Climate change mitigation in aging societies: Motivational and cognitive aspects

C. Degen; H. Fischer; J. Funke; T. Goeschl;
S. Kettner; J. Lohse; C. Schwieren; J. Schröder
The University of Heidelberg

September 14, 2012

Abstract

The success of mitigating climate change depends on actions taken within the upcoming four decades. In Western societies, this timeframe coincides with a demographic shift increasing the age of the median voter and decision maker. The willingness to contribute to climate change mitigation may decrease with age since the benefits may lie beyond the life span whereas the costs are immediate.

In several experimental studies, we investigate cognitive limitations and motivational factors in relation to climate change mitigation. In a first set of studies subjects are given the chance to invest up to 10€ into the reduction of CO_2 via the EU ETS. Contrary to theoretical considerations, we find evidence for a strong and positive effect of age. Furthermore we show that social cues can be used to influence contributions.

Moreover we demonstrate that independent of age most subjects are able to understand complex stock flow problems if the mode of presentation is adequate. System thinking ability is not firmly linked with a motivation to contribute to climate change mitigation. In a training study we show however that an increase of information about climate change can lead to a reduction of contributions.

Draft only: Do not quote without explicit permission

1 Introduction

Within the next 50 years the industrialized world will face two large trends: the process of climate change on the one hand and a demographic shift towards an aging society on the other hand. It is currently assumed that the percentage of eligible voters above the age of 60 will rise from currently 22% to 49% by 2050 (Stat. Bundesamt, 2008). From this particular constellation emerges an important research question: How will aging societies react to the challenges of climate change mitigation, which may - due to their complex nature - not be fully understood and of whose effectiveness growing numbers of political decision makers and voters will not benefit personally due to their own age?

Climate change can be tackled if effective management strategies are operative. However, in democratic societies two preconditions need to be met. First, the aging voter has to fully grasp the complex processes underlying climate change – including the temporal dimensions – in order to recognize the necessity of acting upon it as soon as possible. The level of understanding is dependent on various cognitive capacities, including executive functioning, such as abstract thinking skills and the ability to plan and act strategically (Schönknecht et al., 2005; Toro et al., 2009). Current estimations based on longitudinal studies find that approximately 25% of people in the mid-sixties and even 30% of people in the mid-seventies suffer from verifiable cognitive decline. Thus, it seems conceivable that a certain percentage of political decision makers are overburdened to some degree with this cognitive demand. At the same time however, age may be associated with a richer set of experiences and thus may be beneficial to the decision making process. Second, the political decision maker has to be sufficiently motivated to invest into costly climate change mitigation policies. The assumption that humans are mainly driven by the advancement of their own benefits makes it plausible that an aging society will not be sufficiently motivated to invest in such strategies due to a conflict between the relative longevity of potential effects and the limited lifespan of the decision makers.

In the following studies two differential approaches are administered to investigate the motivational basis of climate change mitigation behavior on the one hand and the cognitive basis of understanding climate change on the other hand by drawing on analytic tools from experimental economics and psychology. In the first part of the paper we present two experiments investigating participants' willingness to invest in the retirement of emission permissions via EU ETS and the potential role of social influence on these decisions. Afterwards, the relation of cognitive capacity and understanding of the underlying structure of the climate system is investigated in a third set of experiments. In this context differential explanatory approaches are examined to advance risk communication to the general public.

2 Study 1 and 2: Motivation and aging societies

2.1 Theoretical considerations

Without doubt climate change mitigation is a long term investment. Due to the longevity of greenhouse gases in the atmosphere there is a temporal divergence between their reduction and the resulting impacts on the climate system (Hasselmann et al., 2003). In societies where the median decision maker, as a consequence of demographic change, is aging this property can influence the incentives to abate CO_2 and other greenhouse gases. While climate change mitigation faces the usual freerider incentives resulting from the social dilemma of non-rival and non-excludable benefits, a temporal freeriding incentive potentially aggravates provision: The current aging generation has to carry mitigation cost that produce benefits that mainly accrue to future generations. From this theoretical perspective the prospects for extensive climate change mitigation are diminished in aging societies. At the core of these considerations stands the assumption that all individuals are mainly driven by the advancement of their own benefit. The last decade of experimental evidence in economics puts this assumption into perspective (e.g. Fehr & Schmidt, 1999; Fehr & Gächter, 2002). While this evidence points at the existence of altruistic motivations as a stable finding in student samples, very little is known about the validity of these findings in more general samples. The objective of our study is to understand whether other-regarding preferences that determine contributions towards a long-term global public good such as climate change mitigation exist and can be understood as being driven, at least in part, by more fundamental factors such as those relating to biological age. There is increasing evidence that aging and other-regarding preferences are connected. List (2004) and Carpenter, Connolly, and Myers (2008) find that social preferences and giving increase with age in laboratory public good games and charitable donations experiments. This indicates that a positive age effect in terms of pro-social orientation may be present. In line with their research we analyze if the specific temporal structure of climate change mitigation impacts these motives.

