your Reality and Substitute my Own!' Why More Knowledge about CO 2 Storage Hardly Improves Public Attitudes. *Energy Procedia*, 37, 7419-7427.

Brunsting, S., de Best-Waldhober, M., Brouwer, A. S., Riesch, H., & Reiner, D. (2013b). Communicating CCS: Effects of Text-only and Text-and-visual Depictions of CO 2 Storage on Risk Perceptions and Attitudes. *Energy Procedia*, 37, 7318-7326.

Brunsting, S., Upham, P., Dütschke, E., Waldhober, M. D. B., Oltra, C., Desbarats, J., & Reiner, D. (2011). Communicating CCS: Applying communications theory to public perceptions of carbon capture and storage. *International Journal of Greenhouse Gas Control*, 5(6), 1651-1662.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of personality and social psychology*, 42(1), 116-127.

Callaghan, K., & Schnell, F. (2009). Who says what to whom: Why messengers and citizen beliefs matter in social policy framing. *The Social Science Journal*, 46(1), 12-28.

Callon, M. (1998). An essay on framing and overflowing: economic externalities revisited by sociology. *The Sociological Review*, 46(S1), 244-269.

CATO. (2015). *Over Cato*, retrieved 16-10-2015 from: http://www.co2-cato.nl/nl/over-cato

CCP. (2014). *What is CO2 Capture and Storage?*, retrieved from: http://www.co2captureproject.org/what_is_co2_capture_storage.html

Chang, C. T. (2007). Health-care product advertising: The influences of message framing and perceived product characteristics. *Psychology and Marketing*, 24(2), 143.

Chong, D. (1996). Creating common frames of reference on political issues. *Political persuasion and attitude change*, 195-224.

Chong, D., & Druckman, J. N. (2007). Framing theory. *Annu. Rev. Polit. Sci.*, 10, 103-126.

Cuppen, E., Brunsting, S., Pesch, U., & Feenstra, Y. (2015). How stakeholder interactions can reduce space for moral considerations in decision making: A contested CCS project in the Netherlands. *Environment and Planning A*, 47(9), 1963-1978.

Daamen, D., de Best-Waldhober, M., Damen, K., & Faaij, A. (2006). *Pseudo-opinions on CCS technologies*, retrieved from: http://www.co2-cato.org/cato-download/302/20090917_123323_Daamen_viewpdf.pdf

D'angelo, P. (2002). News framing as a multiparadigmatic research program: A response to Entman. *Journal of communication*, 52(4), 870-888.

David L. Olson, John R. Birge, Jonathan Linton, Introduction to risk and uncertainty management in technological innovation*, Technovation*, Volume 34, Issue 8, August 2014, Pages 395-398.

Davidson, E. J. (2002). Technology frames and framing: A socio-cognitive investigation of requirements determination. *Mis Quarterly*, 329-358.

De Bruijn, J.A. (2011). *Framing*. Amsterdam: Atlas Contact.

De Bruijn, J. A., Van Bueren, E. M., & Kreiken, F. H. (2012). Framing en reframing in het klimaatdebat. *Bestuurskunde*, 21 (4) 2012.

De Coninck, H., & Benson, S. M. (2014). Carbon Dioxide Capture and Storage: Issues and Prospects. Annual Review of Environment and Resources, 39, 243-270.

De Vreese, C. H. (2005). News framing: Theory and typology. *Information design journal & document design*, 13(1), 51-62.

De Vreese, C. H. (2012). New avenues for framing research. *American Behavioral Scientist*, 56(3), 365-375.

De Vries, G., Terwel, B. W., & Ellemers, N. (2014). Spare the details, share the relevance: The dilution effect in communications about carbon dioxide capture and storage. *Journal of Environmental Psychology*, 38, 116-223.

De Vries, G., Terwel, B. W., & Ellemers, N. (2015). Perceptions of Manipulation and Judgments of Illegitimacy: Pitfalls in the Use of Emphasis Framing when Communicating about CO2 Capture and Storage. *Environmental Communication*, (ahead-of-print), 1-21.

Druckman, J. N. (2001). On the limits of framing effects: who can frame?. *Journal of Politics*, 63(4), 1041-1066.

Druckman, J. N. (2010). Competing frames in a political campaign. *Winning with words: The origins and impact of political framing*, 101-120.

Druckman, J. N., & Bolsen, T. (2011). Framing, motivated reasoning, and opinions about emergent technologies. *Journal of Communication*, 61(4), 659-688.

Dunlap, R., Liere, K. V., Mertig, A., & Jones, R. E. (2000). Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of social issues*, 56(3), 425-442.

Dunn, O. J. (1961). Multiple comparisons among means. *Journal of the American Statistical Association*, 56(293), 52-64.

Epstein, S. (1983). The unconscious, the preconscious and the self-concept. In J. Suls, & A. Greenwald, *Psychological perspectives on the self (Vol. 2)* (pp. 219–247). Hillsdale, NJ: Lawrence Erlbaum.

Epstein, S. (1990). Cognitive-experiential self-theory. In L. Pervin, *Handbook of personality theory and research* (pp. 165–192). New York: Guilford.

Epstein, S. (1993). Implications of cognitive-experiential self-theory for personality and developmental psychology. In D. Funder, R. Parke, C. Tomlinson-Keasey, & K. Widaman, *Studying lives through time: Personality and development*. Washington, DC: American Psychological Association.

Enserink, B., Hermans, L., Kwakkel, J., Thissen, W., & Koppenjan, J. (2010) Policy Analysis of Multi-Actor Systems. The Hague: Lemma.

Entman, R. M. (1993). Framing: Towards clarification of a fractured paradigm. McQuail's reader in mass communication theory, 390-397.

Fagley, N. S., & Miller, P. M. (1990). The effect of framing on choice interactions with risk-taking propensity, cognitive style, and sex. *Personality and Social Psychology Bulletin*, 16(3), 496-510.

Fagley, N. S., & Miller, P. M. (1997). Framing effects and arenas of choice: Your money or your life?. *Organizational behavior and human decision processes*, 71(3), 355-373.

Farrar, D. E., & Glauber, R. R. (1967). Multicollinearity in regression analysis: the problem revisited. *The Review of Economic and Statistics*, 92-107.

FBK. (2012). *Emerging Organizational Behavior Knowledge*, retrieved from: http://bk.fudan.edu.cn/d-1376281854876

Feenstra, C. F. J., Mikunda, T., & Brunsting, S. (2010). *What happened in Barendrecht?! Case study on the planned onshore carbon dioxide storage in Barendrecht*, retrieved from: https://www.ecn.nl/publications/BS/2010/ECN-E--10-057

Feldman, S., & Zaller, J. (1992). The political culture of ambivalence: Ideological responses to the welfare state. *American Journal of Political Science*, 268-307.

Flachaire, E., & Hollard, G. (2008). Individual sensitivity to framing effects. *Journal of Economic Behavior & Organization*, 67(1), 296-307.

Freling, T. H., Vincent, L. H., & Henard, D. H. (2014). When not to accentuate the positive: Re-examining valence effects in attribute framing. *Organizational Behavior and Human Decision Processes*, 124(2), 95-109.

Gagestein, S. (2012). Natuurramp, bonuscultuur of kans: crisisframes. *Bestuurskunde*, 12 (04), 11-20.

Gamson, W. A., & Modigliani, A. (1987). The changing culture of affirmative action. In R. G. Braungart & M. M. Braungart (Eds.), *Research in political sociology* (Vol. 3, pp. 137–177). Greenwich, CT: JAI Press.

Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research policy*, 33(6), 897-920.

Gerend, M. A., & Cullen, M. (2008). Effects of message framing and temporal context on college student drinking behavior. *Journal of Experimental Social Psychology*, 44(4), 1167-1173.

Giraud, R., & Bourgeois-Gironde, S. (2009). Framing effects as Violations of Extensionality. *Theory and Decision*, 385-404.

Goffman, E. (1974). *Frame analysis: An essay on the organization of experience*. Harvard University Press.

Ha-Duong, M., Nadaï, A., & Campos, A. S. (2009). A survey on the public perception of CCS in France. *International Journal of Greenhouse Gas Control*, 3(5), 633-640.

Hänggli, R. (2011). *Frame building and framing effects in direct-democratic campaigns.* (Unpublished doctoral dissertation). University of Zurich, Zurich.

Hänggli, R., & Kriesi, H. (2012). Frame construction and frame promotion (strategic framing choices). *American Behavioral Scientist*, 56(3), 260-278.

Harben, B., & Kim, S. (2010). Political opinion leadership and advertisement attitude: The moderating roles of cognitive and affective responses to political messages. *The Social Science Journal*, 47(1), 90-105.

Hennis, T. (2014). Onderzoek een Mooc: ervaringen en uitkomsten, retrieved from: http://www.slideshare.net/DeOnderwijsdagen/onderzoek-een-mooc-thieme-hennis-owd14

Herzog, H., Drake, E., & Adams, E. (1997*). CO2 capture, reuse, and storage technologies for mitigating global climate change*, retrieved from: http://pubs.awma.org/gsearch/em/1997/12/herzog.pdf

Hiscox, M. J. (2004). Through a glass and darkly: Attitudes toward international trade and the curious effects of issue framing. *International Organization*, 60(03), 755-780.

Holleman, B. C., & Maat, H. L. P. (2009). The pragmatics of profiling: Framing effects in text interpretation and text production. *Journal of Pragmatics*, 41(11), 2204-2221.

