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Focusing Climate Negotiations on a Uniform Common Commitment Can Promote Cooperation

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Discussion Paper No. 267

January 4, 2021

Collaborative Research Center Transregio 190 | www.rationality-and-competition.de
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Forthcoming in PNAS

Focusing climate negotiations on a uniform common commitment can promote cooperation*

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Final version

January 2, 2021

Keywords: cooperation, negotiation design, common commitment, reciprocity, climate policy

*) We gratefully acknowledge research and programming assistance from Benjamin Langer, Cornelius Schröder and Mario Winkler. Financial support by Deutsche Forschungsgemeinschaft through CRC TRR 190 (project number 280092119) and through Germany´s Excellence Strategy (EXC 2126/1– 390838866), as well as by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No 741409) is gratefully acknowledged. This paper reflects only the authors' view, and the funding agencies are not responsible for any use that may be made of the information it contains. Part of this research was conducted while the first author visited the economics department at Harvard University. He would like to thank his hosts for their great hospitality.

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Abstract

International cooperation on the reduction of greenhouse gas emissions, disarmament, or free trade needs to be negotiated. The success of such negotiations depends on how they are designed. In the context of international climate change policy, it has been proposed [e.g., Weitzman *J of the Association of Environmental and Resource Economists* (2014)] that shifting the negotiation focus to a uniform common commitment (such as a uniform minimum carbon price) would lead to more ambitious cooperation. Yet, a proof-of-concept for this important claim is lacking. Based on game theoretical analyses, we present experimental evidence that strongly supports this conjecture. In our study, human subjects negotiate contributions to a public good. Subjects differ in their benefits and costs of cooperation. Participation in the negotiations and all commitments are voluntary. We consider treatments in which agreements are enforceable, and treatments in which they have to be self-enforcing. In both situations, negotiating a uniform common commitment is more successful in promoting cooperation than negotiating individual commitments (as in the Paris agreement) and complex common commitments that tailor the commitment to the specific situation of each party (as attempted with the Kyoto protocol). Furthermore, as suggested by our model, a uniform common commitment benefits most from being enforced.

Significance Statement

Climate change and other threats to modern societies require international cooperation. Utilizing a laboratory experiment and game theoretical analysis, we find that the success of negotiations to promote cooperation strongly depends on the kind of commitment negotiated. In the context of international climate policy, our findings indicate that individual commitments (as negotiated in the Paris Agreement) and complex common commitments (as negotiated in the Kyoto Protocol) tend to have only limited success in promoting cooperation. Shifting the negotiation focus to a uniform common commitment, such as a minimum carbon price, may potentially foster more ambitious cooperation and thus help mitigating climate change.

Main Text

Introduction

International cooperation on climate change, free trade, and disarmament requires successful negotiations about how much each party contributes to the public good. The success or failure of these negotiations depends on how they are designed (1). Particularly, in the context of international climate change policy, it has been hypothesized that negotiating a uniform common commitment would be more successful in achieving cooperation than negotiating individual or complex common commitments (2–5). Yet, a proof-of-concept for this important claim is lacking. Using a laboratory experiment with human subjects and a game theoretical analysis, we fill the gap – and provide strong support for the conjecture.

We consider a canonical public good problem. Asymmetry is known to be an essential complication to international agreements (6), so – besides a control with fully symmetric parties – negotiators in our main laboratory treatment differ in their initial endowment, in how much they benefit from the public good and how much of it they want to be provided. Lack of enforcement is another fundamental problem that hinders international cooperation (7–9), so we look at a situation where parties can write a binding and enforceable contract and at a situation where the agreement has to be self-enforcing. Negotiations differ in two dimensions. First, parties can negotiate a common goal to be achieved either by individual commitments (each party deciding individually how much to contribute) or by a common commitment (all parties deciding jointly and unanimously on all contributions). Second, a common commitment may be achieved either by a complex assignment (tailoring each individual contribution to its individual costs and benefits) or by a uniform rule (disregarding individual differences). In all treatments, participation in the negotiation and commitments are voluntary.