2.2 Experimental Protocol

We report results from two subsequent studies that were conducted using a representative sample of Heidelberg citizens.

2.2.1 Study 1

Study 1 was designed to analyze if individuals, given the theoretical considerations above, are willing to carry monetary cost in order to decrease CO_2 emissions. In this study 143 subjects of diverse demographic backgrounds receive an initial endowment of 10€ and can contribute any share of this endowment to a public account that is used by the experimenters to reduce CO_2. This is achieved by retiring emission permissions via the EU ETS. After taking this decision subjects take part in an abstract public goods game (Goree, 2002). Thereby we aim to disentangle general altruistic preferences from climate change specific factors.

2.2.2 Study 2

Study 2 is a follow up on study 1, in which we concentrate on the role of social influence for the decision to contribute to greenhouse gas mitigation. In the real world it is often observed that pro-environmental behavior is supported by social norms and sanctions. To test experimentally how these mechanisms work on subjects from different demographic backgrounds, we employ three treatment conditions. Equivalently to study 1 subjects receive an initial endowment of 10€ that can be used to reduce CO_2 emissions via the EU ETS in all treatment conditions. The treatment conditions only differ in one aspect from the baseline: Subjects receive additional information before the actual contribution decision. In two treatments, referred to as the *social reference treatments*, subjects are informed about the average contribution decisions from other baseline subjects (Study 1)[1]. In the high social reference treatment we choose 50 subjects with an average contribution of 7€, while in the low social reference treatment we choose 50 subjects with an average contribution of 1€. We also use an additional *irrelevant information treatment* to disentangle social reference effects from simple anchoring. In this treatment instead of receiving information about the average contributions of other subjects they receive the information that subjects from a previous study were recruited from a 7 km radius around Heidelberg. Overall we collect data on 244 subjects; 143 in the baseline condition and 32-36 in each of the three treatment conditions.

2.3 Results

2.3.1 Study 1

Our study does not find support of the theoretical freeriding result. Instead 61% of the 143 subjects contribute to the reduction of CO_2. The average contribution is 31% of the initial endowment across the whole sample and 51% among the group of contributors. Demographic factors also play an important role. While subjects below the age of 40 only contribute 22% on average subjects aged 60 and older contribute 42% (compare Fig. 1). This difference is highly statistically significant (MWT: $z = -2.847$). Women also contribute more than men, yet this difference is not statistically significant.

To analyse the influence of different demographic factors Table 1 presents results from a tobit regression with different sets of control variables.

The age effect persists when we control for other demographic variables such as gender income and education (Model 1). Income and education do not explain contribution behavior. Model 2 includes a richer set of control variables. Both smoking behavior and household size have significant effects on contribution behavior. The positive coefficient of household size indicates that subjects with more beneficiaries of climate change mitigation in their close living environment contribute higher amounts. Smoking on the other hand is a strong predictor for the willingness to incur risk and of short sighted decision making (Anderson & Mellor 2008; Dohmen et al. 2005). Consequently smokers invest less into the reduction of climate change risks over a long time horizon. We also include attitudes towards climate change into Model 2. These represent the answers to two questionnaire items. Subject that are more concerned about the potential consequences of climate change contribute more to its mitigation. Also subjects who believe that the impacts of climate change are felt more immediately contribute more.

[1] We use the true average contribution of a subsample from study 1 observations. Therefore no deception of subjects takes place.