Huang, Y., & Wang, L. (2010). Sex differences in framing effects across task domain. *Personality and Individual Differences*, 48(5), 649-653.

IPCC, 2005: IPCC Special Report on Carbon Dioxide Capture and Storage. Prepared by Working Group III of the Intergovernmental Panel on Climate Change (Metz, B., O. Davidson, H. C. de Coninck, M. Loos, and L. A. Meyer (eds.)). Cambridge and New York, NY: Cambridge University Press.

IPCC (2013). Summary for Policymakers. In: Climate Change 2013: The physical science basis. Contribution of working group I to the fifth assessment report of the Intergovernmental Panel on Climate Change (Stocker, T. F., D. Qin, G-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, & P. M. Midgley [Eds.]). Cambridge and New York, NY: Cambridge University Press.

J. Gale, J.C. Abanades, S. Bachu, C. Jenkins, Special Issue commemorating the 10th year anniversary of the publication of the Intergovernmental Panel on Climate Change Special Report on CO2 Capture and Storage, *International Journal of Greenhouse Gas Control*, Volume 40, September 2015, Pages 1-5.

Jones, C. R., Eiser, J. R., & Gamble, T. R. (2012). Assessing the impact of framing on the comparative favourability of nuclear power as an electricity generating option in the UK. *Energy Policy*, 41, 451-465.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica: Journal of the Econometric Society*, 263-291.

Kim, J., Kim, J. E., & Marshall, R. (2014). Search for the underlying mechanism of framing effects in multi-alternative and multi-attribute decision situations. *Journal of Business Research*, 67(3), 378-385.

Kim, S. B., & Kim, D. Y. (2014). The effects of message framing and source credibility on green messages in hotels. *Cornell Hospitality Quarterly*, 55(1), 64-75.

Kim, S., Goldstein, D., Hasher, L., & Zacks, R. T. (2005). Framing effects in younger and older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 60(4), 215-P218.

Kinder, D. R., & Sanders, L. M. (1996). *Divided by color: Racial politics and democratic ideals*. Chicago: University of Chicago Press.

Klar, S., Robison, J., & Druckman, J. N. (2013). Political Dynamics of Framing. *New Directions in Media and Politics*, 173-181.

Koot, C. (2014). Making up your mind about a complex technology: an investigation into factors that help or hinder the achievement of cognitive closure about CCS (Unpublished doctoral dissertation). University of Leiden, Leiden.

Korsten, A.F.A. (2013). *Framing in de politiek*, retrieved 26-10-2015 from: http://www.arnokorsten.nl/PDF/Democratie/Framing%20in%20de%20politiek.pdf

Kühberger, A. (1995). The framing of decisions: A new look at old problems. *Organizational Behavior and Human Decision Processes*, 62(2), 230-240.

Kühberger, A. (1998). The influence of framing on risky decisions: A meta-analysis. *Organizational behavior and human decision processes*, 75(1), 23-55.

Kühberger, A., Schulte-Mecklenbeck, M., & Perner, J. (1999). The effects of framing, reflection, probability, and payoff on risk preference in choice tasks. *Organizational behavior and human decision processes*, 78(3), 204-231.

Kuklinski, J. H., Quirk, P. J., Jerit, J., & Rich, R. F. (2001). The political environment and citizen competence. *American Journal of Political Science*, 410-424.

Kurz-Milcke, E., Gigerenzer, G., & Martignon, L. (2008). Transparency in risk communication. *Annals of the New York Academy of Sciences*, 1128(1), 18-28.

Lakoff, G., & Johnson, M. (1980). *Metaphors we live by*. Chicago: U of Chicago P.

Lakoff, G. (2004). *Don't think of an elephant: Progressive values and the framing wars—a progressive guide to action*. White River Junction, VT: Chelsea Green Publishing.

Lakoff, G. (2008). *The political mind: A cognitive scientist's guide to your brain and its politics*. London: Penguin.

Lakshminarayanan, V. R., Chen, M. K., & Santos, L. R. (2011). The evolution of decision-making under risk: framing effects in monkey risk preferences. *Journal of Experimental Social Psychology*, 47(3), 689-693.

Lauriola, M., Russo, P. M., Lucidi, F., Violani, C., & Levin, I. P. (2005). The role of personality in positively and negatively framed risky health decisions. *Personality and individual differences*, 38(1), 45-59.

Lee, Y. K., & Chang, C. T. (2010). Framing public policy: The impacts of political sophistication and nature of public policy. *The Social Science Journal*, 47(1), 69-89.

Lee, Y. K., & Chang, C. T. (2011). Missing ingredients in political advertising: The right formula for political sophistication and candidate credibility. *The Social Science Journal*, 48(4), 659-671.

Levin, I. P., & Gaeth, G. J. (1988). How consumers are affected by the framing of attribute information before and after consuming the product. *Journal of consumer research,* 374-378.

Levin, I. P., Schneider, S. L., & Gaeth, G. J. (1998). All frames are not created equal: A typology and critical analysis of framing effects. *Organizational behavior and human decision processes*, 76(2), 149-188.

Levin, I. P., Gaeth, G. J., Schreiber, J., & Lauriola, M. (2002). A new look at framing effects: Distribution of effect sizes, individual differences, and independence of types of effects. *Organizational behavior and human decision processes*, 88(1), 411-429.

Li, M., & Chapman, G. B. (2013). A big fish or a small pond? Framing effects in percentages. *Organizational Behavior and Human Decision Processes*, 122(2), 190-199.

Likert, R. (1932). A technique for the measurement of attitudes, *Archives of Psychology* 140-151.

Mahoney, K. T., Buboltz, W., Levin, I. P., Doverspike, D., & Svyantek, D. J. (2011). Individual differences in a within-subjects risky-choice framing study. *Personality and Individual Differences*, 51(3), 248-257.

Mastop, J., de Best-Waldhober, M., Hendriks, C., Ramirez, A. (2014). *Informed public opinions on CO2 mitigation options in the Netherlands: deliberating expert information and lay beliefs*, retrieved from: http://www.researchgate.net/publication/263357191_Informed_public_opinions_on_CO2_mitigation_options _in_the_Netherlandsdeliberating_expert_information_and_lay_beliefs

Matsen, P. P., Rollinson, P. B., & Sousa, M. (Eds.). (1990). *Readings from classical rhetoric*. Carbondale, Illinois: SIU Press

McElroy, T., & Seta, J. J. (2003). Framing effects: An analytic–holistic perspective. *Journal of Experimental Social Psychology*, 39(6), 610-617.

McElroy, T., Seta, J. J., & Waring, D. A. (2007). Reflections of the self: how self-esteem determines decision framing and increases risk taking. *Journal of Behavioral Decision Making*, 20(3), 223-240.

McGuire, W.J., 2001. Input and output variables currently promising for constructing persuasive communications. In: Rice, R.E., Atkin, C.K. (Eds.), *Public Communication Campaigns*, 3rd ed. Sage, Thousand Oaks, CA, pp. 22–48

Ministry of Economics. (2010). *Uitwerking van de afspraken voor de individuele CO2 opslagprojecten die momenteel in voorbereiding zijn*, retrieved from: http://www.rijksoverheid.nl/documenten-en-publicaties/kamerstukken/2010/11/04/uitwerking-van-de-afspraken-voor-de-individuele-co2-opslagprojecten-die-momenteel-in-voorbereiding-zijn.html.

Noordegraaf-Eelens, L., van Eeten, M., Februari, M., & Ferket, J. (2012). *Waarom Burgers risico's accepteren en waarom bestuurders dat niet zien*. Retrieved 27-02-2015 from: http://repub.eur.nl/pub/38337/

Olson, D., Birge, J., & Linton, J. D. (2014). Risk and Uncertainty Management in Technological Innovation. *Technovation*, 34(8), 395-398.

Peters, E., & Levin, I. P. (2008). Dissecting the risky-choice framing effect: Numeracy as an individual-difference factor in weighting risky and riskless options. *Judgment and Decision Making*, 3(6), 435-448.

Petty, R. E., & Cacioppo, J. T. (1984). The effects of involvement on responses to argument quantity and quality: Central and peripheral routes to persuasion. *Journal of personality and social psychology*, 46(1), 69.

Pidgeon, N. F., Lorenzoni, I., & Poortinga, W. (2008). Climate change or nuclear power—No thanks! A quantitative study of public perceptions and risk framing in Britain. *Global Environmental Change*, 18(1), 69-85.

Reiner, D., Curry, T., de Figueiredo, M., Herzog, H., Ansolabehere, S., Itaoka, K. & Odenberger, M. (2006*). An international comparison of public attitudes towards carbon capture and storage technologies,* retrieved from: http://www.geos.ed.ac.uk/ccs/Publications/Reiner1.pdf

Renn, O., & Levine, D. (1991). Trust and credibility in risk communication. In: R. Kasperson, P.J. Stallen (Eds.), *Communicating Risk to the Public*, Kluwer Academic Publishers, Dordrecht (1991), pp. 175–218

Rizavi, Z. (2007). *Telling USAID's Story: The Use of Framing In A Public Diplomacy Initiative*, retrieved from: http://www.american.edu/soc/communication/upload/07-Zehra-Rizavi.pdf

Rossiter, J. R., Dolnicar, S., & Grun, B. (2015). Why the level-free forced-choice binary measure of brand benefit beliefs works so well. *International Journal of Market Research*, 57(2), 1-9.

