Improving Public Acceptance of Carbon Capture and Storage (CCS) in China

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Abstract. Carbon Capture and Storage (CCS) refers to a set of technologies that can be installed for the reduction of carbon dioxide (CO2) emissions in power generation and industrial processes. CCS is a priority option for China to combat climate change, but its public acceptance remains a bottleneck for its promotion. This study explored the influences of social norm effects and framing effects on improving CCS public acceptance in China. A randomized control trial (RCT) experiment of 2 (with vs. without social norms) × 2 (gain vs. loss frames) was conducted in an online survey. The results revealed that social normative information exerted significant effects on improving participants’ CCS acceptance level, whereas framed information had no salient influences on participants’ attitudes. The advantages of social norms are inspiring and recommendable for China’s CCS public communication strategies.

1. Introduction
China heavily relies on fossil fuels for energy supply and is the world’s top CO2 emitter. To tackle the severe pressure of climate change, China has been seeking effective technologies to reduce its CO2 emission. Experts expect Carbon Capture and Storage (CCS) technology to play an important role for this purpose. CCS refers to a set of technologies that can be installed for the reduction of carbon dioxide (CO2) emissions in power generation and industrial processes. Its procedure consists of the separation of CO2 from large industrial and energy-related sources (large power plants, refineries, the steel-making industry, natural gas production plants, etc.), subsequent compression, and transportation to a storage location deep below the earth surface and long-term isolation from the atmosphere (in geological formations such like unminable coal beds, deep saline aquifers or rock pores) [1-2].

In recent years, CCS trial application has been developing rapidly in China, but the lack of public awareness and acceptance is still a bottleneck of its large scale deployment [3-5]. This study is set to explore the influences of social norm effects and framing effects on participants’ acceptance of CCS with the purpose of inspiring new thinking for CCS public communication strategies.
1.1. Social norms and CCS acceptance
Social norms refer to the shared beliefs how individual group members ought to behave in a given situation. The group in which social norms prevail can be a family, a peer group, an organization or even a whole society [6]. The comparison theory suggests that it is a universal psychological phenomenon that people try to insure the correctness/appropriateness of their attitudes/behaviors by comparing with others [7]. The evidences provided by existing studies showed that social norms have strong influences on people’s environmental attitudes [8-9], and as public environmental awareness awakened, social norm effects may demonstrate special values for the promotion of environment projects [10].

Based on these theories and suggestions, we make our first hypothesis:
H1. CCS information with social norms is more effective to win support than the same information without social norms.

1.2. Framing effects and CCS acceptance
Kahneman and Tversky revealed that people’s choice preference shifted when they were presented with identical information with positive or negative emphasis, and called this phenomenon “framing effects” [11]. According to the theory, telling people that using cloth bags for one year may save 1 dolphin (gain frame) is not as persuasive as telling them that using plastic bags for one year may kill 1 dolphin (loss frame), even though the fact is identical. Framing effects has shown its value on public decisions in the fields of environment protection and energy conservation [12-13]. In our study, we expect the advantages of CCS depicted in a loss frame can more effectively improve participants’ CCS acceptance level than in a gain frame, and make the second hypothesis:
H2. Loss frame is more persuasive than gain frame to win support for CCS.

2. Methods

2.1. Participants
Our participants were 209 undergraduates from a university in Shandong Province (56.65% women, M_age = 19.70, SD = 1.80), an online survey of randomized control trial was conducted with them. They were informed that their personal information would be kept confidential and the survey was in compliance with the ethnical standard of the CAS Ethics Committee.

2.2. Materials and procedure
Electronic questionnaires were used in the 2 (with vs. without social norms) × 2 (gain vs. loss frames) between-subject study. Participants first provided their demographic information (birth date, gender, educational level), and stated their pre-knowledge of CCS. Then they read a brief and authentic description of CCS technology, and were presented with the experimental interventions which combined social norms and gain/loss framing. The normative message was from a survey conducted by CAS scholars on CCS public attitudes and concerns [14], which showed 80.4% of their subjects supported CCS. The four experimental conditions of our study created four experimental groups: Group A and B were with the gain frame which described the shares that CCS could contribute to CO2 emission reduction and the positive climate scenarios; Group C and D were with the loss frame which stated the shares of CO2 emission reduction that might not be realized without CCS application and the negative climate scenarios; Group A and C were presented with social normative message. We randomly assigned participants to one of the four experimental conditions, and evaluated their CCS acceptance level with 3 questions.