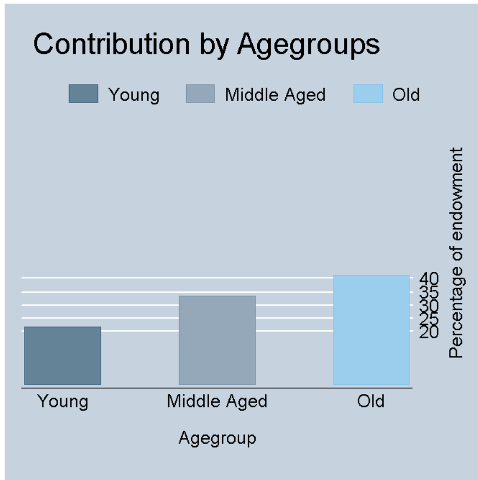

Figure 1: Percentage of initial Endowment spent by Agegroup

The second part of study 1 consists of a standard public good game (Goree, 2002). These games are commonly employed to analyze social dilemma situations. Each subject is grouped with other subjects and can split an initial endowment of 20 tokens between a group account and a private account. For each token in the private account the subjects receive a fixed amount of money. Tokens in the public account are multiplied by a given factor and then divided between all members in the group. Factors are chosen such that a token in the private account always pays more to a given subject than tokens placed in the public account. Therefore freeriding behavior is a dominant strategy for subjects that are mainly interested in monetary outcomes. By looking at the consistency of choice between the abstract and the real public good task, we can investigate to what extent subjects understand the incentive structure underlying the provision of climate change mitigation as a public goods game. The pairwise correlation between behavior in both tasks is very low (0.11) and insignificant. Thus subjects do not see the same incentive structure at work in the abstract public goods game and the decision to contribute to the real public good of climate change mitigation.

2.3.2 Study 2

Study 2 analyses the effects of social information on the decision to contribute to climate change mitigation.

Figure 2 displays average contribution levels across the different treatment conditions. Clearly the display of social information influences contribution decisions. In the low information treatment subjects give amounts below average. In the high information treatment subjects give above average. The difference between the two treatment conditions and between the treatment condition and

Table 1: Contribution Size and Demographic Variables

	Model (1)		Model (2)	
Age	0.0888**	(2.25)	0.0907**	(2.18)
Female	1.631	(1.28)	0.394	(0.32)
Education	0.115	(0.17)	-0.220	(-0.35)
Income	-0.0000737	(-0.10)	-0.000180	(-0.21)
Household Size			0.908**	(2.10)
Smoker			-2.609**	(-2.04)
CC Time			1.200*	(1.76)
CC Fear			0.741*	(1.84)
Constant	-3.558	(-1.01)	-12.26**	(-2.51)
Observations	125		125	

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

the baseline is highly statistically significant (MWT: z = -2.021 and z = 3.463). Similar results apply to the contribution frequency. In the high belief treatment 85% of subjects contribute a positive amount compared to 61% in the baseline treatment. The analysis of the irrelevant information condition reveals that effects reported here are truly due to the social context of the information and not due to unconscious anchoring. Subjects in the irrelevant information treatment do not display contribution behavior different from subjects in the baseline condition. As a manipulation check we asked subjects to estimate the average contributions of other subjects. These beliefs differ significantly between the high beliefs treatment and the baseline.

Table 2 shows tobit regression results of a treatment effect regression that controls for sample composition in the treatment groups. Model 1 confirms the descriptive results from above. Significant positive effects are found for the high belief treatment. Model 2 and 3 reveal differences in the receptiveness for social pressure by looking at interaction effects of treatment conditions and gender/age. Clearly females react much stronger to the high information treatment. Age however does not influence the effect of treatments in a significant way.

2.4 Discussion Studies 1 and 2

We show with two experimental studies that the theoretical concerns about climate change mitigation in aging societies do not rest on a firm empirical base. In both studies freeriding is not a common behavior and especially the older subjects that gain the lowest personal benefits from climate change mitigation are most willing to contribute to mitigation efforts. In public discussion demographic change is often seen as a cause for generational conflict. In the context of climate change our experimental results support a different notion - one of intergenerational altruism. Understanding the impact of social information that

