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Effectiveness of gaming for communicating and teaching climate change

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Effectiveness of gaming for communicating and teaching climate change

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Abstract

Games are increasingly proposed as an innovative way to convey scientific insights on the climate-economic system to students, non-experts and the wider public. Yet, it is not clear if games can meet such expectations. We present quantitative evidence on the effectiveness of a simulation game for communicating and teaching international climate politics. We use a sample of over two hundred students from Germany playing the simulation game KEEP COOL. We combine pre- and postgame surveys on climate politics with data on individual in-game decisions. Our key findings are that gaming increases the sense of personal responsibility, the confidence in politics for climate change mitigation, and makes more optimistic about international cooperation in climate politics. Furthermore, players that chose to defect in the game become more optimistic about international cooperation but less confident about politics. We conclude that simulation games can facilitate experiential learning about the difficulties of international climate politics and thereby complement both conventional communication and teaching methods.

Keywords: climate change, international climate agreements, simulation games, climate change communication, education for sustainable development

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1. Introduction

Effective climate politics rely on public understanding and support for climate change mitigation. Empirically, climate change awareness is an important determinant of public support for climate policies (Rhodes et al. 2017). However, while scientific knowledge on anthropogenic interference with the climate system is increasingly consolidating (IPCC 2014), this does not automatically carry over into public awareness. To the contrary, studies show decreasing public concern about the environment in general (Franzen and Vogl 2013) and about climate change in particular in the US and Western Europe since the mid 2000s (Capstick et al. 2015; Stoutenborough et al. 2014). This calls for innovative ways of science based climate change communication and teaching. For instance, in the US secondary school students show serious misconceptions about climate change (e.g. Shepardson et al. 2011) and graduate students do not feel sufficiently educated in climate change issues (Kuster and Fox 2017). Scholars have highlighted the need to further investigate interactive modes of communication to create a meaningful understanding of the climate system (Ballantyne et al. 2016). For these purposes, our paper contributes to evaluating the potential of revolving around climate change climate games.

There are now dozens of games on climate change ('climate games') available (see Reckien and Eisenack 2013, Wu and Lee 2015 for reviews). Several authors have highlighted the high comparative potential of simulation games for climate change communication and teaching for several reasons (e.g. Gugerell and Zuidema 2017; Mendler de Suarez et al. 2012; Sterman 2011). Simulation games might allow to experience the complex, non-linear dynamics of the climate system, and to test out different strategies without real world consequences. At the same time, they are easily understandable for non-experts and an appealing and entertaining approach to the serious issue of climate change. However, hitherto there is little empirical evidence on the effectiveness of games for climate change communication and teaching (cf. Haug et al. 2011; Klöckner 2015: 205). There is also limited knowledge on how the particular rule-design of climate change games affects the way in which beliefs about climate politics are changed.

The present study extends the few existing ones in at least three ways in order to contribute to a more comprehensive assessment of whether and how games can effectively communicate and teach climate change. First, the effectiveness of a simulation game on climate change is tested quantitatively. Second, we investigate how students' beliefs about international climate politics change through gaming. Finally and third, we study how the kind of decisions made within the game (and thus the game design) changes beliefs about international climate politics.

So far quantitative evaluations of simulation games on climate change have been inconclusive and mainly conducted with small samples of decision makers. Van Pelt et al. (2015) study the effectiveness of communicating climate change risk to water managers, yielding insignificant differences between experimental and control groups. Haug et al. (2011) evaluate the learning effect of a simulation game on European climate policy for policy-makers and experts. The results indicate that central issues in the simulation game, burden sharing and emission trading, become more pronounced in participant's concept maps after the game session. Recently, there have been more systematic studies on effectiveness of games in the context of climate change. Rumore et al. (2016) have conducted a comprehensive study on a role-play on climate change adaptation in different communities. They find a significant increase in awareness about climate change risk and confidence in town's ability to adapt. While they conclude that role-plays are a valuable tool for stakeholder engagement, it remains open how far theses finding can be generalize to other types of climate games. Our study, in contrast, assesses a game that is focused on global climate politics instead of local adaptation strategies.

The study by Sterman et al. (2015) is similar to ours in this respect. They evaluate the computer-backed role-play game WORLD CLIMATE to test acquisition of cognitive knowledge and personal attitude changes on climate change of the 173 participants. They find evidence for an increased understanding of climate dynamics (in particular the distinction of stock and flows). Their results indicate that the game might be an effective tool to teach climate change, but also consider that it conveys insights on the difficulties to enforce a global climate agreement, so that participants might become skeptical about its successfulness. The study employs a pre- and a postgame-questionnaire in different surveys without a common sampling strategy and does not measure in-game behavior like we do. Our study thus aims at not treating the game as a black box. Understanding the latter is crucial, we argue, if climate games shall be well-designed.

In order to shed light on the effectiveness of a simulations game for communicating and teaching international climate politics, we combine a standardized pre- and postgame survey on climate politics with observed data on individual in-game decisions in a carefully selected sample of two hundred German secondary school students playing the simulation game KEEP COOL (Eisenack and Petschel-Held 2004, Eisenack 2013). We test hypotheses using ordered-probit and ordinary least squares estimators. KEEP COOL is characterized by a sophisticated science based climate-economic model conveying the key features of state-of-the-art science on climate change modelling in a board game interface. In order to win, players need to balance their regional economic interests against contributions to global public goods, i.e. the avoidance of dangerous interference with the climate. Players have to choose every round between

cooperative and defective moves, so that an in-game climate change regime can evolve (Meya and Meya 2016).

We find that players significantly change their beliefs about international climate politics in the following ways: they become more confident in the potential for politics to mitigate climate change, become more optimistic about effective international cooperation on climate change mitigation, and perceive themselves as more responsible for climate change mitigation. Interestingly, players do not transfer their in-game decisions directly to their beliefs about international climate politics. Instead, players testing defective strategies within the game become more optimistic about international cooperation in climate politics – highlighting experiential learning as a central asset of simulation games on climate change. These findings provide further support that simulation games in general and KEEP COOL in particular can be promising as innovative tools to teach and communicate international climate politics.

The remainder of this article is structured as follows. We present hypotheses on learning from a simulation game on international climate politics in Section 2. The methods are described in Section 3, and results are reported in Section 4. Section 5 discusses and concludes.

2. Communicating and teaching international climate politics with simulation games

In this section we discuss key design elements for simulation games on international climate politics and associated learning potentials. Subsequently we lay out our hypotheses on how playing a game might change beliefs about climate politics.

2.1 Games on international climate politics

Under the United Nations Framework Convention on Climate Change (UNFCCC) heads of governments have been meeting annually for more than two decades to negotiate the climate change governance regime. However, agreements like the Kyoto Protocol or the Paris Agreement have not been effective in limiting global warming so far. Economic analysis, following early contributions of Hoel (1992), Carraro and Siniscalco (1993) and Barrett (1994), have highlighted free-riding incentives as a main explanation. More recent research suggests that international cooperation on climate change is further complicated through voting behavior and interest group influence (e.g. Wangler et al. 2013), uncertainty about cost and benefits of mitigation (e.g. Finus and Pintassilgo 2013, Meya et al. 2017), non-linearities and tipping points (e.g. Barrett 2013, Dellink et al. 2013, Eisenack and Kähler 2016), and many more. If we consider public opinion to be one determinant of governmental decision making (Lee et al. 2015, Tjernström and Tietenberg 2008,

Ziegler 2017), e.g. through voting in democratic systems, and if we aspire for well-informed and educated decision makers on all institutional levels, it is of utmost importance to convey scientific insights on the reasons for and the challenges to climate politics.

Games are considered promising to communicate and teach complex system dynamics, as they work as playable "interactive system dynamic models" (Mendler de Suarez et al. 2012: 6). This seems to be particularly important in the context of sustainable development. In simulation games, a subgroup of serious games[1], players can engage and influence complex dynamic systems, but are not able to control the outcomes entirely (Dieleman and Huisingh 2006). Based on relatively simple formal rules, simulation games create complexity and provide unique individual experience (Mendler de Suarez et al. 2012).