We find that negotiation design is of first order importance. If negotiations are focused on a uniform common commitment, contribution levels are about twice as high as compared to negotiations focusing on individual or complex common commitments. Negotiating a complex common commitment is slightly more successful at the extensive margin by inducing more parties to participate, but it is dominated at the intensive margin by the uniform commitment because negotiators often fail to coordinate any agreement. Negotiating individual commitments is equally successful as a uniform common commitment in getting parties to participate, but

again at substantially lower contribution levels. One reason for the superior performance at the intensive margin is that negotiating a uniform common commitment turns (reciprocal) cooperation into a weakly dominant strategy for all participating parties. The results are robust and hold not only in the case where contracts are binding and enforceable (as predicted by theory), but even in the case where agreements cannot be enforced but have to be self-enforceable (in which case standard game theory predicts zero cooperation across all treatments).

Our study is motivated by, and potentially important for, international negotiations on climate change (5). There have been two major approaches to negotiating international climate cooperation. In the Kyoto negotiations, the developed countries strived for a complex assignment of national emission caps. However, no such assignment (that the negotiating parties could all agree upon) has been found. Eventually, each country chose its emission cap individually, which then became part of the Kyoto protocol (4, 10). Some countries later withdrew from the Kyoto protocol, others did not live up to their promises, and a planned follow-up protocol was never ratified.

In the Paris negotiations, instead of attempting a common commitment, each country pledged an individually chosen commitment ("nationally determined contributions"). The Paris agreement succeeded in being signed by all countries (although the US decided later to withdraw its participation). However, the announced individual commitments fall substantially short of achieving the two-degree-goal (11, 12).

There is a new proposal that negotiations should focus on a common carbon price (2, 3, 13, 14). Previous authors advocated carbon pricing as an instrument to implement the reduction of carbon emissions at low economic cost (15, 16). The new proposal points to a different and independent argument: A carbon price provides a simple focal point for a common commitment in climate negotiations – one number that applies to all countries in the same way. This facilitates agreement (17) and fosters reciprocity (2, 3, 14, 18, 19) which is key to cooperation (20–24). Yet, evidence showing that negotiating a uniform carbon price can be more successful than negotiating a vector of emissions caps (as in Kyoto) or nationally determined contributions (as in Paris) is lacking.

This paper provides evidence, based on experimental and game theoretical analyses, that a uniform common commitment better promotes cooperation than the alternative commitments.

The advantage of a laboratory experiment is that it allows to study the negotiation outcomes after exogenous changes in the negotiation design, as well as the mechanisms that causally drive behavior. While all theory and experiments necessarily abstract from many real-world complexities, our study informs the important debate about how to approach climate negotiations by providing a "proof of concept", experimentally and theoretically, that negotiating a uniform common commitment may be more successful than previous negotiation designs.

Experiment Design and Related Studies

The human-subject experiment builds on a linear one-shot public good game with four parties who differ in their initial endowments and the costs and benefits of their investments into a common project (see the Supplementary Information for details). The experiment is framed neutrally. If applied to climate change negotiations the investments can be interpreted as emission reductions or carbon prices, but there was no reference to climate change in the experiment. In this game, it is a dominant strategy for each party not to invest anything into the common project, but all parties are better off if all invest.

The public good game is preceded by a three-stage negotiation procedure. At the first stage, all parties decide simultaneously whether to participate in the negotiation. At the second stage, participants make publicly displayed proposals for a potential agreement. Each party can replace its current proposal with a new proposal at any time. At the third stage, they can simultaneously commit to an agreement.

After the negotiation, all parties decide simultaneously how much to invest in the public good. In the treatments with enforcement parties who committed to an agreement in the negotiation phase must match or exceed their commitments, while non-participants and participants who did not reach an agreement can choose any investment they like. In the treatments with no enforcement all parties are unconstrained in choosing their investment level, no matter whether they participated in an agreement.

We compare three negotiation designs that differ in what is being negotiated. In *Individual Commitment* (IC) each participant proposes how much she is willing to invest. While she may also propose how much each other participant should invest, the final, binding proposal is only for her own, individual commitment. In *Complex Common Commitment* (CCC) each participant

proposes how much *each* party should invest. The final proposal specifies the vector of investments, one investment for each of the participants. It becomes a binding commitment if and only if all participants agree to the same vector, implying that each negotiator has the power to veto any given proposal. In *Uniform Common Commitment* (UCC), each participant proposes a uniform minimum investment for all participants. By participating the parties agree that the lowest of all proposals (i.e. the least cooperative proposal) becomes binding for all participants. No party can be committed to a higher contribution than its own proposal. For more details on the experimental procedures see *Materials and Methods* below.