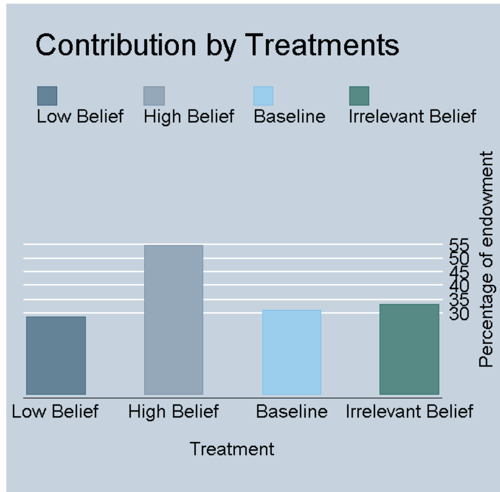

Figure 2: Percentage of endowment spent across treatment conditions

we demonstrate in study 2 is especially important to policy makers. Our results underline the possibility of using soft policy instruments as a supplement to regulation.

3 Study 3: Comprehension of the climate system

3.1 Theoretical considerations

The second set of studies looks at the problem of climate change mitigation in aging societies from a cognitive perspective. It was investigated in how far the climate system is understood by the general public. Moreover, the role of information display was examined more closely.

Fundamentally, the accumulation of CO_2 in the atmosphere is a stock-flow (SF) process. That is, the stock (CO_2 in the atmosphere) accumulates in- and outflows over time (through emissions and absorptions). The underlying principle is often explained by referring to the bathtub analogy: A bathtub that contains a stock of water accumulates the net inflow, i.e. the stock increases if the inflow through the tap exceeds the outflow through the drain, and the stock decreases if the outflow exceeds the inflow. It is very conceivable that equipping the average voter with this type of structural knowledge regarding climate change is important for their decision making. Thus, understanding that a reduction of CO_2 emissions will not suffice to reduce atmospheric CO_2 unless the level of CO_2 emission is smaller than the level of CO_2 absorption (inflow $<$ outflow) is essential for realizing the dimensions of our climate system and as a result take appropriate action.

Table 2: Contribution Size and Treatment Effects

	(Model 1)		(Model 2)		(Model 3)	
Age	0.0844***	(3.07)	0.0843***	(3.13)	0.0918***	(2.98)
Household Size	0.693**	(2.24)	0.740**	(2.43)	0.704**	(2.27)
Female	1.251	(1.45)	0.189	(0.18)	1.237	(1.42)
Income	-0.000296	(-0.64)	-0.000369	(-0.81)	-0.000294	(-0.63)
Education	0.0556	(0.13)	0.0991	(0.23)	0.0121	(0.03)
Smoker	-2.303**	(-2.05)	-2.345**	(-2.14)	-2.287**	(-2.01)
CC Time	0.722*	(1.71)	0.642	(1.55)	0.721*	(1.71)
CC Fear	0.538**	(1.99)	0.625**	(2.32)	0.551**	(2.03)
Belief High	4.364****	(3.54)	1.250	(0.72)	6.698*	(1.94)
Belief Low	-0.931	(-0.71)	-0.346	(-0.18)	-0.651	(-0.13)
Irrelevant	1.351	(1.01)	-0.0107	(-0.01)	1.748	(0.48)
Female*BL			-1.304	(-0.51)		
Female*BH			5.962**	(2.44)		
Female*IR			2.597	(1.00)		
Age*BL					-0.00658	(-0.07)
Age*BH					-0.0499	(-0.72)
Age*IR					-0.00863	(-0.12)
Constant	-9.901***	(-3.24)	-9.482***	(-3.18)	-10.14***	(-3.24)
Observations	232		232		232	

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$, **** $p < 0.001$

However, previous research has repeatedly illustrated that even highly educated students have severe problems understanding SF processes, achieving solution rates as low as 16%, a phenomenon termed SF-failure (Booth Sweeney & Sterman, 2000; Cronin & Gonzalez, 2009; Sterman & Booth Sweeney, 2002, 2007). In this line of research by Sterman and colleagues, participants were typically presented with a brief explanation on the relationship between CO_2 emissions, absorptions, and atmospheric CO_2 concentration. They were then presented with a graph depicting atmospheric CO_2 concentration (stock) stabilizing from the year 2100 onwards and with a graph depicting previous CO_2 emissions (inflow) or absorptions (outflow). Participants were then asked to sketch emission or absorption trajectories in such a way that a stabilizing CO_2 concentration could be achieved. Typically, participants sketched stabilizing in- and outflow trajectories, according to which atmospheric CO_2 concentration would actually increase instead of stabilize (see Fig. 3 below).