Like crafting an analytical or numerical model in scientific research, game design requires breaking down the subjective matter to its key components. Therefore, a natural starting point for a simulation game on international climate politics is to convey the mechanics of state of the art scientific models[2] to a playable game interface (e.g. Sterman et al. 2015). A simulation game on international climate politics can be designed as a more sophisticated version of a common pool game (see also Fennewald and Kievit-Kylar 2012), like the FishBanks (Meadows et al. 1989). Stepping in the role of politicians, players have to decide about trade-offs between mitigation, adaptation and climate change damages in face of a dynamic coupled climate-economic model. On this base, rules can be elaborated further to resemble features of the political, economic and climate system that are central to cooperation.

The literature discusses several ways in which well-designed simulation games can complement traditional communication and teaching methods, in particular:

(1) Simulation games allow active engagement and thereby promote *experiential learning*. Players make individual, first hand experience (Mendler de Suarez et al. 2012) of otherwise abstract phenomena like strategic interaction, path dependency or feed-back effects. This experience may create an enormous learning potential due to the emotions they trigger (Wu and Lee 2015).

(2) Simulation games offer a safe learning environment to test different decisions and experience resulting geophysical, economic and political system dynamics. In climate change many consequences are irreversible and removed in space and/or time. Like in a flight simulator (Sterman et al. 2015), players can take risk and learn by doing without negative consequences for the real

[1] Serious games are defined by design purpose (Wu and Lee 2015) or usage (Crookall 2010), encompassing, beyond entertainment, also communicative and educative objectives.

[2] Regionalized integrated assessment models are one common tool to study the formation of international climate agreements taking into account the climate-economic system dynamics (early contribution by Nordhaus and Yang (1996); for an overview of existing models see Lessmann et al. (2015)).

world (Mendler de Suarez et al 2012). Learning from failure might provoke the consideration of alternative approaches (Dieleman and Huisingh 2006).

(3) Simulation games can make players aware of mismatches of their mental models with complex system dynamics. Policy makers and the public often systematically fail to account for the dynamics of complex systems (Sterman 2011, Sterman et al. 2013), offering a high learning potential of simulation games through changing players' mental models (Mendler de Suarez et al 2012). Scientific illiteracy and difficulties of non-experts have been identified as one barrier to public engagement in climate change (Wibeck 2014).

(4) Simulation games make science more easily accessible and offer a common language for heterogeneous audiences. They can serve as a boundary object between science and policy makers by making scientific analysis of international climate politics assessable and tangible (cf. van Pelt 2015). Moreover, a shared game experience provides common and scientifically sound grounds for starting discussion among different stakeholders like researchers, students, policy makers, the wider public and further actors that are dealing with issues of sustainable development (Dieleman and Huisingh 2006, Eisenack 2013).

2.2 Testing the effectiveness of games on international climate politics

Our approach falls into the category of intervention-oriented research on the effectiveness of serious games (cf. Mayer et al. 2014). In the following we elaborate two sets of hypotheses.

First, we expect that a well-designed simulation game on international climate politics will influence players' beliefs about international climate politics. Engaging in-game with the climate system and experiencing consequences of human interference is likely to increase personal responsibility for climate change mitigation (cf. Mendler de Suarez et al. 2012). However, experiencing the system dynamics could also promote a feeling of pessimism on both personal and political levels, as players learn about systematic obstacles to effective global climate change mitigation (in particular free-riding behavior) and learn that good will alone is not sufficient (cf. Sterman et al. 2015). Moreover, the in-game experience might result in a re-assessment of individuals' expectations on international climate politics and the ability of politicians in limiting climate change. We therefore establish a first set of hypotheses:

Hypotheses 1: Climate games have the ability to change players' beliefs about international climate politics. In particular, gaming

- increases personal *responsibility* to contribute to climate change mitigation (H1.1),
- increases *confidence in politicians* to take actions against climate change (H1.2),

- increases expectations about effective *international cooperation* on climate change (H1.3),
- decreases *pessimism* in climate politics, i.e. the belief that climate politics will be ineffective in any case (H1.4).

Second, we are interested in how, if at all, changes in beliefs are related to in-game behaviour. If a game on international climate politics is indeed fostering experiential learning, attitudes towards climate politics should be correlated with individual decisions made in game (cf. Mayer et al. 2014). Understanding how different components for decision-making offered by a game lead to a conductive game experience is essential for developing well-designed climate games. We classify in-game decisions into two categories: (i) *cooperative* decisions, where players chose climate change mitigating game moves, thereby contributing to the public good; and (ii) *defective* decisions, where player chose greenhouse gas emitting game moves, thereby behaving as free-riders on others' mitigation efforts.

Negative as well as positive correlations between in-game decisions (independent variable) and changing beliefs about international climate politics (dependent variable) seem plausible. When players cooperate in the game, the obstacles to international cooperation might be perceived as manageable and players might expect cooperation in international climate politics also to be more successful. On the other hand, players that tried out defective strategies within the game might be particularly convinced about the necessity of international cooperation, due to the resulting reactions of the climate system experienced. This gives rise to two contradicting hypotheses:

Hypotheses 2: Decisions within a simulation game on international climate politics relate to changes in beliefs about international climate politics. In particular:

- The more cooperative in-game decisions players make, the more optimistic about the success of international climate politics they are subsequently (H2.1).
- The more defective in-game decisions players make, the more optimistic about the success of international climate politics they are subsequently (H2.2).

3. Methods

The effectiveness of the simulation game KEEP COOL is assessed by combing quantitative data on individual in-game decisions with pre- and postgame surveys on international climate politics. In this section we describe the research design, the simulation game KEEP COOL, the instruments for data collection and the statistical methods employed.

3.1 Research design

The study employs the established simulation game KEEP COOL. Participants are students in selected school classes. Participant's beliefs are assessed with a questionnaire before and after they play the game. During the game, their decisions are recorded. Selection biases are minimized as participation was mandatory for the students. The representativeness of the sample is assessed by including items in the pregame questionnaire that can be compared with representative studies for Germany.

The sample heterogeneity is minimized by focusing on students aged between 13 and 16 years from three cities in North-West Germany (Bremen, Delmenhorst, Oldenburg). Game events took place in class rooms, so that external interference is minimal and the setting is relatively close to a laboratory situation. Beliefs about international climate politics are measured directly before and after playing KEEP COOL in order to assess intrapersonal changes.

All game events follow an identical timeline. They start with an introduction of the facilitator and by splitting the students into parallel groups for the game sessions. Subsequently, the pregame questionnaires are filled out individually, then the game is played (about 60 minutes), directly followed by the postgame survey. In order to isolate the effect of KEEP COOL, neither a content related introduction nor a debriefing takes place.

Game events were conducted over three months from 26.11.2014 to 26.02.2015 at six different schools. KEEP COOL was played 43 times, 235 students participated in the survey and for a subset of 200 students data on in-game decisions was recorded.

3.2 The simulation game KEEP COOL

We use KEEP COOL (Eisenack and Petschel-Held 2004) as a prime example for a climate game. It is the first commercially available board game on climate change. It is distinct from most other climate games, in particular, (i) through its detailed simulation of the climate-economic system (Wu and Lee 2015: 414) based on which political issues such as free-riding and agenda setting power can be experienced and political institutions can be tested, and (ii) that it puts the global and political aspects of the topic to the center, and not everyday decisions of young people as many environmental games do (Wu and Lee 2015).

In KEEP COOL each player takes the role of one of six country groups which frequently develop joint positions in climate negotiations: developing countries, Europe, countries in transition (from the former Soviet Union), the *Organization of the Petroleum Exporting Countries* (OPEC), rapidly industrializing countries (in particular China, India, Brazil), and the Umbrella group (in particular the US, Japan, Canada, Australia). Players can chose between carbon emitting and more costly carbon neutral technologies ('black'

and 'green' factories), adapt to climate change or undertake research and development to decrease costs of carbon emitting or carbon neutral technologies. During a game session carbon emissions accumulate in the atmosphere, causing a rising global temperature. The probability and intensity of damages from extreme events increase with global temperature. When a critical threshold of accumulated emissions is crossed, all players lose. Alternatively, the game ends when a player wins by achieving its country groups' economic growth targets and fulfilling randomly assigned lobby interests.[3]

The mechanic of this basic climate-economic model gives rise to a global collective action problem, where each country group has incentives to free-ride on the others mitigation efforts. Remarkably, international climate politics, the core subject of the game, is not explicitly modelled. Instead, politics and possible international institutions emerge from the player's interaction within the game. In fact, as a core rule of KEEP COOL, players are allowed to negotiate on everything. Thus, players find themselves in a situation where they can invent and test different institutions for climate change mitigation and experience both the necessity of and obstacles for global cooperation (Meya and Meya 2016).