Ruxton, G. D. (2006). The unequal variance t-test is an underused alternative to Student's t-test and the Mann–Whitney U test. *Behavioral Ecology*, 17(4), 688-690.

Sandman, P. M. (1993). *Responding to community outrage: Strategies for effective risk communication*, retrieved from: http://www.petersandman.com/media/RespondingtoCommunityOutrage.pdf

Scheufele, D. A. (2000). Agenda-setting, priming, and framing revisited: Another look at cognitive effects of political communication. *Mass Communication & Society*, 3(2-3), 297-316.

Scheufele, D. A., & Iyengar, S. (2012). *The state of framing research: A call for new directions*. New York: Oxford University Press.

Scheufele, D. A., & Tewksbury, D. (2007). Framing, agenda setting, and priming: The evolution of three media effects models. *Journal of communication*, 57(1), 9-20.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theory and empirical tests in 20 countries. In M. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 25, pp. 1-65). New York: Academic Press.

Schwartz, S. H. (2012). An overview of the Schwartz theory of basic values. *Online Readings in Psychology and Culture*, 2(1), 11.

Seigo, S. L. O., Wallquist, L., Dohle, S., & Siegrist, M. (2011). Communication of CCS monitoring activities may not have a reassuring effect on the public. *International Journal of Greenhouse Gas Control*, 5(6), 1674-1679.

Shiloh, S., Salton, E., & Sharabi, D. (2002). Individual differences in rational and intuitive thinking styles as predictors of heuristic responses and framing effects. *Personality and Individual Differences*, 32(3), 415-429.

Shmueli, D. F. (2008). Framing in geographical analysis of environmental conflicts: Theory, methodology and three case studies. *Geoforum*, 39(6), 2048-2061.

Smith, D. (2010). *CO2 Storage in Saline Aquifers, presentation given at the UK Groundwater Forum May 2010*, retrieved through: http://www.groundwateruk.org/downloads/7_Smith_CCS.pdf

Sniderman, P. M., & Theriault, S. M. (2004). The structure of political argument and the logic of issue framing. *Studies in public opinion: Attitudes, nonattitudes, measurement error, and change*, 133-65.

Stanovich, K. E., & West, R. F. (1998). Individual differences in rational thought. *Journal of experimental psychology: general*, 127(2), 161.

Stephens, J. C., Bielicki, J., & Rand, G. M. (2009). Learning about carbon capture and storage: Changing stakeholder perceptions with expert information. *Energy Procedia*, 1(1), 4655-4663.

Stirling, Andrew (2008) Choosing Energy Futures: Framing, Lock-in, and Diversity. In: Dorfman, Paul (ed.) *Nuclear Consultation: Public Trust in Government. Nuclear Consultation Working Group*, University of Warwick, Warwick, pp. 61-71.

Stoutenborough, J. W., Vedlitz, A., & Liu, X. (2015). The Influence of Specific Risk Perceptions on Public Policy Support An Examination of Energy Policy. *The ANNALS of the American Academy of Political and Social Science*, 658(1), 102-120.

Suhay, E., & Druckman, J. N. (2015). The Politics of Science Political Values and the Production, Communication, and Reception of Scientific Knowledge. *The ANNALS of the American Academy of Political and Social Science*, 658(1), 6-15.

Svenson, O., & Benson III, L. (1993). *Framing and time pressure in decision making*. New York, NY: Plenum Press.

Ter Mors, E., Weenig, M., Ellemers, N., & Daamen, D. (2006). The influence of (in) congruence of communicator expertise and trustworthiness on acceptance of CCS technologies, retrieved from: http://www.co2-cato.org/publications/library1/the-influence-of-incongruence-of-communicator-expertise-and-trustworthiness-on-acceptance-of-ccs-technologies

Terwel, B. W., Harinck, F., Ellemers, N., & Daamen, D. D. (2011). Going beyond the properties of CO 2 capture and storage (CCS) technology: how trust in stakeholders affects public acceptance of CCS. *International Journal of Greenhouse Gas Control*, 5(2), 181-188.

Terwel, B. W., & Daamen, D. D. (2012). Initial public reactions to carbon capture and storage (CCS): differentiating general and local views. *Climate Policy*, 12(3), 288-300.

Terwel, B. W., ter Mors, E., & Daamen, D. D. (2012). It's not only about safety: Beliefs and attitudes of 811 local residents regarding a CCS project in Barendrecht. *International Journal of Greenhouse Gas Control*, 9, 41-51.

Terwel, B. W., & ter Mors, E. (2015). Host community compensation in a carbon dioxide capture and storage (CCS) context: Comparing the preferences of Dutch citizens and local government authorities. *Environmental Science & Policy*, 50, 15-23.

Tversky, A., & Kahneman, D. (1981). The framing of decisions and the psychology of choice. *Science*, 211(4481), 453-458.

Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. *Journal of business*, S251-S278.

Van de Kaa, E. J. (2008). *Extended prospect theory: findings on choice behaviour from economics and the behavioural sciences and their relevance for travel behaviour*. (Unpublished doctoral dissertation) Delft University of Technology, Delft.

Van der Heijden, E., Klein, T. J., Müller, W., & Potters, J. (2012). Framing effects and impatience: Evidence from a large scale experiment. *Journal of Economic Behavior & Organization*, 84(2), 701-711.

Van der Velde, N.M. (2012). *Bom onder Barendrecht? CCS in Barendrecht: een studie naar beïnvloeding van framing in de media door een event*, retrieved from: http://dspace.library.uu.nl/handle/1874/254157

Van Eeten. (2010). *Techniek van de onmacht*. Retrieved 4-03-2015 from: http://www.nsob.nl/wp-content/uploads/pdf/201001%20Techniek%20van%20de%20onmacht.pdf

Visser, M. (2005). *In hoeverre zijn framing en kanspresentatie van invloed op de persuasiviteit van een voorlichtingstekst over chlamydia-preventie?,* retrieved from: http://www.studiosus.nl/scripties/1429_chlamydiapreventie.doc

Wang, A. (2007). Priming, framing, and position on corporate social responsibility. *Journal of Public Relations Research*, 19(2), 123-145.

Wang, X. T. (1996). Framing effects: Dynamics and task domains. Orga*nizational Behavior and Human Decision Processes*, 68(2), 145-157.

Weaver, D. H. (2007). Thoughts on agenda setting, framing, and priming. *Journal of communication*, 57(1), 142-147.

Zaal, M. P., Terwel, B. W., ter Mors, E., & Daamen, D. D. (2014). Monetary compensation can increase public support for the siting of hazardous facilities. *Journal of Environmental Psychology*, 37, 21-30.

Zhang, W. H., & Wang, X. T. (2008). Self-frame, risk perception and risky choice. *Acta Psychologica Sinica*, 40, 633–641.

Appendices

A. Sources used to identify factors

A.1 Studies used to identify factors

As mentioned in Paragraph 2.2.1, the following studies were used to extract factors from:

Studies used to identify possible factors			
Benford & Snow, 2000	Druckmann & McBernott, 2008	Kuhberger, 1995	Peters, 2008
Benford, 1997	Entman, 1993	Kuhberger, 1998	Pidgeon et al., 2008
Bernstein et al., 1999	Fagley & Miller, 1990	Kuhberget et al., 1999	Renn & Levine, 1991
Bloomfield, 2006	Fagley & Miller, 1997	Lakshminarayanan et al., 2011	Sandman, 2012
Bolsen et al., 2014	Fagley et al., 2010	Lauriola et al., 2005	Scheufele & Iyengar, 2012
Brewer & Gross, 2005	Flachaire & Hollard, 2008	Lauriola et al., 2005	Scheufele & Tewksbury, 2007
Cacioppo & Petty, 1982	Freling et al., 2014	Lee & Chang, 2010	Shilo et al., 2002
Callaghan & Schnell, 2009	Gerend & Cullen, 2008	Lee & Chang, 2011	Shiloh et al., 2002
Chang, 2007	Hänggli & Kriesi, 2012	Levin & Gaeth, 1988	Shmeuli, 2008
Chong & Druckman, 2007	Hänggli, 2011	Levin et al., 1998	Stanovich & West, 1998
De Bruijn et al., 2012	Huang & Wang, 2010	Levin et al., 2002	Tversky & Kahneman, 1978
De Vreese, 2005	Jones et al., 2012	Li & Chapman, 2013	Tversky & Kahneman, 1981
De Vreese, 2012	Kim et al., 2014	Mahoney et al., 2011	Tversky & Kahneman, 1986
Druckman & Bolsen, 2011	Klar et al., 2013	McElroy & Seta, 2002	Van der Velde, 2012
Druckman, 2001	Korsten, 2013	McElroy & Seta, 2003	Wang et al., 2001
Druckman, 2010		McElroy et al, 2007	Wang, 1996

Sources discarded

The following sources were checked briefly but were not included when selecting factors or when finding was to test the effectiveness on framing.