The fact that highly educated students were not able to grasp the underlying system structure implies that the correct solving of this particular task is independent of general cognitive capacities, e.g. Intelligence. It seems much more plausible that the specifics of the task format used in previous research confounded results. In line with this assumption, previous research found that participants have difficulties understanding coordinate systems and graphs (Car-

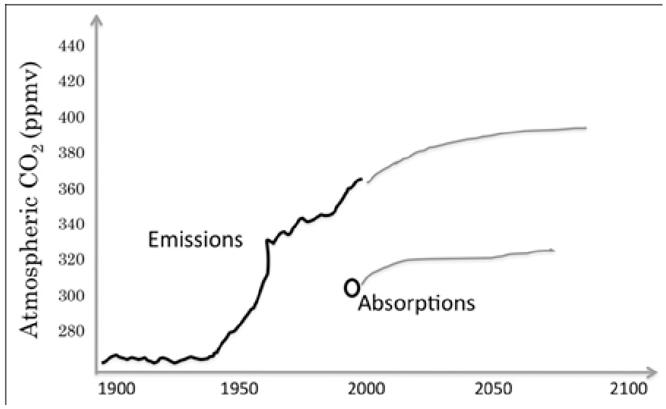

Figure 3: Typical answer in the original paradigm (adopted from Sterman, 2008, p.223). Participants were asked to sketch CO2 emissions and absorptions in such a way that a stabilizing stock of atmospheric CO2 concentration could be achieved. Participants typically made use of a pattern matching heuristic, sketching stabilizing emission and absorption trajectories. Since in that scenario emissions always exceed absorptions, CO2 concentration would actually continue to rise instead of stabilize.

penter & Shah, 1998; Gattis & Holyoak, 1995; Shah & Carpenter, 1995). Thus, difficulties with the task format might have led to an underestimation of participants' actual understanding of SF dynamics in general, and the climate system in particular. In this study it was therefore investigated whether SF failure truly is a fundamental error in human reasoning, necessarily leading to severe misunderstanding of the climate system, and what role general cognitive ability on the one hand and age on the other hand play.

3.2 Experimental Protocol

3.2.1 Task 1: Textual SF

Three completely textual SF tasks using three different scenarios (money inside a piggy bank, water inside a bathtub, atmospheric CO_2 concentration) were administered. In each task, participants first received a short introduction to the problem describing the respective in- and outflows. Participants were then asked to name a correct strategy to achieve the requested stock (stabilizing or rising).

3.2.2 Task 2: Interpretation and Production (I/P) of SF coordinate systems

To illustrate the influence of presentation of the problem on solution rates we adopted coordinate systems used in previous research (e.g., Sterman & Booth Sweeney, 2007). Two distinct scenarios were administered: an atmospheric

CO2 scenario and a playground scenario in which the number of children on a playground was depicted. A short introduction to the problem was followed by a presentation of a coordinate system depicting in- and outflows. Four distinct sub-tasks explored 1) fundamental understanding of the graphs, 2) estimate of resulting stock, 3) verbal production of necessary in- and outflows given a decreasing stock and 4) graphical production of necessary in- and outflows given a decreasing stock. Note that answers to the third sub-task were deliberately simple to test mere translation of verbal into graphical answer format.

3.3 Results

3.3.1 Textual SF

In line with our hypothesis, the majority of our sample was able to answer SF questions in the textual task format, yielding an average correct solution of M = 86%. There was no age-related variance. These results suggest that the general population is able to grasp the underlying problem structure of SF dynamics- regardless of age. Moreover, general intelligence does not influence solution rates. However, the context of the question did have a slight effect: Specifically, solution rates ranged from 98% and 90% in the bathtub and piggy bank scenario, respectively down to 70% in the CO_2 task, suggesting that the concept of climate change is somewhat harder to grasp. Again, age and intelligence effects were absent.

3.3.2 I/P SF

The majority of our sample (M = 97%) was able to correctly read and interpret graphs presented to them (question 1). Verbal production tasks were also correctly answered by the majority of participants (M = 83%, M = 89%, for question 2 and 3, respectively). However, in line with our expectations, translating verbal answers into a graphical presentation (question 4) was only accomplished by 57% of the sample. A McNemar test yielded a significant difference between the mean solution rate of both verbal production tasks and the graphical production task, $\chi^2(1, N = 107) = 8.65$, $p = .003$, indicating that for most participants, answers were easier to provide in a verbal than in a graphical format.