3.3 Instruments for data collection

An overview on the studied concepts, the variables to measures them, and the instruments for data collection is given in Table 1. The pregame questionnaire includes basic demographic information and prior experience with games. Furthermore, it contains eleven established items from three different representative studies on environmental attitudes in Germany (BMUB/BfN 2014; GESIS 2010, Infratest 2010). Six items were newly designed to capture beliefs about international climate politics. In the postgame survey, respondents are additionally asked for their motivation and engagement during the game, how well they comprehend the game rules, and whether they cooperated with other players in the game. All items in the questionnaires were rated on a five point Likert scale from completely disagree to completely agree (see supplementary material).

A standardized observatioten sheet is used to track in-game decisions. Cooperative and defective decisions are only recorded if they are underpinned by a flow of game currency. Thus, we abstract from 'soft' cooperation and defection like verbal agreements or emotional support. We measure cooperation and defection by players' decisions for carbon neutral or carbon emitting technologies. A description of all variables used for the statistical analysis is given in Table 2. Two pretests were conducted prior to the survey, the first with university students and the second with 41 participants under field conditions.

[3] A detailed description and in depth reflection on KEEP COOL is given by Eisenack (2013).

Participants reported a good understanding of the items: only a small portion stated strong or slight difficulties with single questions (2.4%) or terms (14%).

Table 1: Overview on research design

	pregame	in-game	postgame
concept	• beliefs about international climate politics	• cooperation and defection	• beliefs about international climate politics
variables	• items: *responsibility, polconfidence, intercoop, pessimism*	• decisions for carbon neutral (*green*) and carbon emitting (*black*) technologies	• items: *responsibility, polconfidence, intercoop, pessimism*
instrument for data collection	• pregame survey with standardized closed form questionnaire	• tracking in-game decisions with standardized observation sheet	• postgame survey with standardized closed form questionnaire

Table 2: Descriptions of dependent, independent and control variables

	Dependent variables
responsibility	Item „I feel personally responsible to stop climate change.“
polconfidence	Item: „I think politicians will do everything necessary to stop climate change.“
intercoop	Item: „I believe that there will be an effective international climate protection agreement in the future.”
pessimism	Item: “Politics will not mitigate climate change, anyway.”
	Independent variables
black	Player’s total number of decisions for carbon emitting technologies
green	Player’s total number of decisions for carbon neutral technologies
game	Dummy variable for playing KEEP COOL; 1 = yes, 0 = no
	Control variables
umbrella	Dummy for game role ‘USA & Partners’; 1 = yes, 0 = no
polconfidence-pre	Item *polconfidence* in pregame survey.
intercoop-pre	Item *intercoop* in pregame survey.
gender	Gender of player; 1 = female, 2 = male
age	Age of player
experience	Item: “How often do you play board or parlour games?“
motivation	Item: “I played Keep Cool engaged and highly motivated.”
rules	Item: “I have well understood the rules of the game.“
teamplay	Item: “I have worked together with other players in the game.”

Note: Items have been translated from their original German versions to English.

3.4 Statistical analysis

We take a two-step approach to test the influence of playing a simulation game on the beliefs about international climate politics. First, we test whether playing KEEP COOL has any systematic effect on beliefs at all. Therefore, we pool pregame and postgame survey results in a panel regression and study the coefficient and significance of the dummy variable *game* on beliefs. We estimate a linear fixed-effects panel model to account for time-invariant interpersonal heterogeneity

$$attitude_{i,t} = \alpha_i + \beta\, game_{i,t} + u_{i,t}, \quad (1)$$

where $t = 1, 2$ indicates pre- and postgame time, $game_{i,t}$ is the dummy variable for whether the game has been played, α_i are individual fixed-effects for player $i = 1, \dots, N$ and $u_{i,t}$ is the error term.

Second, we employ an ordinary least square linear regression to relate in-game decisions to postgame beliefs about international climate politics

$$attitude_i = \beta_0 + \beta_1\, black_i + \beta_2 green_i + \boldsymbol{\beta x_i} + u_i, \quad (2)$$

where $black_i$ and $green_i$ are the independent variables, and $\boldsymbol{x_i}$ is a vector of control variables for individual i according to Table 2, and u_i is the error term. For robustness checks, several sets of control variables are compared. While ordinary least square regression eases interpretation, we also run an ordered-probit regression to confirm or qualify results.

4. Results

We first discuss the representativeness of the sample and the quality of the instruments. Subsequently we turn to the descriptive statistics on in-game decisions and belief changes, to the effect of gaming on beliefs, and finally to how this relates to in-game decisions.

4.1 Representativeness

Participants are aged between 13 and 16 years (mean: 14.5, standard deviation: 1.3) with balanced gender ratio. We first compare responses in the pregame survey with the *16th Shell Youth Study* (Infratest 2010), which is a standardized, quantitative and representative survey on beliefs and attitudes of German adolescents (n = 2060, age 12 to 25).

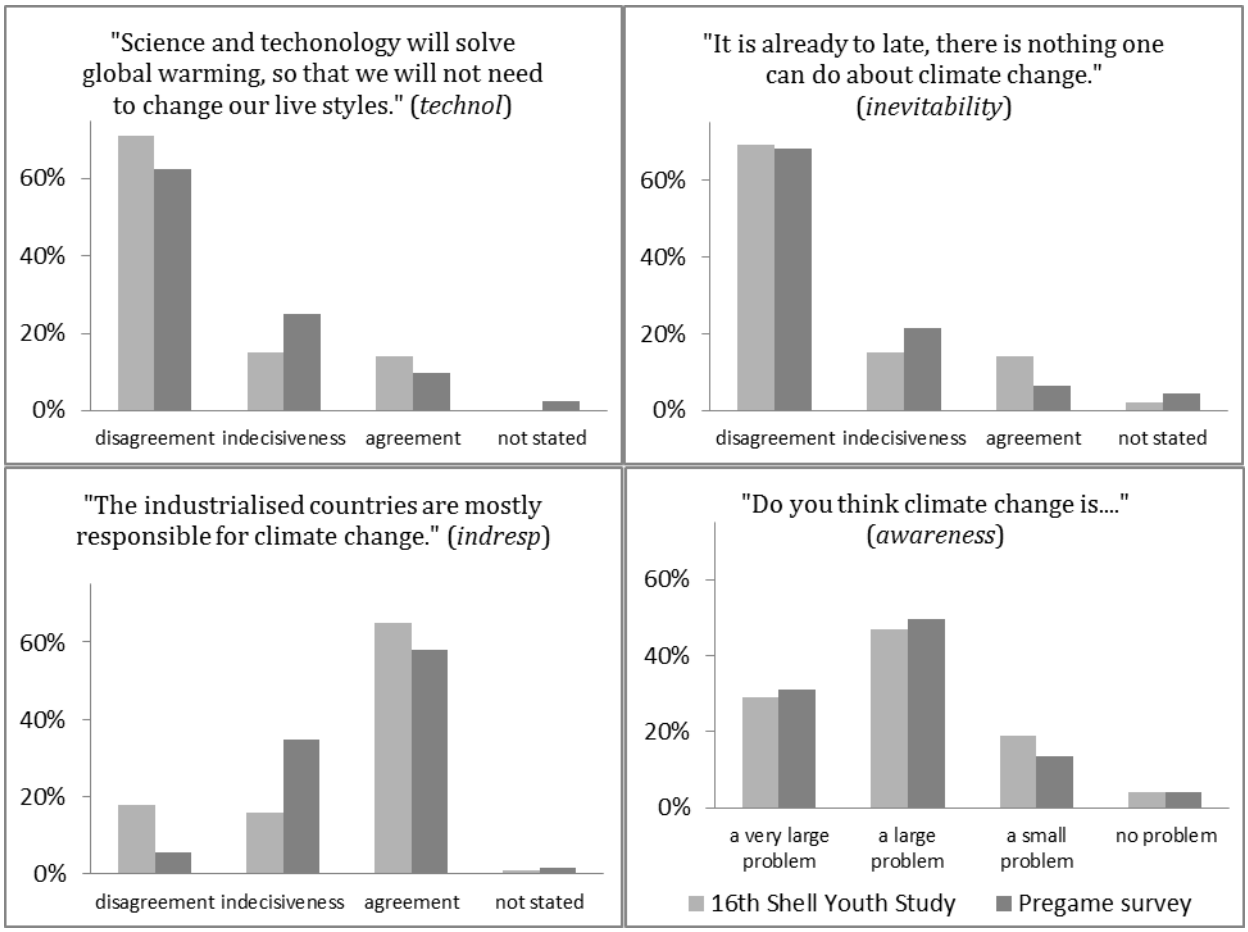

Figure 1: Comparison of four selected items from the pregame survey with the 16th Shell Youth Study. Where responses were given on five and seven point Likert scales, respectively, these are summarized to three categories (agreement, indecisiveness, disagreement) for comparability.