3. Results

3.1. Pre-survey knowledge of CCS
Participants’ self-reported scores showed that most of them had zero awareness of CCS before the survey (Figure 1).

Figure 1. Participants’ Pre-knowledge of CCS

3.2. The influence of normative and framed information on CCS acceptance
IMB SPSS Statistics 23 software was used to analyse the reliability of our data. The Cronbach’s $\alpha$ was 0.972 among the three questions evaluating participants’ CCS acceptance level, indicating an excellent data reliability. Therefore, the mean scores of the three items was used to represent participants’ CCS acceptance. Then we conducted a $2 \times 2$ ANOVA with the social normative message and the framed information as the independent variables and the CCS acceptance as the dependent variable. The social normative message had a significant effect on the CCS acceptance. The support degree of CCS was stronger when the normative information was included (M = 6.15, SD = 1.06) versus not included (M = 5.78, SD = 1.26; F (1, 205) = 5.90, $p = 0.02$). The main effect of the framed information on the CCS acceptance was insignificant. There was no difference of the CCS acceptance levels between the gain framing group (M = 5.95, SD = 1.16) and the loss framing group (M = 5.98, SD = 1.20; F (1, 205) = 0.27, $p = 0.60$). The interactive effect of social norms and framed information on CCS acceptance was insignificant (F (1, 205) = 0.95, $p = .33$).

4. Discussion
The current study tested the influences of social norm effects and framing effects on participants’ CCS acceptance level. The study results showed that social norm effects had a saliently positive influence whereas framing effects were ineffective, these results revealed some meaningful implications for CCS public communication policy.

4.1. Results of social norm effects
Our Hypothesis 1 has been proved that information with social norms is more effective to win participants’ support for CCS than the same information without social norms. As the comparison theory revealed, most of our participants had not enough knowledge to make firm judgments about CCS and tended to seek reference of other people’s opinion [7]. For the participants of the social norm groups, “other people’s supportive attitudes” reduced their attitude ambivalence and enhanced their agreeing levels with CCS. As some important studies on social norm effects revealed, these participants measured heuristically what was the correct attitude to take by comparing with the
normative message. They took the message as a short-cut of information processing and decision-making, and made the same choice as “many others did” in seeking clues of the best choices. By following the social normative message, they presumably avoided making wrong judgements, socially or cognitively [15-17].

4.2. Results of framing effects
Contrary to Hypothesis 1, the analytical results didn't support our Hypothesis 2. The results showed that gain/loss frames did not produce salient influences on participants’ attitudes. Based on related existing studies, we attribute these results to two elements: 1. The social significance of CCS. CCS is a transitional solution for CO2 emission reduction, its “uncertain” influences may benefit all or cost huge social prices. Such a social significance is beyond the cognitive illusion or mental computational errors induced by information framing [18]. 2. Participants' self-involvement in the decision problem. They were not only making choices for the general social benefit, but also found their own environmental benefits and safety were involved in. The double dimensions of decision-making are similar with Zhao’s study (2010) which showed that information framing could not affect people’s judgments of the vital public issue of social justice which related to every one’s important interest [19]. While social norms made participants assured of CCS benefits with the reference of many others’ opinion, gain/loss frames of CCS advantages failed to elicit better attitudes in the circumstances due to the influences of the two elements.

4.3. Implications for CCS public communication strategies
The significant effects of social norms in our study implies that social norm effects can be adopted as a new strategy of public communication for CCS promotion. Social norms often exert a subtle influence on people’s attitudes without their clear awareness. This attribute makes it highly instrumental for improving CCS public acceptance. We recommend that normative message of CCS should be shaped intentionally in the process of CCS publicity to serve for the desirable goal of CCS development. The practice can include first getting the support of people with higher education and use their opinions as normative messages. Some previous studies on Chinese public attitudes of CCS with participants of higher educational background showed high supportive rates [14,3,5]. Given the publicity channels of CCS is currently very limited in China, and the understanding abilities of the technology is diversified among the public, supportive attitudes of people with higher education may play a leading role in the public attitude shaping process.

5. Conclusions
Participants' attitudes toward CCS were placed under the intervention of social norms and gain/loss frames in a randomized control trial (RCT) experiment. The results demonstrated that social normative information significantly improved participants CCS acceptance, but gain/loss frames showed no effects. We recommend social norm effects to be adopted as a new strategy of CCS public communication in China.

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