Our study is closely related to an important experimental literature on minimum contributions in public good games (25), because our uniform commitment treatment imposes a minimum contribution level. This literature mostly corroborates our finding that imposing a minimum contribution is effective in promoting cooperation, and it does so under various laboratory conditions. For instance, it has been shown that a minimum contribution level may promote cooperation (*i*) regardless of whether it is imposed endogenously, exogenously, or by a central authority (26, 27), (*ii*) for a variety of payoff functions including concave ones (28), and (*iii*) under various forms of payoff asymmetries among subjects (29–32). A few studies mention potential challenges. For instance, there is evidence that, in specific circumstances, a minimum contribution level might crowd out contributions of otherwise cooperative subjects, yet other experiments find no or only small crowding out (27, 28, 33). Other studies come to mixed conclusions regarding subjects' willingness to voluntarily participate in coalitions to provide the public good (34, 35). Finally, a related theoretical literature studies the effectiveness of commitment devices absent strong institutions, such as through the usage of deposits (36). Our study contributes to this literature by comparing the effectiveness of uniform common commitment negotiations with both individual and complex common commitments negotiations, and by studying how these three negotiation designs differ regarding participation decisions and enforcement. It is designed to capture some of the key features of the three leading approaches to negotiating climate cooperation that have been implemented or proposed.

Game-theoretic Analysis and Predictions

A game-theoretic analysis of the treatments with enforcement, assuming that all parties are rational and purely self-interested, predicts that the success of climate negotiations depends on the negotiation design (for the full analysis see *SI Appendix*, *S3 Theoretical predictions and hypotheses*)). In IC, because commitments are individual and non-reciprocal, it is a dominant strategy for each party to commit to an investment level of zero. In stark contrast, in UCC there is a unique Nash equilibrium in weakly dominant strategies that achieves the socially efficient outcome if at least three parties participate in the negotiations. This is because the participant proposing the lowest uniform commitment determines the outcome. Assuming that enough parties participate, if this participant raises her proposed commitment, she raises it for all participants, making herself (and everybody else) better off. Thus, each participant is predicted to propose the commitment level that she would like to be imposed on all participants. At the same time, high investment proposals are protected against exploitation, because nobody has to invest more than any other participant. In this sense, UCC successfully builds reciprocity ("I will if you will") into the negotiation design.

Finally, in CCC there are multiple equilibria. If at least three parties participate in the negotiations, almost any vector of investments is a Nash equilibrium in the negotiation subgame. No standard refinement selects one of these equilibria as the most plausible one to be played. While there are many equilibria yielding an efficient outcome, none of them gives rise to equal payoffs. Without a focal point for an agreement, coordination is difficult (2, 17). Each negotiator prefers an agreement in which others are committed to invest more and she herself is committed to invest less. Whether parties are able to solve this coordination problem is an empirical question that is addressed by our experiments.

Based on the game-theoretic analysis of the experiment with enforcement we predict IC negotiations to be least effective and UCC negotiations to be very effective. The efficiency of the CCC negotiations may equal that of IC or UCC or be somewhere in between. At the same time, however, more effective negotiation designs tend to give stronger incentives to free-ride by not participating in the negotiations in the first place. A party that does not participate in the negotiations benefits from the commitment of the negotiators while she is free to choose how much to invest herself. This may mitigate the success of effective negotiation design.

On the other hand, there is reason to expect that the participation rate will be high in all treatments, including UCC. A large body of behavioral and experimental research shows that many people are "conditional cooperators", willing to invest more than predicted by pure self-interest if others invest as well (37–39). It has been suggested that conditional cooperators are also more willing (than predicted by their narrow self-interest) to participate in institutions that promote cooperation (35).

In the treatments with no enforcement parties have to rely on non-binding agreements. Here the assumption that all parties are rational and purely self-interested implies that agreements are cheap talk and that nobody will invest anything in the common project no matter what the negotiation design. However, behavioral economics, economic psychology, and experimental evidence suggest that non-binding agreements and promises do affect behavior (40, 41).