The responses are fairly similar distributed (Figure 1). Where item anchors are identical (item *awareness*) a Chi-square test rejects the zero hypothesis that both distributions are independent. Both studies show similar response patterns for the inevitability of climate change, the historic responsibility of industrialized countries, the trust in technological solutions and problem awareness. Overall, the similarities in responses indicate some representativeness of our study for youths in Germany.

4.2 Objectivity, reliability and construct validity

The *objectivity* of surveys is generally high due to the standardized closed-form questionnaires, which were filled out by the players under presence of the first author. As the objectivity of observing in-game decisions is more critical, we only record cooperation and defection that is visible through a flow of in-game currency. A standardized observation sheet and a detailed facilitation guideline were used to guarantee objectivity.

To assess the *reliability* of the instruments, both beliefs and in-game decisions were measured with several different variables. In addition to those given in Table 2, further items were constructed: *governcoop* ("I think governments of the world will realize that cooperation is the best way to stop climate change"), *egoism* ("Climate change will not be stopped, because all countries only care for themselves"), *needless* ("We do not need international agreements to protect the climate. It is sufficient if every country conducts the climate change mitigation that is good for herself"). All six items were, firstly, checked for systematic changes between pregame and postgame survey. Three items (*polconficence, intercoop, pessimism)* show unidirectional changes across all five anchors of the Likert-scale. Secondly, we assessed correlations between items, and excluded items with little or implausible item intercorrelations (*egoism, needles, governcoop*). Again the same subset of items (*polconfidence, intercoop, pessimism)* shows significant correlations. Thirdly, the discriminatory power of the items was assessed by correlating each item with a sum index of all other items. The items *egoism, needles* and *governcoop* show little discriminatory power. Based on these considerations the items *polconfidence, intercoop* and *pessimism* were selected for further analysis, together with the established item *responsibility*.

Reliability of the independent variables (*black* and *green*) was tested by pairwise considering correlations with the following further variables: the global mean temperature (which is tracked in the game), and in-game emission reductions by closing 'black factories'. The variable *black* is significantly positive related with temperature, both measuring defection. Emissions reductions are significantly positive correlated with *green* factories, both measuring cooperation. Interestingly, *black* and *green* are not significantly correlated. This suggests that both variables capture different notions of cooperation, but might also be partly an artefact of the differences of player's roles (wealthy country groups are able to invest more; this is one reason why we control for players of the Umbrella Group).

Finally, we tested the validity of the instruments by correlating the measured variables pairwise with items from established studies. Two core items (*polconfidence* and *intercoop*) are significantly correlated with established items showing intuitive signs. For instance, *polconfidence* is positively related to a perceived futility of individual action and *intercoop* is negatively correlated to the statement that climate change is inevitabile. Interestingly, in-game decisions for carbon neutral technology (*green*) is significant positively correlated with the statement that actors pursue their own political and economic goals.

4.3 In-game decisions and change in beliefs

Participants show clear changes in their beliefs about international climate politics after playing KEEP COOL. For illustration, in Figure 2 the two lowest and highest categories of the five point Likert scale have been summed up to 'disagreement' and 'agreement'. The feeling of personal responsibility (*polconfidence*) is

higher after playing the game, probably due to higher problem awareness for climate change from the occupation within the game. Players get a stronger expectation that there will be effective international cooperation (*intercoop*). This is probably because they experienced the necessity of global cooperation for climate change mitigation in the game. On the contrary, the expectation that politicians will solve the problem (*polconfidence*) decreases. This might be due to in-game experience of contradictory incentives and trade-offs between climate change mitigation and economic growth politicians are facing.

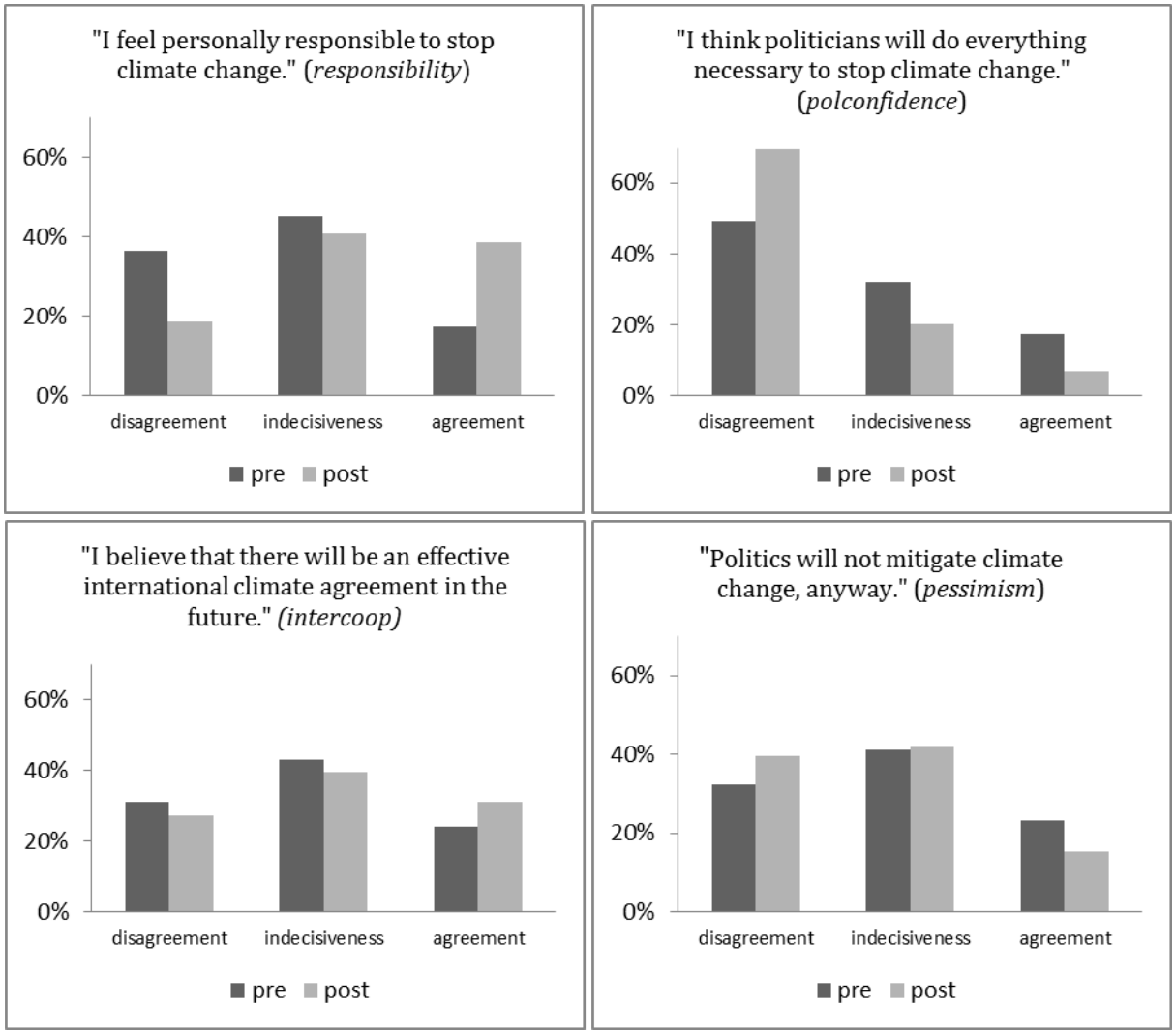

Figure 2: Comparison of pregame and postgame survey results for selected items (n = 235) (Disagreement, indecisiveness and agreement in percent).