Studies excluded for factors	
Shmeuli, 2008	Kurz-Milcke et al., 2008
Barberis & Huang, 2009	Bai, 2005
Kim et al., 2014	D'Angelo, 2002
Van der Heijden et al., 2012	Callon, 1998
Harben & Kim, 2010	Van der Kaa, 2008
Holleman & Maat, 2009	Scheufele, 2000
Rizavi, 2007	Korsten, 2013
Visser, 2005	Hoogenboom, 2014
Davidson, 2002	Stirling, 2008
Gagestein, 2012	Suhay & Druckman, 2015
Bourgeois-Gironde & Giraud, 2009	Weaver, 2007
De Bruijn, 2010	Wang, 2008

A.2 Factor overview from Brunsting et al. 2011

As discussed in Paragraph 2.3.2, Brunsting et al. (2011) have adopted in their report an overview of (types) of factors that was used integrally as an input when selecting factors for this research.

	communication input factors			
	source of information	**message**	**channel/medium**	**receiver**
relevant features of input factors	attractiveness/likeability of message presenter, mainly determined by physical appearance and degree of familiarity and similarity to audience	level of objective, locus of change, and locus of risk or benefit (from local to worldwide)	information type: documentary, news, opinion, interview	socio-demographic variables: age, gender, education (level, technical or non-technical), employment, distance to planned CCS project
	one source or multiple sources (with dissimilar interests).	execution strategy: surprise, humor, imagery, fear appeals, experts, tone of voice and words chosen (demonstration project, end-of-pipe solution, reverse engineering)	pacing: external (e.g., television message) or internal (e.g., print media)	current knowledge, opinions, and behavior towards CCS technology in general and related topics such as CO2, climate change, alternative energy solutions, stakeholders involved, perceived relation between CCS and climate mitigation
	source credibility (multiple sources can enhance message credibility but not each other's credibility)	message strategy/type of appeal: informational, affective, social, empowerment/efficacy, self-identity, personal norms.	one-sided versus two-sided	current behavior and attitudes towards the specific project. Related to, for example, perceived procedural justice, perceived fairness in distribution of costs/benefits, and perceived quality of information, communication, and participation efforts.
	trust in the source	message format: testimonial, demonstration, problem-solution		Level of involvement with CCS technology in general, related topics, and specific CCS projects.
		framing, number, and strength of arguments used		ability to process information
		repetition, length, complexity		need for cognition
examples of input factors	media , journalists	project duration, scope, costs, financial compensation, etc	newspaper	local public
	business NGOs, international NGOs	contribution to climate effort, impact on development of renewables, etc	brochure, leaflet	representatives of (local) authorities
	local ENGOs/community activities	number and/or characteristics of people who support the technology and/or project	electronic media	representatives of (local) associations
	peer groups, e.g., friends and family	invitation to public consultation, creation of opportunities for joint decision-making or protest	project information centre, site tour	national public
	national and local governments/politicians	ascribe desirable characteristics to people who support the project (or who oppose to it)	town hall meeting	international public
	regulatory/permitting authorities		press conference	
	project developers		telephone hotline	
	research institutes, experts		education program	

Figure 9: Factor overview, figure adapted from Brunsting et al. (2011), p. 1654

B. Different Schools of thought on framing

As mentioned in Paragraph 2.1 several schools of thought have studied framing from different perspectives. In this appendix these different perspectives are described shortly. The conclusions from these analyses are shown in Paragraph 2.1.

B.1 Framing in relation to Priming and Agenda setting

Scheufele & Tewksbury (2007) give a good introduction to the relationship between Priming, Agenda Setting and Framing. Also based on Scheufele & Iyengar (2012) in this research the following conceptual models are used to explain the different concepts.

Agenda-setting

McCombs and Shaw (1972) describe agenda-setting as the theory that when an issue is covered more and bigger in the media, receivers see the issue also as more important.

It therefore deals with the highlighting of issues, by presenting them more often. This is visualized to the right.

Priming (second-level Agenda-setting)

Based on the psychological explanation as given by Collins & Loftus (1975), priming is the process that takes places after the first presentation of an issue. (Scheufele & Iyangar, 2012) By making an aspect more salient it is more likely to be used to judge other issues, this is visualized to the right.

Framing

In this way framing can be visualised as a way of coupling issues, it deals a lot more with the linkage of several aspects to issues, or to enforce an existing link.

In framing the goal of this is mostly to couple the issue/aspect to certain emotions. In the example to the right, issue 1 being something an audience likes, and therefore linking issue 3 to this, makes an audience more likely to be positive towards issue 3.
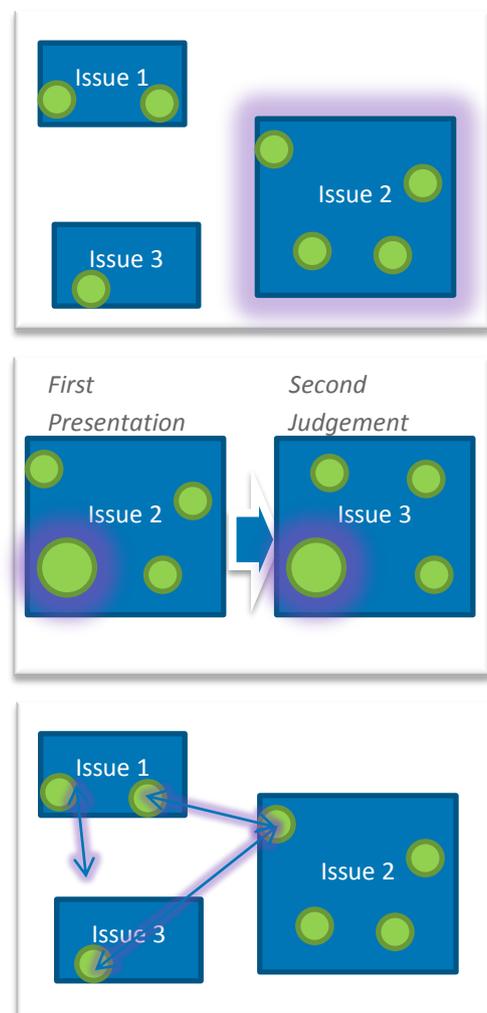
Figure 10: Conceptual representations of Framing, Priming and Agenda setting

There are several schools of literature that describe framing, based from different perspectives. To explain the concept some aspects of literature are already discussed. In this section an overview is created summarizing several findings of schools of thought.

B.2 Framing literature from Psychology

As already discussed one of the first examples of framing literature, and perhaps the most famous is the article by Tversky & Kahneman (1978). As discussed this example deals purely with the equivalence framing effects. Another good example of pure framing from this point of view is the Broken B experiment from Bruner & Minturn (1955). The presented a symbol that could be interpreted as a B with a slightly detached line, or a 13. They presented this symbol among some number, or some letters, which greatly determined the interpretation of the symbol. As already discussed this narrow definition of equivalence framing is not used fully in this research, but a more broad definition is taken.

In 1981 Tversky and Kahneman elaborated on their original research and identified a specific type of framing, risky choice framing, which Levin et al. (1998) categorized amongst two others, leading to three types of framing effects:

- Goal Framing: When framing the goal in a persuasive message the results of the action are either framed positive or negative (% money saved vs. %money lost). The hypothesis is that negative results tend to have more effects (fine vs. discount) - Levin et al. (2002) found no significant effects in goal framing.
- Attribute Framing: In attribute framing the hypothesis is that subjects perceive an object different when one of the key attributes is framed positive or negative. (% fat vs. % lean in ground beef) - In Levin et al. (2002) this effect was found to be significant
- Risky choice Framing: In the risky choice theory the hypothesis is that subjects will tend to go for the more risky action when results are represented negatively when a choice is given (see the original example Tversky & Kahneman (1981) described above - In Levin et al. (2002) this effect was found to be significant.

For this research of course the latter is most important, when looked at the use of Risk/Safety variable. Levin et al. (1998) describe risky choice framing with the following figure.

Figure 11: Risky choice framing

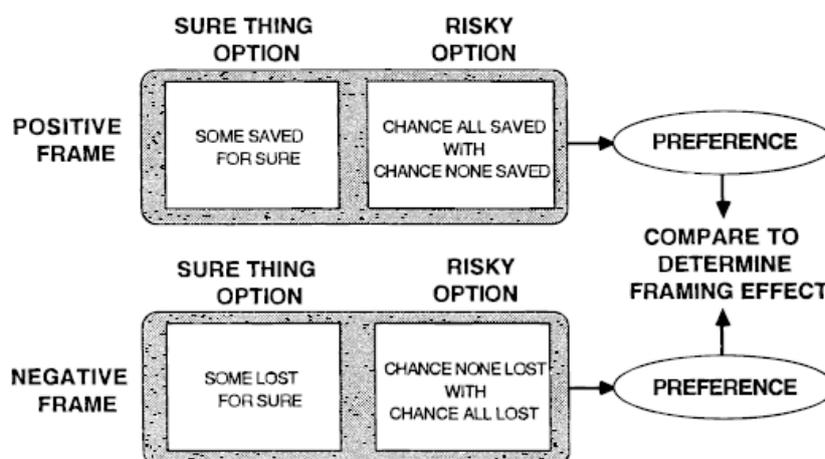This has an important remark that what is measured by a risky choice framing problem is always a risk preference, which is altered by framing. Levin et al. (1998) have found substantial evidence that risky choice framing does occur, but results differ per study. Therefore also the conclusion can be drawn that Risk preference is per definition a subject that can be susceptible to framing effects, following a whole school of framing studies into this phenomenon.

Conclusion: The perception of risk is highly dependent on how the risks are presented.