Results

Figure 1 shows the results of the experiment with enforcement and confirms that negotiation design strongly affects negotiated outcomes. Cooperation levels, as measured by commitments and actual investments (averaged over *all* subjects), are much higher in UCC compared to IC and CCC. The average commitment measured in percent of the socially optimal level is almost twice as high in UCC (73%) as in IC (40%) and CCC (33%). All differences are statistically significant. The average investment in UCC is even higher, 83% of the social optimum, while the investments in IC and CCC reach only 45% and 48%, respectively. This difference is again statistically highly significant, while the difference between IC and CCC is not statistically significant. See *SI Appendix, S3 Additional experimental results and statistical analysis* for the full statistical analysis.

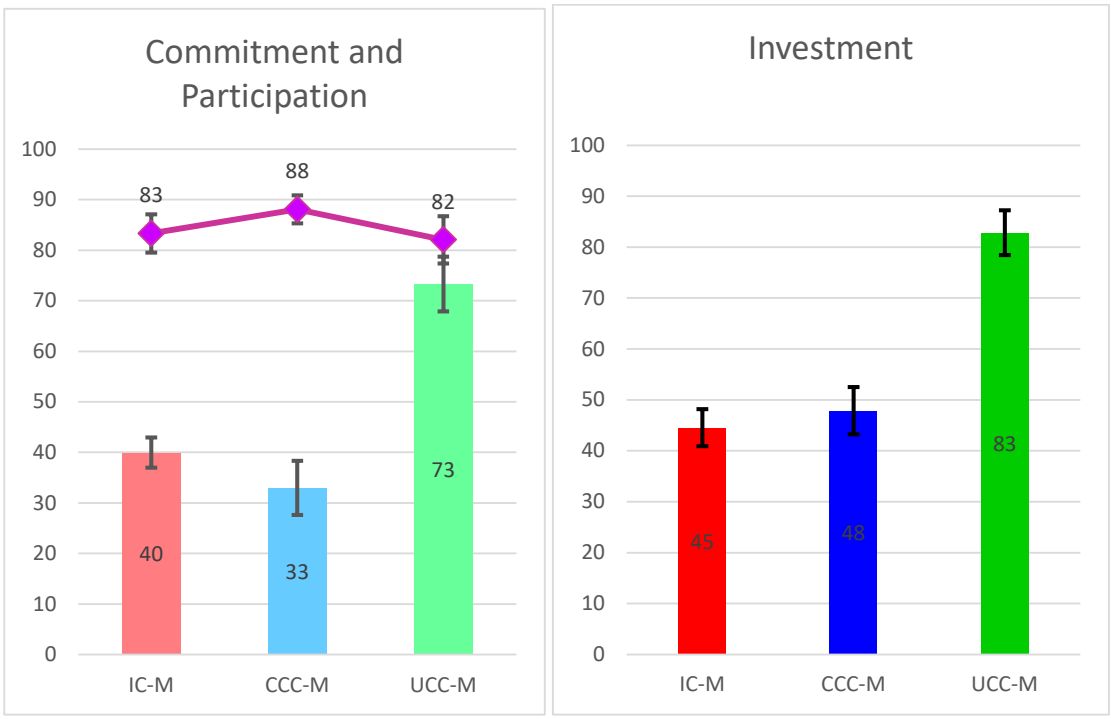

Fig. 1. Enforcement treatments: Cooperation measured by commitments, participation and investments across negotiation treatments when contracts are enforced. The bars display the average commitments (left diagram) and investments (right diagram) in percent of the socially optimal investment level in the three treatments. The averages are calculated with respect to the whole group of subjects, regardless of whether subjects participated in the negotiation or not, thus illustrating the groups' overall cooperation level. The violet diamonds above the bars in the left diagram display the participation rates. Error bars represent SE of the mean clustered at the matching group level. The results are based on 1,060 observations of commitment, investment and participation decisions of 212 individuals. Each individual participated in one treatment only and took decisions in five anonymous and randomly re-matched groups.