Two sided t-tests reveal that the change in beliefs before and after playing the game for *responsibility, intercoop and pessimism*[4] are significant at the $p < 0.05$ level[5].

[4] The p-value for the two-sided t-test for the item *polconfidence* is 0.21.

We see high variability of players' decisions and of game outcomes between the game sessions, in particular with respect to cooperation and defection. While in six sessions players managed to decarbonize their economy by the end of the game, in eleven and ten sessions climate change was moderate and severe, respectively, and in five sessions even tipped across the edge of dangerous climate change. Also variables for in-game cooperation (*green*) and defection (*black*) vary much between players and game sessions (Figure 3). There are purely cooperative and purely defective sessions, but also a continuum between these extremes.

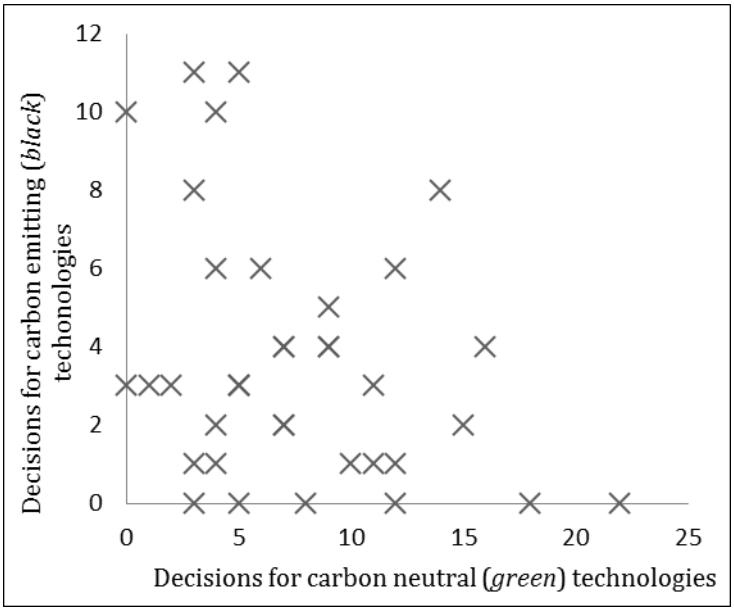

Figure 3: In-game decisions per session (n=38) for carbon neutral *(green*) and carbon-emitting (*black*) technologies.

4.4 Effect of gaming on beliefs

Next, we are interested whether the observed changes in beliefs relate to gaming. We test the zero hypotheses that playing KEEP COOL (the dummy variable *game*), has no effect on beliefs about international climate politics (see Table 3).

We find that playing KEEP COOL indeed significantly affects the sense of personal responsibility for climate change positively (*responsibility*), confirming *Hypotheses H1.1*. This is probably caused by higher problem awareness, for instance due to experiencing climate change impacts in the game. Also the expectation of effective cooperation in international climate politics (*intercoop*) increases (*Hypothesis H1.3*). Thus, experiencing the complex dynamics of international climate politics does not prevent players from

[5] This also holds when (i) using a non-parametric test like the Wilcoxon signed rank test, (ii) aggregating the data in three answer categories as depicted in Figure 2, (iii) or considering only the subset of responses for which also data on in-game decision exist.

becoming more optimistic regarding the evolution of an international climate regime. Also the perception that politics cannot do anything against climate change (*pessimism*) is significantly lowered by gaming (*Hypothesis H1.4*). Stepping in the shoes of country group's leaders, players learn the option space global climate politics has.

Table 3: Panel regression of effect of playing KEEP COOL on beliefs about international climate politics

	Dependent variable:			
	responsibility	*polconfidence*	*intercoop*	*pessimism*
	(1)	(2)	(3)	(4)
game	0.467***	0.083	0.137**	-0.234***
	(0.059)	(0.068)	(0.062)	(0.077)
Observations	463	462	460	455
R^2	0.216	0.007	0.021	0.041

Note: Standard errors in parentheses; *p<0.1; **p<0.05; ***p<0.01

There is no significant effect for confidence in politicians (*polconfidence*) (*Hypothesis H1.2*). This merits attention in light of the positive effect on *intercoop*, which seems closely related. This might indicate that changing beliefs relate to more specific characteristics of in-game experience not captured by the dummy variable *game*. To get a more in depth understanding, we next relate beliefs to in-game decisions and personal attributes.

4.5 Effect of in-game decisions on beliefs

Finally, we are interested in how playing KEEP COOL changes beliefs about international climate politics. We test how players' cooperative or defective in-game decisions relate to postgame beliefs[6] (Table 4).

The analysis reveals that raising the own emissions in the game (*black*) has a significant negative impact on the probability to believe politicians will do everything necessary to stop climate change (*polconfidence*, models 1–3). This supports the hypothesis that less cooperative in-game behavior makes players less optimistic about climate politics (*Hypothesis 2.1)*. Players trying out a defective strategy might have experienced the structures and incentives hindering global cooperation. Following this interpretation, KEEP COOL facilitates experiential learning about the obstacles to international climate treaty making.

[6] Ordered-probit and logit regressions, which are more suitable for ordinal data such as responses on a Likert scale, yield qualitative identical results (see Appendix). We report here the results for OLS regressions, as readers might be more convenient in reading those.

In contrast, players' expectation on an effective international climate agreement (*intercoop*) is positively related to raising their own emissions (models 4–6). One reason might be that defective players have experienced the impacts of unmitigated climate change in the game, thereby getting insights into the shortcomings of voluntary action. Hence, players defecting in the game might become convinced of the necessity of a global environmental agreement in order to prevent dangerous climate change like they experienced in game.

Hypothesis 2.2 is also supported by the significantly negative relation of *polconfidence* to *green* (models 2, 3). Players with more carbon neutral technologies in the game become less optimistic that politicians will sufficiently act. Thus, players choosing a more cooperative strategy are not naïve in assuming real world politicians will act the same. In fact the opposite might be true: Players testing a more climate friendly strategy might have suffered from free-riding and hence become more sensitive to the difficulties of free-riding.

Lastly, we turn to the control variables. Players perceiving themselves as cooperative within the game (*teamplay*) have a significant higher optimism in politicians stopping climate change and effective international climate politics, which is in line with *Hypothesis 2.1*. The answers in the pregame survey (*polconfidence-pre, intercoop-pre*) have a strong and significant influence on the postgame survey results. Interestingly, through playing the game, expectations of male players that politicians will do anything necessary to stop climate change rises more than for female players. Players with a better understanding of the game rules (*rules*), show a significant higher confidence in politicians solving the climate issue. Player that felt highly motivated and engaged in KEEP COOL (*motivation*) become more optimistic about an effective climate treaty, but not so in terms of confidence in politicians. This might give some evidence for the importance of emotions for learning from simulation games.

In general, these findings show that players do not translate their more or less climate friendly in-game decisions one-to-one to their beliefs about climate politics. KEEP COOL facilitates both choosing climate friendly and damaging technologies to win the game and in some regards players choosing less (more) climate friendly technologies exhibit more (less) optimistic beliefs about international climate politics. Thus, we find playing climate friendly in-game not to be a prerequisite for learning for sustainability. Instead, the experience from testing out in-game strategies matters and might result in different beliefs about international climate politics.

Table 4: Linear regression of in-game decisions, personal attributes and beliefs about international climate politics

	Dependent variable:					
	polconfidence			*intercoop*		
	(1)	(2)	(3)	(4)	(5)	(6)
black	-0.128**	-0.154**	-0.155**	0.126**	0.121*	0.109*
	(0.063)	(0.065)	(0.064)	(0.062)	(0.064)	(0.064)
green		-0.069*	-0.069*		-0.015	-0.018
		(0.039)	(0.038)		(0.038)	(0.038)
teamplay			0.137**			0.155**
			(0.059)			(0.060)
polconfidence-pre	0.407***	0.401***	0.401***			
	(0.064)	(0.064)	(0.063)			
intercoop-pre				0.348***	0.347***	0.337***
				(0.081)	(0.081)	(0.080)
umbrella	0.211	0.407**	0.399**	-0.132	-0.089	-0.087
	(0.165)	(0.198)	(0.195)	(0.163)	(0.197)	(0.195)
gender	0.262**	0.253**	0.282**	0.088	0.086	0.140
	(0.117)	(0.116)	(0.117)	(0.115)	(0.115)	(0.117)
age	0.027	0.020	0.021	0.006	0.005	-0.0004
	(0.069)	(0.068)	(0.068)	(0.067)	(0.068)	(0.068)
experience	0.029	0.025	0.018	0.019	0.018	0.017
	(0.075)	(0.075)	(0.074)	(0.076)	(0.076)	(0.075)
motivation	-0.026	-0.008	-0.057	0.165**	0.169**	0.118
	(0.081)	(0.081)	(0.082)	(0.079)	(0.080)	(0.082)
rules	0.165**	0.177**	0.188**	-0.066	-0.063	-0.053
	(0.074)	(0.074)	(0.073)	(0.074)	(0.074)	(0.074)
constant	0.273	0.369	-0.025	1.278	1.299	0.922
	(1.059)	(1.054)	(1.054)	(1.035)	(1.039)	(1.039)
Observations	184	184	182	182	182	180
Adjusted R^2	0.202	0.212	0.232	0.114	0.109	0.140

Note: Standard errors in parentheses; *p<0.1; **p<0.05; ***p<0.01.