B.3 Framing literature from Neurology/Cognitive Science

One of the most famous books on framing by Lakoff (2004), 'Don't think of an elephant', a good introduction is given on the "cognitive unconscious structures" that influence framing effects. One of the most important notions Lakoff states that an internal frame, as explained earlier cannot easily be changed. The strength of the frame depends on how often the different (connection of) Neurons has been used and for a frame to change this mental structures repetition is essential.

One of the principles that Lakoff describes explicitly is the principle of systemic causation. From our youth we are continuously trained to the principle of (direct) causation: when we throw a lamp of a table, it breaks. However the concept of 'Systemic Causation' is less obvious for humans to grasp, also because we do not possess any explicit language to describe this. The elements of systemic causation are, as Lakoff (2004, p. 37) describes:

- A network of direct causes – The cause has several steps for it occurs
- Feedback loops – There is a delay for the causation
- Multiple causes – Different sources influence something together
- Probabilistic causation – The causation follows through a chance relation

These elements are in Lakoff's view all, or partly present in a systemic causal relationship. In this research the conclusion is drawn that all are present in risks around sociotechnical projects, and therefore risks are per definition can be seen as systemic causal relationships. This influences therefore the way an audience creates the perspective on these subjects.

In their earlier work Lakoff & Johnson (1980) give some annotations of metaphors in general. An important notion for this research is that the metaphors, to which frames belong, always are shaping the way humans see the world. A frame on itself is therefore not only a way to change perception, but is part of this perception and therefore the issue.

Conclusion: Because the principle of Systemic Causation is essential in the principle of risks, Framing is important and applicable in these situations.

Framing does not only change perception, but can also change the issue itself

B.4 Framing literature from Political Science

The majority of the recent attention on framing follows from the discussion about framing in politics. Even the quite neurological oriented book of Lakoff (2004) as discussed in the former Paragraph was originally sprung from a strong political orientation and as a handbook to Democrats.

And this is very logical. Framing and politics are very much intertwined. Politics deals in essence with a view on the world and selecting certain aspects to highlight and pay attention to. Therefore there are a lot of comparisons between framing and politics.

Examples are numerous. The book of De Bruijn (2011) gives a lot of examples. A conclusion that is relevant for this study is the notion that politics is in essence meant to translate policy into understandable information for voters. (De Bruijn, 2011, p.45) This makes the appliance of framing per definition inevitable. It is not possible to give a complete overview of every problem or policy. Korsten (2013) takes this one step further and defines politics in essence as a *"battle for concurrent frames."* (p. 9) Following from these notions one can conclude that framing is not only a part of politics, but it defines politics as well.

Both conclusions follow from the fact that the political arena always deals with so called *"wicked problems."* Characteristics of wicked problems are originally defined by Rittel & Weber (1973) and later generalized and sharpened by Conklin (2006). For this research the following aspect is considered important when discussing politics:

- Solutions to wicked problems are not right or wrong.

This aspect is important in the discussion about sociotechnical, political, discussions because they are in essence the core of politics: no party has a right or wrong solution, but try to get their solution accepted as the most appropriate solution.

Conclusion: Politicized issues are per definition very susceptible for framing, because the nature of wicked problems.

B.5 Framing literature from Public Administration (Risk Communication)

In public administration a lot of recent research is done into aspects that relate closely to framing: The principle of nudging. For this research we will focus on one specific aspect: risk communication, which in essence is not a part of public administration, but research overlaps.

One of the most interesting recent contributions, dealing with a very concrete situation in the Netherlands from a perspective interesting for this research is Noordegraaf-Eelens et al. (2012). The essay they publish was produced in a program from the Dutch ministry of Internal Affairs dealing with the construction of a governmental vision on the responsibility of the government when dealing with (physical) risks. Noordegraaf-Eelens et al. try to highlight the fact that a government has the assumption that its civilians are risk-averse. The chosen solution is to communicate that risks are as low as possible, constantly emphasizing the minimalistic chance of occurrence. For the sake of simplicity this attitude is further denoted in this research as a "calculation" approach: Risks are acceptable when the (monetized) advantages outweigh the (monetized) damage of the risks.

This strategy is flawed, according to Noordegraaf-Eelens et al.; it does not incorporate the fact that citizens are constantly accepting risks due to several reasons. Aspects as the fact that a person <u>voluntarily</u> accepted the risk or the <u>division</u> of risks are in no way used when communication is done in a calculation-oriented approach.

The authors propose several aspects to improve communication about risks. The first is that when looked at the examples in their study there is always another value at stake when a risk is accepted: Courage, Reciprocity

or Fairness. The authors summarize this to three core orientations towards risk that a party can use when communication about risks. These three strategies are further explained in Paragraph 4.2, but summarized:

- o *Calculation Strategy*: A risk is acceptable if the (monetized) advantages outweigh the (monetized) damage of the risks.
- o *Division Strategy*: A risk is acceptable if different risks are divided equally amongst a population.
- o *Acceptance Strategy*: A risk is acceptable because nothing is without risk, so not accepting means no action at all.

If we combine this with some notions from Sandman (2012):

- Acknowledgement is key to successful risk communication: not stating that risks are low, but provide honesty on the fact risks cannot always be controlled and are in place. (p. 85)
  - o This includes acknowledging points made by your opponent.
- Communication about risks requires training and is dependent on the messenger (p. 126)

Conclusion: Risk framing is more than formulation. It deals also with the core strategy how a communicating party looks at risks.

Successful communication about risks incorporates another value (that is emphasized).

Using a risk communication strategy other than a calculation strategy might also be successful in risk communication.

C. Questions used from pre-survey

Q1.1 Welcome to edX and thank you for taking the survey!   This survey will take about 10 to 15 minutes. Your participation is voluntary, and you will not be penalized for not completing this section. All of the information that you provide here is confidential. Your answers here, combined with your edX course data, may be used in scientific research related - but not confined - to online education.   The research is in accordance with the edX Privacy Policy.

On behalf of the entire DelftX team, thank you very much, Jan Paul van Staalduinen and Mario Grinwis

Q5.1 What is your nationality (country)?

- ○ Afghanistan (1)
- ○ Albania (2)
- ○ Algeria (3)
- ○ Andorra (4)
- ○ Angola (5)
- ○ Antigua and Deps (6)
- ○ Argentina (7)
- ○ Armenia (8)
- ○ Etc.

Q5.2 What is your nationality (country) of your parents?

- ○ Afghanistan (1)
- ○ Albania (2)
- ○ Algeria (3)
- ○ Andorra (4)
- ○ Angola (5)
- ○ Antigua and Deps (6)
- ○ Argentina (7)
- ○ Armenia (8)
- ○ Belarus (16)
- ○ Etc.

Q5.3 Where do you currently live?

- ○ Afghanistan (1)
- ○ Albania (2)
- ○ Algeria (3)
- ○ Andorra (4)
- ○ Angola (5)
- ○ Antigua and Deps (6)
- ○ Argentina (7)
- ○ Armenia (8)
- ○ Etc.

Q5.4 What is your ethnicity?

- ○ Arab (0)
- ○ Asian Indian (1)
- ○ Black / African (2)
- ○ Caucasion / White (3)
- ○ Chinese (4)
- ○ Filipino (5)
- ○ Hispanic / Latino (6)
- ○ Japanese (7)
- ○ Korean (8)
- ○ Native Indian / Indigenous Indian (9)
- ○ Pacific Islander (10)
- ○ Vietnamese (11)
- ○ Other Asian (12)
- ○ Mixed ethnicity (13)
- ○ Other (14) _____

Q5.5 What is your gender?

○ Male (0)
○ Female (1)
○ Other (2)

Q5.6 How old are you?

Q6.1 What is the highest level of education that you have?

○ Doctorate (1)
○ Masters or professional degree (2)
○ Bachelor's degree (3)
○ Associate's degree (4)
○ Secondary / High School (5)
○ Junior high / junior high / middle school (6)
○ Elementary / primary school (7)
○ None (8)
○ Other (9) _____

Q6.2 To what extent are the following values a life-guidance principle to you?

	Not At All (0)	Somewhat (1)	Quite a bit (2)	Very much (3)	Extremely (4)
POWER (social power, authority, wealth) (4)	❍	❍	❍	❍	❍
ACHIEVEMENT (success, capability, ambition, influence on people and events) (5)	❍	❍	❍	❍	❍
HEDONISM (gratification of desires, enjoyment in life, self-indulgence) (6)	❍	❍	❍	❍	❍
STIMULATION (daring, a varied and challenging life, an exciting life) (7)	❍	❍	❍	❍	❍
SELF-DIRECTION (creativity, freedom, curiosity, independence, choosing one's own goals) (8)	❍	❍	❍	❍	❍
UNIVERSALISM (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection) (9)	❍	❍	❍	❍	❍
BENEVOLENCE (helpfulness, honesty, forgiveness, loyalty, responsibility) (10)	❍	❍	❍	❍	❍
TRADITION (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty) (11)	❍	❍	❍	❍	❍
CONFORMITY (obedience, honoring parents and elders, self-discipline, politeness) (13)	❍	❍	❍	❍	❍
SECURITY (national security, family security, social order, cleanliness, reciprocation of favors) (14)	❍	❍	❍	❍	❍

Q6.3 How would you describe your political stance?

○ Liberal (left-wing) (0)
○ Conservative (right-wing) (1)
○ Neutral (2)
○ I'd rather keep this for myself (3)

Q6.7 Which of the following best describes your occupation?