The game-theoretic analysis assumes that all people are purely self-interested. Therefore, it predicts that IC yields zero investments and that investments should never exceed commitments. Figure 1 shows, however, that IC is to some extent effective and that in all three treatments some subjects invest more than they are committed to do. This is consistent with overwhelming evidence that many people (and countries) are not purely self-interested, but are willing to make voluntary contributions to the public good (12, 42). However, the data also show that this motivation alone falls substantially short of achieving the socially efficient outcome.

Because UCC is so effective in achieving cooperation of the parties that participate in negotiations, it could also be more susceptible to free-riding by non-participants. Yet, the participation rate in UCC is with 82% almost as high as in IC (83%). The rate in CCC is with 88% statistically significantly higher, but the difference is small in absolute terms. Thus, as shown in Figure 1, differences in participation rates do not impede the effectiveness of UCC.

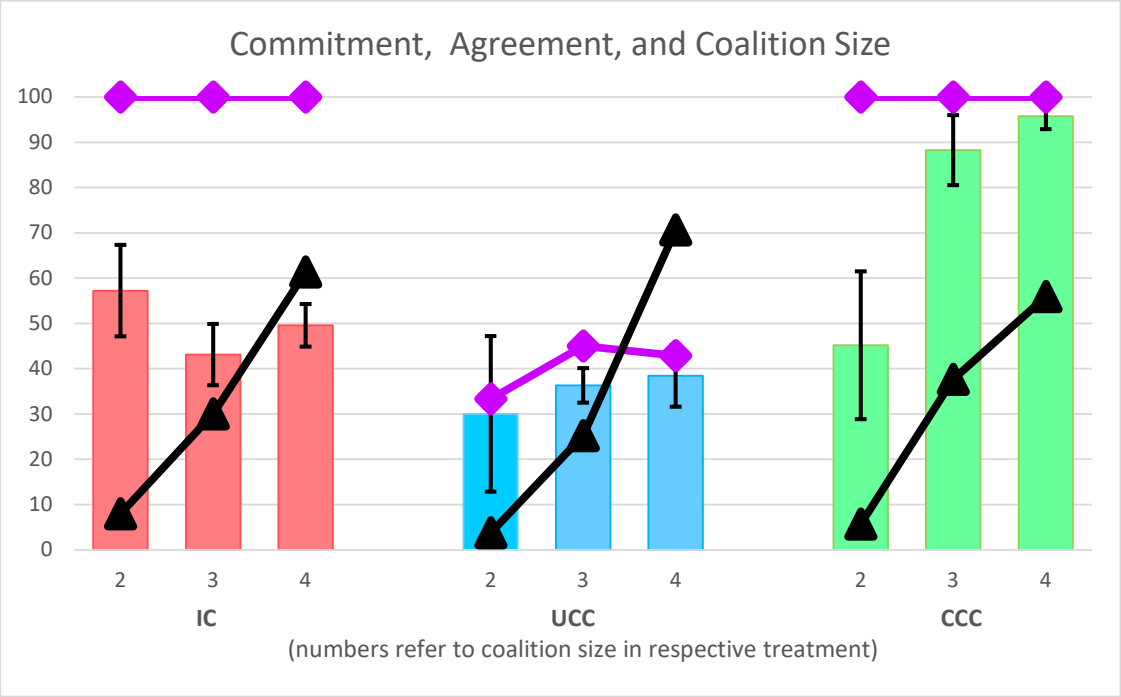

Fig. 2. Inside negotiations: Commitment, agreement, and coalition size when contracts are enforced. The bars show average commitments (in percent of the socially optimal investment level) conditional on participation as a function of the coalition size in each treatment. In contrast to Fig. 1 subjects who did not participate in negotiations are not included. Error bars represent SE of the mean clustered at the matching group level. The commitment levels in UCC are generally much higher than the commitment levels in IC and CCC. The black triangles show the distribution of the number of participants in negotiations ("coalition size"). In all treatments, larger coalitions are much more frequent than smaller coalitions. The purple diamonds show the frequency of agreements for different coalition sizes. Full agreement is built into IC and UCC, while CCC negotiations fail in more than half of all cases. This is the main reason for the poor performance of CCC. In those cases where an agreement is reached, commitments in CCC reach on average 87% of the efficient level.