5. Discussion and conclusions

This study has provided quantitative evidence on the effectiveness of a simulation game to communicate and teach scientific insights on international climate politics. Results were based on a sample of over two hundred secondary school students in Germany using the simulation game KEEP COOL. A main innovation of this paper was to study the potential of a simulation games for experiential learning in the context of climate change by linking in-game decisions to changing beliefs about climate politics.

We found, first, that players indeed change their beliefs about international climate politics. After playing the game, respondents report significantly more confidence in the potential for climate politics, more optimism about international cooperation on dealing with climate change, and a higher personal responsibility. Second, changes in beliefs relate to players in-game decisions in a non-trivial way. Our analysis shows that students playing KEEP COOL in a more cooperative way tend to become more optimistic about politicians solving the problem, but become more skeptical about an effective international climate agreement.

These findings confirm the potential of simulation games for experiential learning in the context of climate change, where players can test different mitigation policies and experience the consequences of the associated system dynamics. Simulation games can effectively communicate and teach the mechanisms of international climate politics. While it is often held that climate friendly in-game decisions needs to be rewarded in order to stimulate learning for sustainability, our results indicate that effective climate games do not need to require climate protection as winning condition from the players. On the contrary, it might be a good design choice if players experience obstacles to climate protection by reproducing them on their own within the game.

Future research could extend our analysis in multiple ways. Employing a control group with conventional learning methods would assess the results. Varying the sample, for instance to policy makers in the context of climate change, or to students from other countries, could provide insights on generalization. Interactions between players and learning effects could be compared between board game and the digital version of KEEP COOL (Eisenack et al. 2016, Erb 2015, Marscheider and Meya 2017). Moreover, observations indicate that players are emotionally strongly affected by the game. Investigating the role of emotions for learning from simulation games on climate change might be a promising path for future research. Relatedly, communication within a game is often intensive and has been found to improve the management of complex public goods (Lindahl et al. 2015).

Any such study has its limitations. First, while our aim was to study gaming effectiveness in an aggregated and quantitative way, we did not study the process of belief formation. Second, we were interested in the changes in believes immediately after playing the game, as this offers entry points for subsequent group discussion or debriefing. Yet, the long-term effect remains unstudied. Third, we tested changes of beliefs before debriefing took plays to get an isolated measure for the potential of KEEP COOL. However, debriefing is critical to learn from game experience (Crookall 2010; Mendler de Suarez et al. 2012). The differences in the players' game experience and their changes in beliefs would offer fruitful entry points. Thus, the potential for experiential learning assessed in this study is likely to be a rather conservative estimate. Finally, while the sample holds some representativeness for Germany, it is unclear how far our results can be generalized. In other countries, pre-existing knowledge and beliefs about climate change and games might be substantially different. However, representative surveys reveal that the German population is only slightly more concerned about climate change than the European average (European Commission 2015: 24, 53)[7].

Overall, our findings emphasize the potential of gaming to communicate and teach climate change. They contribute to the validation of the effectiveness of games, and show how well-designed climate games can complement conventional methods. Climate games offer an environment where alternative strategies can be tested. Moreover, they help to develop individual beliefs about sustainable development by experiencing complex system dynamics that are not tangible in everyday life.

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[7] The *International Social Survey Program* shows that within-country differences of environmental concerns are higher than cross-country differences, and that concerns of the German population are not far above the surveyed mean (Franzen and Vogl 2013).

References

Ballantyne, A. G., Wibeck, V., & Neset, T. S. (2016). Images of climate change–a pilot study of young people's perceptions of ICT-based climate visualization. *Climatic Change*, *134*(1-2), 73-85.

Barrett, S. (2013): Climate treaties and approaching catastrophes. *Journal of Environmental Economics and Management*, 66(2), 235-250.

Barrett, S. (1994): Self-enforcing international environmental agreements. *Oxford Economic Papers,* 46, 878-894.

[BMUB/ BfN] Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit and Bundesamt für Naturschutz (2014): Naturbewusstsein 2013. Bevölkerungsumfrage zu Natur und biologischer Vielfalt. Available at: https://www.bfn.de/fileadmin/MDB/documents/themen/gesellschaft/Naturbewusstsein/Naturbewusstsein_2013.pdf (accessed 03.06.2016)

Capstick, S.; Whitmarsh, L.; Poortinga, W.; Pidgeon, N.; Upham, P. (2015): International trends in public perceptions of climate change over the past quarter century. *WIREs Climate Change*, 6, 35–61.

Carraro, C. and Siniscalco, D. (1993): Strategies for the international protection of the environment. *Journal of Public Economics*, 52(3), 309-328.

Crookall, D. (2010): Serious games, debriefing, and simulation/gaming as a discipline. *Simulation & gaming*, 41(6): 898-920.

Dellink, R., Dekker, T. and Ketterer, J. (2013): The fatter the tail, the fatter the climate agreement. Simulating the influence of fat tails in climate change damages on the success of international climate negotiations. *Environmental and Resource Economics*, 56(2), 277-305.

Dieleman, H. and Huisingh, D. (2006): Games by which to learn and teach about sustainable development: exploring the relevance of games and experiential learning for sustainability. *Journal of Cleaner Production*, 14(9), 837-847.

Eisenack, K. (2013): A Climate Change Board Game for Interdisciplinary Communication and Education. *Simulation & Gaming*, 44 (2-3), 328-348.

Eisenack, K. and Kähler, L. (2016) Adaptation to climate change can support unilateral emission reductions, *Oxford Economic Papers* 68 (1), 258-278.

Eisenack, K.; Marscheider, N.; Meyer, E. and Bethlehem, L. (2016): KEEP COOL mobil - das mobile Multiplayerspiel zur Klimapolitik. Carl-von-Ossietzky Universität Oldenburg. Retrieved from http://www.keep-cool-mobil.de

Eisenack, K. and Petschel-Held, G. (2004): KEEP COOL—Gambling with the Climate. Wiesbaden. Spieltrieb GbR (Pfarrgasse 2, 65321 Niedermeilingen, Germany). Retrieved from http://www.climate-game.net

Eisenack, K. and Reckien, D. (2013): Climate Change and Simulation/Gaming. *Simulation & Gaming*, 44 (2-3): 245 – 252.

Erb, U. (2015): Possibilities and Limitations of Transferring an Educational Simulation Game to a Digital Platform. *Simulation & Gaming*, 46(6): 817–837.

European Commission (2015): Public opinion in the European Union. Standard Eurobarometer 83. Survey conducted by TNS opinion & social at the request of the European Commission. Available at: http://ec.europa.eu/public_opinion/archives/eb/eb83/eb83_publ_en.pdf (last access 01.03.2015).

Fennewald, T. J. and Kievit-Kylar, G. (2012): Integrating climate change mechanics into a common pool resource game. *Simulation & Gaming*, 44(2-3), 427–451.

Finus, M. and Pintassilgo, P. (2013): The role of uncertainty and learning for the success of international climate agreements. *Journal of Public Economics*, 103, 29-43.

Franzen, A. and Vogl, D. (2013): Two decades of measuring environmental attitudes: A comparative analysis of 33 countries. *Global Environmental Change*, *23*(5), 1001-1008.