A negative correlation between age and solution rates on the I/P tasks (-.331, p=.001) was found. Thus, older individuals had lower solution rates than younger participants. This effect is independent of the achieved level of education. Moreover, we find a positive correlation between IQ raw scores (assessed via LPS 50+) and performance on I/P tasks (.461, p=.000).

3.4 Discussion Study 3: Comprehension of the climate system

We show that most people are able to understand SF problems when presented textually rather than in coordinate systems. We find that solutions to one and the same task were increased by up to 50% when a verbal compared to a graphical answer was needed. Especially older people of our sample were partially overburdened when asked to interpret and produce graphical task formats. Thus, previous research may have underestimated peoples' capacity to understand SF problems (e.g. climate change dynamics). On a more general level, results suggest that the complexities of climate change can generally be understood regardless of age. While it may well be reasonable to convey complex information in the form of suitable graphs, participants' understanding of a problem should not be retrieved graphically. Comprehension is also partially dependent on cognitive capacities.

4 Study 4: A (missing) link between comprehension and motivation

4.1 Theoretical considerations

It has been argued that people's misunderstanding of SF structures inherent to climate change could explain their lack of motivation to contribute to climate change mitigation (Sterman, 2008). While this is a plausible hypothesis, the influence of a better comprehension of climate change on mitigation efforts is not necessarily positive. A full understanding of the problem could also lead to fatalistic tendencies leading to lower efforts. We test these competing hypotheses experimentally on a subsample of our subjects.

4.2 Experimental Protocol

85 of our initial subjects from study 1 take part both in the contribution task (Study 1) and the SF task (Study 3). Furthermore we use a special treatment condition by inviting 40 subjects to take part in a 3h training about climate change. In this training we cover topics about climate change, stock flow problems and emission reductions. After the training session the 40 assigned subjects are given another opportunity to reduce CO_2 while the other 45 subjects serve as a control group.

4.3 Results

4.3.1 Connection of motivation, IQ and comprehension

For 85 subjects we find a marginally significant correlation between IQ (raw score) and willingness to invest into the retirement of CO_2 emission permits (.213, $p=.051$). Performance on the I/P task assessing understanding of the underlying problem structure, is not significantly related to willingness to invest.

Figure 4: Percentage of endowment spent. Training vs. Control group

4.3.2 Effect of the training

Figure 4 displays a strong and counterintuitive finding. While the control group only slightly decreases the contribution to the reduction of CO_2 the contribution of the training group drops below 50% of its initial value. The difference between the control group and the trained group is highly statistically significant (MWT: z= 2.834)

As the training does not influence important attitudes (existence, fear, time structure) towards climate change, measured by questionnaire items, the change in motivation has to be explained in a different way and is subject to further research.

5 General Discussion and Conclusion

In the face of demographic change the aging decision maker becomes an important object of study in all areas of public and private decision making. With respect to climate change mitigation policies we present results from two different sets of studies that analyze motivational and cognitive aspects as well as the link between those dimensions.

At first it is shown that the theoretical concerns regarding the interaction of demographic change and the motivation to mitigate climate change are not grounded on empirical realities. A conflict between generations that is often regarded as a side effect of demographic change does not appear in the context of climate change. Rather more mature subjects are willing to contribute more to the mitigation of climate change. Clearly in this context it would be interesting to disentangle effects of biological aging from generational effects. Unfortunately the experimental procedure employed does not allow for this. Furthermore, as shown in Study 2, individuals can be influenced by the presentation of social cues. For the policy maker this information is of great importance as it reveals a possibility for soft policy intervention. By presenting the socially wanted behavior, citizens can be nudged to increase their own efforts regarding climate change mitigation. By crowding in motivation rather than crowding out motivation, which is a real concern with more conventional forms of government intervention, the efforts to increase climate change mitigation can be strengthened.