Two other factors are decisive for the superior performance of UCC, illustrated by Figure 2. The first is the choice of commitment levels by the negotiating parties. The reciprocal nature of UCC negotiations creates incentives to choose the socially optimal commitment if the coalition size is sufficiently large. Indeed, overall, UCC negotiators commit to an average of 89% of the socially optimal investment. If all four parties participate in the negotiations, UCC negotiators reach almost full efficiency (96%, see Figure 2). If CCC negotiators come to an agreement, they reach a significantly lower level of efficiency (87% on average), but this is still much higher than the average commitment for IC negotiators of only 48%.

The second factor is the likelihood that any given group of negotiators will reach an agreement. Because there are many efficient and inefficient equilibrium agreements in CCC,

coordination is difficult. Indeed, on average, only 43% of all CCC negotiations result in a common commitment with little variation across coalition sizes (see purple diamonds in Figure 2). The failure to successfully coordinate in complex negotiations reduces the overall commitment level in CCC (averaged across all negotiators) to 37%. On the other hand, there is always an agreement in IC and UCC. By definition, the individual commitments in IC do not require coordination. UCC negotiations impose the rule that the lowest proposed investment level becomes binding for all participants, so an agreement to the lowest common denominator is always reached. [3]

We conclude that while (on average) IC fails to promote individual cooperation and CCC fails to promote coordination, UCC achieves both, agreement and high investment levels.

Robustness: No Enforcement Treatment and Additional Results

For international agreements, enforcement is an important challenge. Although some enforcement is often possible (e.g., through shaming, the threat of retaliation in repeated interaction or just because sticking to one's previous commitments and promises in negotiations is 'the right thing to do') (8, 9), it cannot be taken for granted. Thus, as a robustness check, we conducted a stress test of our institutions, where agreements are not binding and can be violated at no cost. In the treatments without enforcement investment levels are lower, as expected. But surprisingly, our qualitative results are unaffected (see Fig. 3). Parties invested 52% of the efficient level in UCC but only 34% in both, IC and CCC. This not only refutes the standard game-theoretic prediction of no investments in all three treatments, it also shows that negotiation design systematically affects cooperation even when agreements are non-binding, just as in the treatments with enforcement. A possible explanation is given by recent results in behavioral economics on promises and honesty (40, 41, 43). When people are given an opportunity to increase their payoff by breaking a promise, some of them do, but many do not or do not fully

[3] Even though participants often failed to reach an agreement in CCC, lack of negotiation time does not seem to have been the critical issue. We asked subjects after the experiment whether they felt that more time would have been needed. On a scale from 1 ("do not agree at all") to 7 ("fully agree"), a large majority of 62.5% answered with 1 or 2 while only 12.5% answered with 6 or 7. Perhaps not surprisingly, the average answer in in IC (2,3) and UCC (1,2) was even lower than in CCC (2.72), but not by much.

exploit the opportunities for cheating (44). As a result, non-binding agreements do affect behavior, but they are not as powerful as enforceable contracts.

From our treatments with and without enforcement, we conclude that negotiating a uniform commitment is much more successful in promoting cooperation than the alternative negotiation designs. Even without enforcement a uniform common commitment achieves significantly higher average investments than individual commitments and common complex commitments with enforcement. Moreover, UCC benefits most from an enforcement technology: Enforcement increases investments by 31 percentage points in UCC, but only by 11 and 14 percentage points in IC and CCC, respectively. That is, while enforcement is clearly important, it is not sufficient to achieve cooperation. Rather, its effectiveness – in line with our theoretical analysis – depends on negotiation design.