GESIS - Leibniz-Institut für Sozialwissenschaften (2010): ALLBUS 2010 - The German General Social Survey. Documentation. Available at: http://www.gesis.org/fileadmin/upload/dienstleistung/daten/umfragedaten/allbus/Fragebogen/ALLBUS_2010.pdf (accessed 03.06.2016).

Gugerell, K. and Zuidema, C. (2017): Gaming for the energy transition. Experimenting and learning in co-designing a serious game prototype. *Journal of Cleaner Production*, http://dx.doi.org/10.1016/j.jclepro.2017.04.142

Haug, C.; Huitema, D. and Wenzler, I. (2011): Learning through games? Evaluating the learning effect of a policy exercise on European climate policy. *Technological Forecasting & Social Change*, 78, 962 – 981.

Hoel, M. (1992). International environmental conventions: the case of uniform reductions of emissions. *Environmental and Resource Economics*, 2(2), 141-159.

[Infratest] TNS Infratest Sozialforschung (2010): Fragebogen der Shell Jugendstudie 2010. Available at: http://www.shell.de/content/dam/shell-new/local/country/deu/downloads/pdf/youth-study-2010questionaire.pdf.

IPCC (2014): Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

Kuster, E. L. and Fox, G. A. (2017): Current state of climate education in natural and social sciences in the USA. *Climatic Change*, *141*(4), 613-626.

Lessmann, K., Kornek, U., Bosetti, V., Dellink, R., Emmerling, J., Eyckmans, J., Nagashima, M., Weikard, H. and Yang, Z. (2015). The stability and effectiveness of climate coalitions: A comparative analysis of multiple integrated assessment models. *Environmental and Resource Economics*, 62(4), 811-836.

Lindahl, T., Bodin, Ö., & Tengö, M. (2015). Governing complex commons - The role of communication for experimental learning and coordinated management. *Ecological Economics*, *111*, 111-120.

Marscheider, N.; Meya, J.N. (2017): Die internationale Klimapolitik auf dem Smartphone. Globales Lernen am Beispiel des digitalen Planspiels KEEP COOL mobil. In: Oliver Emde, Uwe Jakubczyk, Bernd Kappes, Bernd Overwien (Herausgeber), Mit Bildung die Welt verändern? Globales Lernen für eine nachhaltige Entwicklung. Verlag Barbara Budrich. 250 Seiten.

Mayer, I.; Bekebrede, G.; Harteveld, C.; Warmelink, H.; Zhou, Q.; Ruijven, T., Lo, J.; Kortmann, R. and Wenzler, I. (2014). The research and evaluation of serious games: Toward a comprehensive methodology. *British Journal of Educational Technology*, *45*(3), 502-527.

Meadows, D.; Fiddaman, T. and Shannon, D. (1989): FISH BANKS, LTD. Durham. University of New Hampshire, Institute for Policy and Social Science Research.

Mendler de Suarez, J.; Suarez, P.; Bachofen, C.; Fortugno, N.; Goentzel, J.; Gonçalves, P.; Grist, N.; Macklin, C.; Pfeifer, K.; Schweizer, S.; van Aalst, M.; Virji, H. (2012): Games for a New Climate: Experiencing the Complexity of Future Risks , Technical report, The Frederick S. Pardee Center for the Study of the Longer-Range Future, Boston University, Boston (MA, USA).

Meya, J.N., Kornek, U., Lessmann, K. (2017): How empirical uncertainties influence the stability of cli-mate coalitions. *International Environmental Agreements: Politics, Law and Economics*. https://doi.org/10.1007/s10784-017-9378-5

Meya, J.N., Meya, L. (2016): Das Klima aufs Spiel setzen. Simulation der internationalen Klimaverhandlungen mit dem Planspiel KEEP COOL. *Gesellschaft-Wirtschaft-Politik*, 2/2016, 249-259.

Nordhaus, W. D. and Yang, Z. (1996). A regional dynamic general-equilibrium model of alternative climate-change-strategies. *American Economic Review*, 86(4), 741-765.

Reckien, D. and Eisenack, K. (2013): Climate Change Gaming on Board and Screen: A Review. *Simulation & Gaming*, 44, 253 – 271.

Rumore, D., T. Schenk, and L. Susskind (2016): Enhancing Communities' Readiness to Adapt to Climate Change Through Role-Play Simulations, *Nature Climate Change,* 06/2016, 745 - 750.

Rhodes, E., Axsen, J., and Jaccard, M. (2017): Exploring Citizen Support for Different Types of Climate Policy. *Ecological Economics*, *137*, 56-69.

Shepardson, D. P., Niyogi, D., Choi, S. and Charusombat, U. (2011): Students' conceptions about the greenhouse effect, global warming, and climate change. *Climatic Change*, *104*(3), 481-507.

Sterman, J. D. (2011): Communicating climate change risks in a skeptical world. *Climatic Change*, 108(4), 811-826.

Sterman, J. D., Fiddaman, T., Franck, T., Jones, A., McCauley, S., Rice, P., Sawin, E. and Siegel, L. (2013). Management flight simulators to support climate negotiations. *Environmental Modelling & Software*, 44, 122-135.

Sterman, J.; Franck, T.; Fiddaman, T.; Jones, A.; McCauley, S.; Rice, P.; Sawin, E.; Siegel, L.; Rooney-Varga, J.N. (2015): WORLD CLIMATE: A Role-Play Simulation of Climate Negotiations. *Simulation & Gaming*, 46, 348–382.

Stoutenborough, J. W., Liu, X. and Vedlitz, A. Trends in public attitudes toward climate change (2014): The influence of the economy and Climategate on risk, information, and public policy. *Risk, Hazards & Crisis in Public Policy*, 5, 22–37.

Tjernström, E. and Tietenberg, T. (2008): Do differences in attitudes explain differences in national climate change policies?. *Ecological Economics*, *65*(2), 315-324.

van Pelt, S.C.; Haasnoot, M.; Arts, B.; Ludwig, F.; Swart, R. and Biesbroek, R. (2015) Communicating climate (change) uncertainties: Simulation games as boundary objects. *Environmental Science & Policy*, 45, 41-52.

Wangler, L., Altamirano-Cabrera, J. C. and Weikard, H. P. (2013): The political economy of international environmental agreements: a survey, *International Environmental Agreements: Politics, Law and Economics*, 13(3), 387-403.

Wibeck, V. (2014): Enhancing learning, communication and public engagement about climate change – some lessons from recent literature, *Environmental Education Research*, 20(3), 387-411.

Wu, J. S. and Lee, J. J.(2015): Climate change games as tools for education and engagement. *Nature Climate Change*, 5, 413–418.

Ziegler, A. (2017), Political orientation, environmental values, and climate change beliefs and attitudes: An empirical cross country analysis, *Energy Economics* 63, 144-153.

6. Appendix

6.1 Ordered-probit regression table

Table 5: Ordered-probit regressions of in-game decisions, personal attributes and beliefs about international climate politics.

	Dependent variable:					
	polconfidence			*intercoop*		
	(1)	(2)	(3)	(4)	(5)	(6)
black	-0.169**	-0.205**	-0.213**	0.168**	0.161*	0.148*
	(0.081)	(0.084)	(0.084)	(0.081)	(0.083)	(0.083)
green		-0.093*	-0.095*		-0.020	-0.024
		(0.050)	(0.050)		(0.049)	(0.049)
teamplay			0.182**			0.204***
			(0.077)			(0.079)
polconfidence-pre	0.529***	0.526***	0.536***			
	(0.086)	(0.086)	(0.087)			
intercoop-pre				0.458***	0.457***	0.451***
				(0.107)	(0.107)	(0.108)
umbrella	0.299	0.567**	0.568**	-0.175	-0.118	-0.117
	(0.209)	(0.254)	(0.255)	(0.210)	(0.253)	(0.254)
gender	0.310**	0.299**	0.345**	0.122	0.119	0.193
	(0.149)	(0.149)	(0.153)	(0.148)	(0.148)	(0.152)
age	0.015	0.005	0.005	0.009	0.007	-0.0003
	(0.087)	(0.087)	(0.088)	(0.086)	(0.087)	(0.088)
experience	0.035	0.030	0.022	0.023	0.022	0.021
	(0.095)	(0.096)	(0.096)	(0.097)	(0.097)	(0.098)
motivation	-0.030	-0.006	-0.069	0.223**	0.228**	0.165
	(0.102)	(0.102)	(0.106)	(0.103)	(0.103)	(0.107)
rules	0.218**	0.239**	0.257***	-0.091	-0.087	-0.0075
	(0.094)	(0.095)	(0.097)	(0.095)	(0.095)	(0.096)
Observations	184	184	182	182	182	180
Log Likelihood	-222.033	-220.279	-214.602	-219.636	-219.553	-214.332

Note: Standard errors in parentheses; *p<0.1; **p<0.05; ***p<0.01

6.2 Supplementary material

6.2.1 Pregame questionnaire (German original)

Angaben zur Person

Wie alt bist Du? ____ Jahre Geschlecht : **1** weiblich **2** männlich

0_1 Wie häufig spielst Du Brett- beziehungsweise Gesellschaftsspiele?