○ Student - full-time (0)
○ Student - part-time (1)
○ Professional - full-time (2)
○ Professional - part-time (3)
○ Unemployed (4)
○ Parent / care-giver (5)
○ Retired (6)
○ Other (7)

D. Questionnaire framing experiment

Q1.1 Exercise on framing   To test how much you have learned from the course we would like to test your ability to frame an environmental issue. The exercise will take about 5 minutes. In addition to the exercise some questions are included to see if frames formulated in the exercise can be related to your background and opinion.   The research will always be in accordance with the edX Privacy Policy.   To perform the required analyses on this survey and use them for scientific purposes, we need your permission to use your input. All data will be processed anonymously and on group level. Participation is voluntary; we will understand if you do not want to give permission and you will not be penalized for it. Also, you can withdraw permission later in the process.

Q45 Please tick one of the following boxes

❍   I do give permission to use my input for scientific purposes (1)
❍   I do not give permission to use my input for scientific purposes (2)

Q1.2 Have you already answered this questionnaire before (in the testing phase)?

❍   Yes (1)
❍   No (2)

Q2.1 I think technological progress is

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Not important at all for our society:Very important for our society (1)	○	○	○	○	○	○	○
Not harmful at all for our society:Very harmful for our society (2)	○	○	○	○	○	○	○

Q2.2 To what extent do you think the following issues are a problem for our society?

	No problem at all (1)	Very small problem (2)	Small problem (3)	Moderate problem (4)	Big problem (5)
Air pollution and smog (1)	○	○	○	○	○
Climate change, global warming (2)	○	○	○	○	○
Ozone depletion (3)	○	○	○	○	○

Q2.3 The following text is adapted from an article, it is shortened drastically, but core elements are maintained.

CO$_2$ Capture and Storage

Background

In the Netherlands, a lot of energy is used. This energy is mainly produced by fossil fuels such as oil, natural gas, and coal. During the production of energy from fossil fuels carbon dioxide (CO$_2$) is released. International agreements have been made to reduce CO$_2$ emissions. Reduction of CO$_2$ can be achieved in several ways. One of these ways is the implementation of CO$_2$ Capture and Storage technology (CCS). The capture and deep underground storage of CO$_2$ is also considered in the Netherlands.

Should the Netherlands implement it?

< Here the appointed frame is shown as explained in appendix E and F.>

Q28.1 Did you participate in any debate on CO2 Capture and Storage before?

❍ No (1)
❍ Yes, my role was: (2) _____

Q28.2 My knowledge of CO2 Capture and Storage before reading the article was:

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Very low, no knowledge:Very high, a lot of knowledge (1)	❍	❍	❍	❍	❍	❍	❍
I had not yet formed an opinion:I had fully formed my opinion (2)	❍	❍	❍	❍	❍	❍	❍

Q28.3 Questions about your opinion on CO2 Capture and Storage (CCS).I think the implementation of CCS is:

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Unfavorable:Favorable (1)	❍	❍	❍	❍	❍	❍	❍
Foolish:Wise (2)	❍	❍	❍	❍	❍	❍	❍
Bad:Good (3)	❍	❍	❍	❍	❍	❍	❍
Harmful:Beneficial (4)	❍	❍	❍	❍	❍	❍	❍

Q28.4 Do you support implementation of CCS?

❍ Yes (1)
❍ No (2)

Q28.5 How certain are you of your opinion?

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)
Uncertain:Certain (1)	❍	❍	❍	❍	❍	❍	❍

Q29.1 As a local citizen living near a potential CCS site I would

❍ not accept the implementation of CCS (1)
❍ accept the implementation of CCS (2)

Q29.2 As a national policy maker I would

❍ implement CCS (1)
❍ not implement CCS (2)

Q30.1 When you think of CO2 Capture and Storage, what kind of elements do you think about? Please list as many thoughts as you have. Enter your answers in the boxes below. List only one thought in each box. Use as many boxes as you need.Please state your thoughts as concisely as possible; one word is often sufficient

Q30.2 Now think of three (or less) frames that can be used in the debate around CCS:

		This frame can be used to:	
		Promote CCS (1)	Oppose CCS (2)
Frame 1		○	○
Frame 2		○	○
Frame 3		○	○

Q31.1 In my view the text I have read (a few pages ago) was:

	1 (1)	2 (2)	3 (3)	4 (4)	5 (5)	6 (6)	7 (7)	8 (8)
Not Manipulative:Manipulative (1)	❍	❍	❍	❍	❍	❍	❍	❍
Short:Long (2)	❍	❍	❍	❍	❍	❍	❍	❍
Not informative at all:Very informative (3)	❍	❍	❍	❍	❍	❍	❍	❍
Objective:Subjective (4)	❍	❍	❍	❍	❍	❍	❍	❍

Q31.2 The following element was most influential on my opinion on CCS:

❍ The messenger (John) (1)
❍ The opinion of the messenger (2)
❍ The safety/risk concerns in general (3)
❍ The height of the risk/safety issues (4)
❍ The division of risks amongst regions (5)
❍ The possibility to carry out any project if there are risks/safety issues (6)
❍ Other: (7) _____

Q32.1 You are at the end of this survey. Thanks a lot for cooperating!

DISCLAIMER: The percentages used in the article were fictitious and not realistic.

This survey had two goals. First we are interested in your framing capabilities. Second we will assess the effect of how emphasis on different aspects in the CCS discussion can influence opinion on CCS. You were assigned randomly to one of 24 different versions of an article. We created this article ourselves, to make it possible to vary experimental dimensions. It was relevant for the research objective to make you believe the article was real.

 If you have any questions regarding this research, please contact Gerdien de Vries (g.devries-2@tudelft.nl)

E. Different frames used

For the frame two types were used: frame that promoted CCS, and frames that opposed CCS. In this appendix the frames are shown as a menu of choice: Different frames were constructed by selecting one option from each row.

First the general introduction was inserted. This general introduction text was almost literally adopted from De Vries et al. (2014):

CO_2 Capture and Storage

Background

In the Netherlands, a lot of energy is used. This energy is mainly produced by fossil fuels such as oil, natural gas, and coal. During the production of energy from fossil fuels carbon dioxide (CO_2) is released. International agreements have been made to reduce CO_2 emissions. Reduction of CO_2 can be achieved in several ways. One of these ways is the implementation of CO_2 Capture and Storage technology (CCS). The capture and deep underground storage of CO_2 is also considered in the Netherlands.

Should the Netherlands implement it?

<Here one of the frames was inserted, or for the neutral group nothing was inserted and the heading was removed.>

Positive frames

The different variables as described in Paragraph 4.2.1. that were tested in this research were converted into frames using Excel. The scheme below describes the different variations that were used to do so for the positive frames. The scheme can be read from top to bottom, selecting 1 option from each row and then in this way constructing a frame.

Messenger Options:	According to John van der Heijden, CEO of an oil company in the Netherlands: "	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "		
Communication Strategy options:	The <Risks/Safety Number>		Division of advantages & disadvantages is fair amongst regions in the Netherlands, in other regions different civilians have the same issues with	Without
Pure Framing (Risk/Safety)	Safety of CO2 Capture & Storage is very high with a chance of no leakage of 98%.	Risks of CO2 Capture & Storage are very low with a chance of leakage of 2%.	Risks/Safety	Risks/Safety
Continuing			of other projects. Here the citizens benefit also from the advantages there.	issues no project could ever be carried out. Development of anything would be impossible.

Figure 12: Possibilities for positive frames

Leading to the following 12 **positive** frames:

According to John van der Heijden, CEO of an oil company in the Netherlands: "Safety of CO2 Capture & Storage is very high with a chance of no leakage of 98%. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, CEO of an oil company in the Netherlands: "Division of advantages & disadvantages is fair amongst regions in the Netherlands, in other regions different civilians have the same issues with risks of other projects. Here the citizens benefit also from the advantages there. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "Without risks issues no project could ever be carried out. Development of anything would be impossible. So CCS should be allowed in the Netherlands.''
According to John van der Heijden, CEO of an oil company in the Netherlands: "Division of advantages & disadvantages is fair amongst regions in the Netherlands, in other regions different civilians have the same issues with safety of other projects. Here the citizens benefit also from the advantages there. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, CEO of an oil company in the Netherlands: "Without safety issues no project could ever be carried out. Development of anything would be impossible. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "Risks of CO2 Capture & Storage are very low with a chance of leakage of 2%. So CCS should be allowed in the Netherlands.''
According to John van der Heijden, CEO of an oil company in the Netherlands: "Without risks issues no project could ever be carried out. Development of anything would be impossible. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "Safety of CO2 Capture & Storage is very high with a chance of no leakage of 98%. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "Division of advantages & disadvantages is fair amongst regions in the Netherlands, in other regions different civilians have the same issues with risks of other projects. Here the citizens benefit also from the advantages there. So CCS should be allowed in the Netherlands.''
According to John van der Heijden, CEO of an oil company in the Netherlands: "Risks of CO2 Capture & Storage are very low with a chance of leakage of 2%. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "Division of advantages & disadvantages is fair amongst regions in the Netherlands, in other regions different civilians have the same issues with safety of other projects. Here the citizens benefit also from the advantages there. So CCS should be allowed in the Netherlands.''	According to John van der Heijden, energy scientist at a university of technology in the Netherlands: "Without safety issues no project could ever be carried out. Development of anything would be impossible. So CCS should be allowed in the Netherlands.''