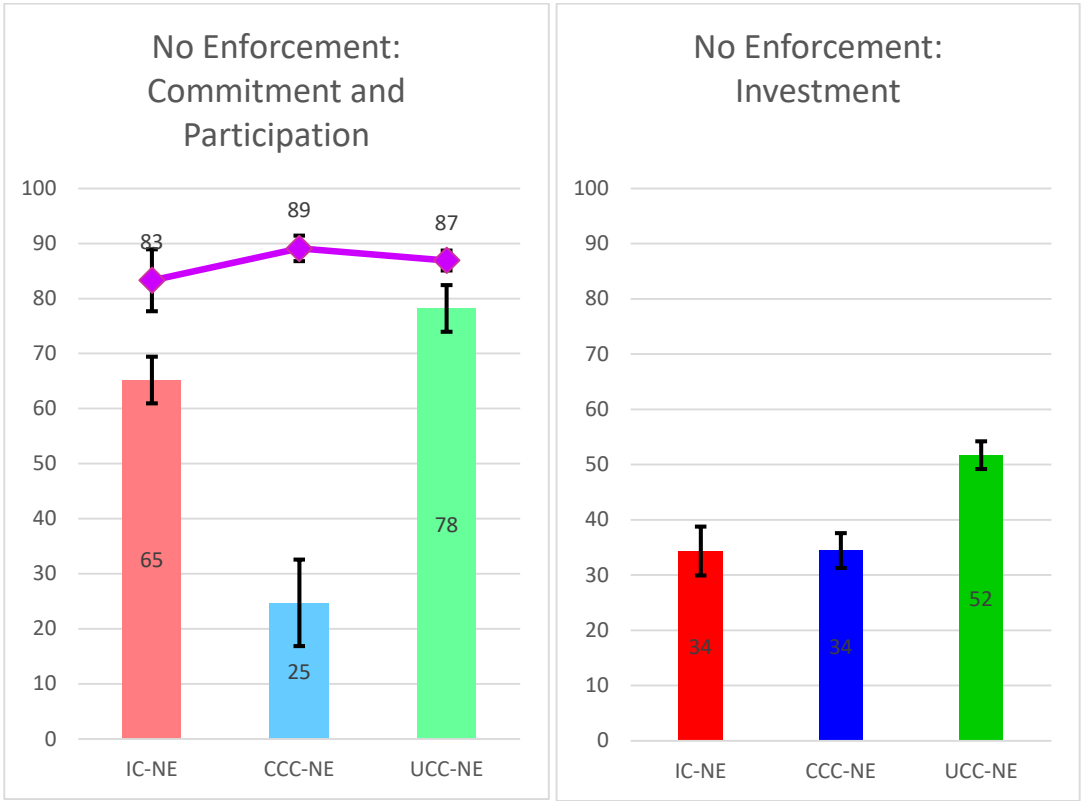

Fig. 3. No Enforcement treatments: Cooperation measured by non-binding commitments, participation and investments across negotiation treatments when there is no enforcement. Fig. 3 corresponds to Fig. 1, but without enforcement. The bars display the average non-binding commitments (left diagram) and investments (right diagram) in percent of the socially optimal investment level in the three treatments. Because in this treatment commitments are not enforced, they are denoted as "non-binding commitments". The averages are calculated with

respect to the whole group of subjects, regardless of whether subjects participated in the negotiation or not, thus illustrating the groups' overall cooperation level. The violet diamonds above the bars in the left diagram display the participation rates. Error bars represent SE of the mean clustered at the matching group level. The results are based on 760 observations of commitment, investment and participation decisions of 152 individuals. Each individual participated in one treatment only and took decisions in five anonymous and randomly re-matched groups.

Our results and interpretations are also robust to learning and variations in the (as)symmetry of parties. In all treatments, subjects interacted anonymously over five rounds. In each round, groups were randomly re-matched (stranger treatment). If we look at the behavior over time, we find a small negative time trend for investments, very similar in all treatments, of about 2 percentage points per period. There is no time trend in participation decisions in any of the treatments (see *SI Appendix*, *S3 Additional experimental results and statistical analyses*).

In an additional experiment we consider a *symmetric* public good game (with enforcement) in which all four parties have the same payoff function (see supplementary materials for details). Without asymmetries, a natural focal point for cooperation is equal and efficient investments, which removes the complexity of CCC negotiations and thus mitigates one key difference between UCC and CCC. In fact, while the participation rates are somewhat smaller than in the baseline, overall investment levels are now very similar in UCC (57 %) and CCC (58%, no statistically significant difference), but still significantly smaller in IC (41%). This shows that the lack of a focal point in the asymmetric CCC negotiations is the main driver for the superior performance of UCC in the baseline experiment (see *SI Appendix*, *S3 Additional experimental results and statistical analyses*).