The message of the second set of studies is also more positive than theoretical considerations of climate change in an aging society would warrant. First of all it is demonstrated that important aspects of climate change can very well be understood by the general population - regardless of age. Given the nature of our sample, members of the general public (and not only highly educated students) are able to understand SF problems when presented qualitatively. Based on these findings, we suggest that display formats used in media reports should be modified. Specifically, we suggest that quantitative information is reduced to a minimum in order to render abstract topics more accessible and to communicate risk more effectively. This is even more important given that the way information is presented does not only affect understanding of the problem, but also the quality of decision-making (Covey, 2011). Moreover the ability to understand complex processes in the climate system is not strongly linked to the motivation to increase mitigation efforts. Results from the training study show however that increasing the information about climate change can have unexpected and unwanted effects. To understand through which channels such effects can operate is left for further research.

Acknowledgement: *We thank the panel SÖF (Sozial Ökologische Forschung) within the BMBF Germany (Bundesministerium für Bildung und Forschung) who provided funds for conducting this study. We are grateful to our student research assistants Dennis Daseking, Florian Bisinger, Korbinian Dress, Elisabeth Dorfmeister and Johanna Köhling who helped with sampling and conducting this study.*

6 References

Anderson, L. R., und J. M. Mellor. (2008). Predicting health behaviors with an experimental measure of risk preference. *Journal of health economics 27 (5): 1260–1274.*

Booth Sweeney, L. B. & Sterman, J. D. (2000). Bathtub dynamics: initial results of a systems thinking inventory. *System Dynamics Review*, 16, 249–286.

Carpenter, J., C. Connolly, und C. K Myers. (2008). Altruistic behavior in a representative dictator experiment. *Experimental Economics 11* (3): 282–298.

Carpenter, P. A., & Shah, P. (1998). A model of the perceptual and conceptual processes in graph comprehension. *Journal of Experimental Psychology: Applied, 4(2).*

Covey, J. (2011). The effects of absolute risks, relative risks, frequencies, and probabilities on decision quality. *Journal of Health Communication, 16(7).*

Cronin, A.M., Gonzalez, C., & Sterman, D. (2009). Why don't well-educated adults understand accumulation? A challenge to researchers, educators, and citizens. *Organizational Behavior and Human Decision Process, 108, 116-130.*

Dohmen, T., A. Falk, D. Huffman, und U. Sunde. (2008). Are risk aversion and impatience related to cognitive ability? *CEPR Discussion Paper No. DP6398*

Fehr, E., und K. M Schmidt. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics 114 (3)*: 817.

Fischbacher, U., und S. Gächter. (2010). Social preferences, beliefs, and the dynamics of free riding in public goods experiments. *The American Economic Review 100 (1)*: 541–556.

Gattis, M., & Holyoak, K. J. (1996). Mapping conceptual to spatial relations in visual reasoning. J*ournal of Experimental Psychology: Learning, Memory, and Cognition, 22(1)*, 231-239.

Goeree, J. K, C. A Holt, und S. K Laury. (2002). Private costs and public benefits: unraveling the effects of altruism and noisy behavior. *Journal of Public Economics 83 (2)*: 255–276.

Hasselmann, K., M. Latif, G. Hooss, C. Azar, O. Edenhofer, C. C. Jaeger, O. M. Johannessen, C. Kemfert, M. Welp, und A. Wokaun. (2003). The challenge of long-term climate change. *Science 302 (5652)*: 1923–1925.

Horn, W. (1983): L-P-S Leistungsprüfsystem. 2. Auflage. Hogrefe, Göttingen.

List, J. A. (2004). Young, Selfish and Male: Field evidence of social preferences. *The Economic Journal 114 (492)*: 121–149.

Schönknecht, P. et al. (2005). Prevalence and natural course of aging-associated cognitive decline in a population-based sample of young-old subjects. *American Journal of Psychiatry, 162*, 2071-2077.

Shah, P., & Carpenter, P. A. (1995). Conceptual limitations in comprehending line graphs. *Journal Of Experimental Psychology: General*, 124(1).

Sterman, J. D. & Booth Sweeney, L. (2002). Cloudy Skies: Assessing Public Understanding of Global Warming. *System Dynamics Review, 18(2)*, 207-240.

Sterman, J.D. & Booth Sweeney, L (2007). Understanding public complacency about climate change: adults' mental models of climate change violate conservation of natter. *Climatic Change, 80*, 213-238.

Sterman, J.D. (2008). Risk communication on climate: Mental models and mass balance. *Science, 23*, 532-533.