1 nie **2** mehrmals im Jahr **3** etwa jeden Monat **4** etwa jede Woche **5** täglich

0_2 Wie häufig spielst Du Computerspiele?

1 nie **2** mehrmals im Jahr **3** etwa jeden Monat **4** etwa jede Woche **5** täglich

Wahrnehmung des Klimawandels

Im Folgenden spielen wir ein Spiel zur internationalen Klimapolitik. Wir würden Dir vorher gerne ein paar Fragen zu Deinen Einschätzungen zum Klimawandel und zur Klimapolitik stellen.

1_3 Hast Du vom Klimawandel bereits etwas gehört?
1 ja
2 ja, aber weiß nicht was das ist
3 nein

1_4 Hältst Du den Klimawandel für…
1 kein Problem
2 ein kleines Problem
3 ein großes Problem
4 für ein sehr großes Problem

Einschätzungen und Einstellungen zum Klimaschutz

Im Folgenden würden wir Dich gerne nach Deiner Meinung zum Klimaschutz fragen. Bitte sag uns, ob die folgenden Aussagen überhaupt nicht, eher nicht, teils teils, eher oder voll und ganz zu treffen.

	über-haupt nicht	eher nicht	teils teils	eher	voll und ganz
2_5v Ich fühle mich persönlich verantwortlich, den Klimawandel aufzuhalten.	**1**	**2**	**3**	**4**	**5**
2_6 Ich fühle mich durch den Klimawandel bedroht.	☐	☐	☐	☐	☐
2_7v Ich denke, dass die Politiker und Politikerinnen, alles notwendige tun werden, um den Klimawandel aufzuhalten.	☐	☐	☐	☐	☐
2_8 Ich als Einzelner kann keinen großen Beitrag gegen den Klimawandel leisten.	☐	☐	☐	☐	☐
2_9v Es ist zwecklos, meinen Beitrag für die Umwelt zu leisten, solange andere sich nicht	☐	☐	☐	☐	☐

genauso verhalten.					
2_10v Es ist bereits zu spät, gegen den Klimawandel kann man nichts mehr tun.	☐	☐	☐	☐	☐
2_11 Wissenschaft und Technik werden die Umwelt- und Klimaprobleme lösen, ohne dass wir unsere Lebensweise ändern müssen.	☐	☐	☐	☐	☐
2_12 Ich tue das, was für das Klima richtig ist, auch wenn mich das mehr Geld oder Zeit kostet.	☐	☐	☐	☐	☐

Einstellungen zur internationalen Klimapolitik

Bitte kreuze an, inwieweit Du den Aussagen zur internationalen Klimapolitik zustimmst.

	über-haupt nicht	eher nicht	teils teils	eher	voll und ganz
3_13v Ärmere Staaten sollten beim Klimaschutz von reicheren Staaten unterstützt werden.	☐	☐	☐	☐	☐
3_14v Für den Klimawandel sind vor allem die reichen Industrieländer verantwortlich.	☐	☐	☐	☐	☐
3_15v Es müsste verbindliche internationale Abkommen für den Umweltschutz geben, an die sich Deutschland und andere Länder halten müssten.	☐	☐	☐	☐	☐

Einschätzungen zur internationalen Klimapolitik

Bitte kreuze an, inwieweit Du den folgenden Einschätzung zur internationalen Klimapolitik zustimmt.

	über-haupt nicht	eher nicht	teils teils	eher	voll und ganz
4_16v Ich denke, die Staaten der Welt werden einsehen, dass Zusammenarbeit die beste Lösung ist, um den Klimawandel aufzuhalten.	☐	☐	☐	☐	☐
4_17v Der Klimawandel wird nicht aufgehalten, weil alle Länder nur an sich denken.	☐	☐	☐	☐	☐
4_18v Ich glaube, dass es in der Zukunft ein wirkungsvolles internationales Abkommen zum Klimaschutz geben wird.	☐	☐	☐	☐	☐
4_19v Wir brauchen keine internationalen Absprachen um das Klima zu schützen. Es reicht, wenn jedes Land so viel Klimaschutz macht, wie gut für es selbst ist.	☐	☐	☐	☐	☐
4_20v Die Politik bringt sowie nichts, um den Klimawandel aufzuhalten.	☐	☐	☐	☐	☐

6.2.2 Postgame questionnaire (German original)

Nachdem Du Keep Cool gespielt hast, würden wir Dich gerne noch einmal nach Deiner Meinung zum Klimaschutz befragen. Inwieweit stimmst Du den Folgenden Aussagen zu?

	über-haupt nicht	eher nicht	teils teils	eher	voll und ganz
2_5n Ich fühle mich persönlich verantwortlich, den Klimawandel aufzuhalten.	**1**	**2**	**3**	**4**	**5**
2_7n Ich denke, dass die Politiker und Politikerinnen, alles notwendige tuen werden, um den Klimawandel aufzuhalten.	☐	☐	☐	☐	☐
2_9n Es ist zwecklos, meinen Beitrag für die Umwelt zu leisten, solange andere sich nicht genauso verhalten.	☐	☐	☐	☐	☐
2_10n Es ist bereits zu spät, gegen den Klimawandel kann man nichts mehr tun.	☐	☐	☐	☐	☐

Einstellungen zur internationalen Klimapolitik

Bitte kreuze an, inwieweit Du den Aussagen zur internationalen Klimapolitik zustimmst.

	über-haupt nicht	eher nicht	teils teils	eher	voll und ganz
3_13n Ärmere Staaten sollten beim Klimaschutz von reicheren Staaten unterstützt werden.	☐	☐	☐	☐	☐
3_14n Für den Klimawandel sind vor allem die reichen Industrieländer verantwortlich.	☐	☐	☐	☐	☐
3_15n Es müsste verbindliche internationale Abkommen für den Umweltschutz geben, an die sich Deutschland und andere Länder halten müssten.	☐	☐	☐	☐	☐

Einschätzungen zur internationalen Klimapolitik

Bitte kreuze an, inwieweit Du den folgenden Einschätzung zur internationalen Klimapolitik zustimmt.

	über-haupt nicht	eher nicht	teils teils	eher	voll und ganz
4_16n Ich denke, die Staaten der Welt werden einsehen, dass Zusammenarbeit die beste Lösung ist, um den Klimawandel aufzuhalten.	☐	☐	☐	☐	☐
4_17n Der Klimawandel wird nicht aufgehalten, weil alle Länder nur an sich denken.	☐	☐	☐	☐	☐
4_18n Ich glaube, dass es in der Zukunft ein wirkungsvolles internationales Abkommen	☐	☐	☐	☐	☐

zum Klimaschutz geben wird.					
4_19n Wir brauchen keine internationalen Absprachen um das Klima zu schützen. Es reicht, wenn jedes Land so viel Klimaschutz macht, wie gut für es selbst ist.	☐	☐	☐	☐	☐
4_20n Die Politik bringt sowie nichts, um den Klimawandel aufzuhalten.	☐	☐	☐	☐	☐

Spielerfahrung

Bitte sag uns, wie Du Dein eigenes Verhalten beim Spielen erlebt hast.

	über-haupt nicht	eher nicht	teils teils	eher	voll und ganz
5_21 Ich war engagiert und motiviert beim Spiel dabei.	☐	☐	☐	☐	☐
5_22 Ich hatte das Gefühl die Spielregeln des Spiels gut zu verstehen.	☐	☐	☐	☐	☐
5_23 Ich habe im Spiel mit anderen zusammengearbeitet.	☐	☐	☐	☐	☐
5_24 Ich habe vor allem versucht das 5 wirtschaftliche und politische Ziel meiner Region zu erreichen.	☐	☐	☐	☐	☐

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