Table 37: Positive frames

Negative frames

The different variables as described in Paragraph 4.2.1. that were tested in this research were converted into frames using Excel. The scheme below describes the different variations that were used to do so for the negative frames. The scheme can be read from top to bottom, selecting 1 option from each row and then in this way constructing a frame.

Messenger Options:	According to John van der Heijden, CEO of an oil company in the Netherlands:	According to John van der Heijden, representative of an environmental agency in the		
Communication Strategy options:	The <Risks/Safety Number>		Division of advantages & disadvantages is unfair, citizins living near CCS will	There can never be certainty about the
Pure Framing	Safety of CO2 Capture & Storage is very low with a chance of no leakage of 98%.	Risks of CO2 Capture & Storage are very high with a chance of leakage of 2%.	Risks/Safety	Risks/Safety
Continuing			issues for the whole country.	, so we should play on the safe side in this project and not carry
Positive	So CCS should not be allowed in the Netherlands.			

Figure 12: Possibilities for negative frames

Leading to the following 12 **negative** frames:

According to John van der Heijden, CEO of an oil company in the Netherlands: "Safety of CO2 Capture & Storage is very low with a chance of no leakage of 98%. So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, CEO of an oil company in the Netherlands: "Division of advantages & disadvantages is unfair, citizens living near CCS will carry all risks issues for the whole country. So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, representative of an environmental agency in the Netherlands: "There can never be certainty about the risks, so we should play on the safe side in this project and not carry out irresponsible experiments. So CCS should not be allowed in the Netherlands.''
According to John van der Heijden, CEO of an oil company in the Netherlands: "Division of advantages & disadvantages is unfair, citizins living near CCS will carry all safety issues for the whole country.So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, CEO of an oil company in the Netherlands: "There can never be certainty about the safety, so we should play on the safe side in this project and not carry out irresponsible experiments. So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, representative of an environmental agency in the Netherlands: "Risks of CO2 Capture & Storage are very high with a chance of leakage of 2%. So CCS should not be allowed in the Netherlands.''
According to John van der Heijden, CEO of an oil company in the Netherlands: "There can never be certainty about the risks, so we should play on the safe side in this project and not carry out irresponsible experiments. So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, representative of an environmental agency in the Netherlands: "Safety of CO2 Capture & Storage is very low with a chance of no leakage of 98%. So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, representative of an environmental agency in the Netherlands: "Division of advantages & disadvantages is unfair, citizins living near CCS will carry all risks issues for the whole country.So CCS should not be allowed in the Netherlands.''
According to John van der Heijden, CEO of an oil company in the Netherlands: "Risks of CO2 Capture & Storage are very high with a chance of leakage of 2%. So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, representative of an environmental agency in the Netherlands: "Division of advantages & disadvantages is unfair, citizins living near CCS will carry all safety issues for the whole country. So CCS should not be allowed in the Netherlands.''	According to John van der Heijden, representative of an environmental agency in the Netherlands: "There can never be certainty about the , so we should play on the safe side in this project and not carry out irresponsible experiments. So CCS should not be allowed in the Netherlands.''

Table 38: Negative frames

F. Data preparation

Several steps have been carried out to prepare the data for analysis. First the data was cleaned. Therefore incomplete responses were removed and respondents that not gave permission to use their information were removed. After this, in another dataset data from the pre-survey was coupled to the experimental data. Both steps are discussed explicitly in Paragraph 4.1.

Second the four scales for the opinion on CCS were combined into one indicator: opinion. This was verified by testing the reliability of the scale, with a Cronbach's alpha of **0,945** this reliability was found to be high enough.

Third the frame numbers were used to determine the value of the four different independent variables. The conversion table is shown below.

Frame	Direction	Messenger	Risk/Safety	Strategy	Direction	Messenger	Risk/Safety	Strategy
0	0	0	0	0	0	0	0	0
1	Positive	Biased	safety	Calculate	1	-1	1	1
2	Positive	Biased	safety	Divide	1	-1	1	2
3	Positive	Biased	safety	Accept	1	-1	1	3
4	Positive	Biased	risks	Calculate	1	-1	-1	1
5	Positive	Biased	risks	Divide	1	-1	-1	2
6	Positive	Biased	risks	Accept	1	-1	-1	3
7	Positive	Unbiased	safety	Calculate	1	1	1	1
8	Positive	Unbiased	safety	Divide	1	1	1	2
9	Positive	Unbiased	safety	Accept	1	1	1	3
10	Positive	Unbiased	risks	Calculate	1	1	-1	1
11	Positive	Unbiased	risks	Divide	1	1	-1	2
12	Positive	Unbiased	risks	Accept	1	1	-1	3
13	Negative	Biased	safety	Calculate	-1	-1	1	1
14	Negative	Biased	safety	Divide	-1	-1	1	2
15	Negative	Biased	safety	Accept	-1	-1	1	3
16	Negative	Biased	risks	Calculate	-1	-1	-1	1
17	Negative	Biased	risks	Divide	-1	-1	-1	2
18	Negative	Biased	risks	Accept	-1	-1	-1	3
19	Negative	Unbiased	safety	Calculate	-1	1	1	1
20	Negative	Unbiased	safety	Divide	-1	1	1	2
21	Negative	Unbiased	safety	Accept	-1	1	1	3
22	Negative	Unbiased	risks	Calculate	-1	1	-1	1
23	Negative	Unbiased	risks	Divide	-1	1	-1	2
24	Negative	Unbiased	risks	Accept	-1	1	-1	3

Table 39: Conversion of frames to variables

Fourth some interaction variables were created to test several interaction effects; these were created by multiplying or adding variables to create unique labels.

Furthermore 5 variables were created by converting elements and frames mentioned by respondents in the usage of certain language elements. In the table below the way this is done is shown.

Variable	Computation
Use of the word Risk	AANTAL.ALS(G1:O1;"*risk*")
Use of the word Safe	AANTAL.ALS(G1:O1;"*safe*")
Use of the word fair/division/divide	AANTAL.ALS(G1:O1;"*fair*")+AANTAL.ALS(G1:O1;"*divi*")+AANTAL.ALS(G1:O1;"*people*")
Use of the word high/low, numbers or percentages	AANTAL.ALS(G1:O1;"*high*")+AANTAL.ALS(G1:O1;"*low*")+AANTAL.ALS(G1:O1;"*height*")+AANTAL.ALS(G1:O1;"*1*")+AANTAL.ALS(G1:O1;"*9*")+AANTAL.ALS(G1:O1;"*%*")
Use of the word accept and impossible	AANTAL.ALS(G1:O1;"*accept*")+AANTAL.ALS(G1:O1;"*impossible*")

Table 40: Computation of language variables

The words tested for the strategies were selected based on Noordegraaf-Eelens et al. (2012). In their research different examples of frames are mentioned, but more importantly the different levels of argumentation belonging to each strategy (p. 32). In their study they base the argumentations on basic branches found in ethics: *utilism, deontology* and *value-ethics*.

G. Variables in final dataset

No.	Variable Name	Description	Question from Survey:
1	City	City	Deduced from location by Qualtrics
2	State	State	Deduced from location by Qualtrics
3	Country	Country	Deduced from location by Qualtrics
4	Frame	Frame	Frame that a respondent have been shown
5	TechProgress	Attitude towards Technological Progress	I think technological progress is-Not important at all for our society:Very important for our society
6	TechHarmful	Attitude towards Technological Harmfullness	I think technological progress is-Not harmful at all for our society:Very harmful for our society
7	AirPollution	Attitude towards Airpollution as problem	To what extent do you think the following issues are a problem for our society?-Air pollution and smog
8	ClimateChange	Attitude towards ClimateChange as problem	To what extent do you think the following issues are a problem for our society?-Climate change, global warming
9	OzoneDepletion	Attitude towards OzoneDepletion as problem	To what extent do you think the following issues are a problem for our society?-Ozone depletion
10	Participate	Participation in debate before surve	Did you participate in any debate on CO2 Capture and Storage before?
11	ParticipateText	Explanation on role of participation	Did you participate in any debate on CO2 Capture and Storage before?-TEXT
12	PrevKnowledge	Amount of previous knowledge	My knowledge of CO2 Capture and Storage before reading the article was:-Very low, no knowledge:Very high, a lot of knowledge
13	PrevOpinion	How much a respondent had already formed an opinion	My knowledge of CO2 Capture and Storage before reading the article was:-I had not yet formed an opinion:I had fully formed my opinion
14	Opinion1	Perception measure: Unfavorable-Favorable	Questions about your opinion on CO2 Capture and Storage (CCS). I think the implementation of C...-Unfavorable:Favorable
15	Opinion2	Perception measure: Foolish-Wise	Questions about your opinion on CO2 Capture and Storage (CCS). I think the implementation of C...-Foolish:Wise

No.	Variable Name	Description	Question from Survey:
16	Opinion3	Perception measure: Bad-Good	Questions about your opinion on CO2 Capture and Storage (CCS). I think the implementation of C...-Bad:Good
17	Opinion4	Perception measure: Harmful-Beneficial	Questions about your opinion on CO2 Capture and Storage (CCS). I think the implementation of C...-Harmful:Beneficial
18	Support	Support for CCS as self	Do you support implementation of CCS?
19	Certainty	Certaint of opinion on CCS	How certain are you of your opinion?-Uncertain:Certain
20	SupportLocal	Support for CCS as local citizen	As a local citizen living near a potential CCS site I would
21	SupportNational	Support for CCS as policymaker	As a national policy maker I would
22	Element1	Thought on CCS	When you think of CO2 Capture and Storage, what kind of elements do you think about? Please list...-Thought 1
23	Element2	Thought on CCS	When you think of CO2 Capture and Storage, what kind of elements do you think about? Please list...-Thought 2
24	Element3	Thought on CCS	When you think of CO2 Capture and Storage, what kind of elements do you think about? Please list...-Thought 3
25	Element4	Thought on CCS	When you think of CO2 Capture and Storage, what kind of elements do you think about? Please list...-Thought 4
26	Element5	Thought on CCS	When you think of CO2 Capture and Storage, what kind of elements do you think about? Please list...-Thought 5
27	Element6	Thought on CCS	When you think of CO2 Capture and Storage, what kind of elements do you think about? Please list...-Thought 6
28	Frame1	Frame constructed on CCS	Now think of three (or less) frames that can be used in the debate around CCS: : -Frame 1-
29	Frame2	Frame constructed on CCS	Now think of three (or less) frames that can be used in the debate around CCS: : -Frame 2-
30	Frame3	Frame constructed on CCS	Now think of three (or less) frames that can be used in the debate around CCS: : -Frame 3-
31	Frame1Opinion	Direction of Frame 1	Now think of three (or less) frames that can be used in the debate around CCS: : This frame can be used to:-Frame 1
32	Frame2Opinion	Direction of Frame 2	Now think of three (or less) frames that can be used in the debate around CCS: : This frame can be used to:-Frame 2
33	Frame3Opinion	Direction of Frame 3	Now think of three (or less) frames that can be used in the debate around CCS: : This frame can be used to:-Frame 3

No.	Variable Name	Description	Question from Survey:
34	TextManipulative	Perceived manipulativity of tekst	In my view the text I have read (a few pages ago) was:-Not Manipulative:Manipulative
35	TextLength	Perceived length of tekst	In my view the text I have read (a few pages ago) was:-Short:Long
36	TextInformative	Perceived informativity of tekst	In my view the text I have read (a few pages ago) was:-Not informative at all:Very informative
37	TextObjective	Perceived objectivity of tekst	In my view the text I have read (a few pages ago) was:-Objective:Subjective
38	MostInfluential	Element most influential on opinion	The following element was most influential on my opinion on CCS:
39	Nationality	Nationality	What is your nationality (country)?
40	NationalityParents	Nationality of Parents	What is your nationality (country) of your parents?* *the list includes "Mixed nationality"
41	LivingPlace	Living Place	Where do you currently live?
42	Ethnicity	Ethnicity	What is your ethnicity?
43	EthnicityText	Ethnicity - Open answer other	What is your ethnicity?-TEXT
44	Gender	Gender	What is your gender?
45	Age	Age	How old are you?
46	EducationLevel	Highest level of education	What is the highest level of education that you have?
47	EducationlevelText	Highest level of education - Open answer other	What is the highest level of education that you have?-TEXT
48	Power	Score on Value: Power	To what extent are the following values a life-guidance principle to you?-POWER (social power, authority, wealth)
49	Achievement	Score on Value: Achievement	To what extent are the following values a life-guidance principle to you?-ACHIEVEMENT (success, capability, ambition, influence on people and events)
50	Hedonism	Score on Value: Hedonism	To what extent are the following values a life-guidance principle to you?-HEDONISM (gratification of desires, enjoyment in life, self-indulgence)
51	Stimulation	Score on Value: Stimulation	To what extent are the following values a life-guidance principle to you?-STIMULATION (daring, a varied and challenging life, an exciting life)
52	SelfDirection	Score on Value: SelfDirection	To what extent are the following values a life-guidance principle to you?-SELF-DIRECTION (creativity, freedom, curiosity, independence, choosing one's own goals)

No.	Variable Name	Description	Question from Survey:
53	Universalism	Score on Value: Universalism	To what extent are the following values a life-guidance principle to you?- UNIVERSALISM (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection)
54	Benevolence	Score on Value: Benevolence	To what extent are the following values a life-guidance principle to you?- BENEVOLENCE (helpfulness, honesty, forgiveness, loyalty, responsibility)
55	Tradition	Score on Value: Tradition	To what extent are the following values a life-guidance principle to you?- TRADITION (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty)
56	Conformity	Score on Value: Conformity	To what extent are the following values a life-guidance principle to you?- CONFORMITY (obedience, honoring parents and elders, self-discipline, politeness)
57	Security	Score on Value: Securit	To what extent are the following values a life-guidance principle to you?- SECURITY (national security, family security, social order, cleanliness, reciprocation of favors)
58	PoliticalStance	Political Stnce	How would you describe your political stance?
59	Occupation	Occupation	Which of the following best describes your occupation?
60	EnvironmentConcerns	Concern for Environment	Constructed from 7,8,9: Average
61	Opinion	Total opinion on CCS	Constructed from 14,15,16,17: Average
62	RoundedOpinion	Rounded total opinion on CCS	Constructed from 61: Rounded
63	NegPos	Positive/Negative frame	Constructed from Frames
64	Independence	Independent/Biased Messenger frame	Constructed from Frames
65	RiskSafety	Risk/Safety frame	Constructed from Frames
66	Strategy	Calculation/Division/Acceptation frame	Constructed from Frames
67	NegPos_num	Positive/Negative frame - coded	Constructed from Frames
68	Independence_num	Independent/Biased Messenger frame - coded	Constructed from Frames
69	RiskSafety_num	Risk/Safety frame - coded	Constructed from Frames
70	Strategy_num	Calculation/Division/Acceptation frame - coded	Constructed from Frames

H. Selection of factors

In this appendix the selection of criteria the shortlist of factors is shown. This selection was carried out by ranking all factors from the longlist on five criteria:

- Number of studies with proven effect: Specific preference for studies on technical subjects
- Possibility to generalize
- The expectation to have interaction effects with other effects
- Factors that were not researched specifically for CCS had a preference
- Factors that had a practical (policy) applicability were given preference
- Simplicity to measure a factor.

Factor	Number of studies	Generalize	Interaction	Addition to literature	Practical	Simple to measure
Independence of messenger (credibility)	+	+	++	+	++	+
Use of the word Risk vs. Safety	+	++	+	++	++	+
Risk communication strategies	0	++	+	++	++	0
Gender	++	+	++	+	+	++
Age	++	+	++	+	+	++
Knowledge on technology	+	+	++	+	+	++
Attitude towards technology	+	+	++	+	+	++
Attitude towards environment	+	+	++	+	+	++
Political orientation	+	+	++	+	++	++
Values of respondents	++	+	++	+	0	++
Country	0	+	++	+	0	++
Level of education	+	+	++	+	+	++

Factor	Number of studies	Generalize	Interaction	Addition to literature	Practical	Simple to measure
Holistic/Analytic processing method	++	+	++	+	0	0
Newspaper Reading	+	+	+	+	+	+
Age of messenger	+	+	+	+	++	0
Gender of messenger	+	+	+	+	++	0
Emotion of messenger	+	+	+	+	++	0
Include (more) values	++	++	+	+	0	0
3P-model	0	+	++	++	++	-
Hero/Villain/Victim model	+	+	+	++	+	0
Goal framed Positive/Negative (Gain vs. Loss)	++	+	0	0	+	+
Goal (risks) framed in lives/money/feelings	++	+	0	0	+	+
Play with scale effects: size of problem	+	-	0	+	0	-
Keep options open/be Certain	+	+	+	++	+	-
Play with denials	++	+	+	0	+	+
Win-Win/Win-Lose/Complete story	++	0	0	0	+	+
Ask for actions/feeling/facts	++	0	0	+	++	0
Frame effects as short vs. long term	+	+	0	+	+	0
let frame solve dilemma	0	0	+	++	+	0
Rational/Experiential decision making method (CEST)	++	+	++	0	0	-
Openness to alternatives in general	+	+	+	+	0	+
Need for confirmation/Self-confidence	+	+	+	+	-	0
Experience with problem	+	0	+	+	+	+

Factor	Number of studies	Generalize	Interaction	Addition to literature	Practical	Simple to measure
Stubbornness	++	+	+	0	0	0
Level of income	++	+	0	+	+	+
Need for cognition	+	+	+	+	+	-
Medium	0	++	+	++	++	-
Background information	+	++	+	+	+	0
Amount of frames shown	++	+	0	+	+	+
Frame multiple problems	+	+	+	+	+	0
Use of the word Stockage vs. Storage	0	0	+	++	++	+
Partner up with NGO	0	+	+	+	++	0
Split up in Capture, Transport and Storage	0	0	0	++	++	+
Presentation as 'mythical solution'	0	0	+	+	+	+
Repetition/length/complexity	+	+	+	+	+	0
Inclusion of Irrelevant information	+	+	+	+	+	+
Emphasis on local benefits or context	+	0	+	++	+	0
Difference between regions	0	+	+	+	+	+
Include monitoring information	0	0	+	++	++	0
Involvement in the CCS-project	+	0	+	++	+	0

Table 41: Selection of Factors

The factors that were selected for the empirical research are marked bold; the factors selected for the shirt list are marked italic.