Conclusions

Our study provides causal evidence that a negotiation design that focuses on a uniform common commitment can be more successful in achieving cooperation than individual commitments or complex common commitments. Negotiating a uniform common commitment is superior in our experiments both when agreements are binding and when they are not. Moreover, as predicted by theory and confirmed by the experiments, when enforcement is available, it can most effectively promote cooperation when negotiators focus on a uniform common commitment.

Because our laboratory study controls away potentially confounding factors in the world outside the laboratory, we caution that, of course, one cannot conclude from our study that switching the negotiation style will automatically lead to more cooperation in the real-world. For instance, the number of parties in the negotiation might differently affect the effectiveness of each of the negotiation designs, which in turn might affect the number of parties that should be invited to the negotiations. We leave such questions to future studies.

That said, our study complements previous discussions and previous evidence in several, less-controlled field studies suggesting that reciprocal common commitments may indeed be crucial for achieving cooperation (4, 20, 45). It also offers a '*proof of concept*' for a key negotiation design choice when the goal of the negotiation is to promote cooperation.

The Paris agreement will be reviewed and further developed over the next years. How to achieve more ambitious cooperation will be an important concern in this process. Our study suggests that parties should consider shifting a focus of the negotiations to a uniform, reciprocal target. One natural candidate would be a uniform minimum price for carbon emissions. It is a simple and transparent policy instrument that is relatively easy to measure and to compare across countries, and that can be flexibly implemented with taxes, markets for emission rights, or hybrid policies (24). Because a uniform price minimizes total costs of reducing CO_2 emissions, it is also a widely accepted goal already, supported by advocates of a carbon tax as well as by promoters of cap-and-trade.

While our experiments exogenously imposed the kind of contract that could be agreed upon, it would be interesting to study the choice of agreement that negotiators strive for (27, 32), and how this depends on the problem under consideration. For price agreements, it often seems natural to look for a uniform common commitment that applies the same price to all parties, such as a uniform minimum price for carbon, a uniform minimum tax on corporate profits or a uniform maximum tariff on imports. In other contexts, however, a uniform proportional rule may be more appropriate. For instance, countries may wish to contribute to a Green Fund in proportion to their GDP or to their cumulative carbon emissions in the past. We must leave such questions to future research.

An important concern is that with 192 countries there will always be some countries that are unwilling to support an ambitious climate policy for political or economic reasons. Integrating

these parties in an international agreement based on the lowest common denominator, as stipulated by the unanimity rule of our UCC design, would impede any cooperation. Thus, as forcefully advocated by Nordhaus (5, 14) it may be preferable to start out negotiating a uniform carbon price within a "climate club" of some of the main players (e.g. the US, Europe, China, and Japan), and to extend the carbon price to other countries using sticks (e.g. border adjustment taxes) and carrots (e.g. support through a Green Fund) at a later stage.

Materials and Methods

The experiment (including six pilot sessions) was preregistered at AsPredicted.org (see *SI Appendix*, *S5 Preregistration*). The full study protocol was approved by the Institutional Review Board ("Ethics committee" of the Faculty of Economics) at the University of Munich where the study was conducted, and it included informed consent by all participants (see *SI Appendix*, *S6 Ethics approval*). It took place at the Munich Experimental Laboratory for Economic and Social Sciences (MELESSA) in 2018. There were 23 sessions, each divided into two matching groups, and 500 participants in total. Sessions lasted about 90 minutes and yielded average earnings of € 19.91 (approx. $ 24.00). Table S1 in *SI Appendix* displays the demographic summary statistics of all experimental sessions.

Subjects interacted anonymously via a computer network. After reading the instructions and answering test questions the subjects played the negotiation game five times with random rematching within each matching group after each period ("stranger condition"). Then they had to complete a short questionnaire. Finally, the computer randomly selected one period for payment (see *SI Appendix, S7 Instructions*, for the full text of the instructions).

In the **experiment with enforcement** four parties can write a binding contract on "investments" in a public good, called "group project". If investments $x_i \in [0, x_i^{max}]$, $i \in \{A, \dots, D\}$, are made, the payoff of party i is given by

$$U_i = w_i - x_i + a_i \cdot \begin{cases} \sum_{j=1}^{4} x_j , & if \ \sum_{j=1}^{4} x_j \leq \bar{X}_i \\ \bar{X}_i, & if \ \sum_{j=1}^{4} x_j > \bar{X}_i \end{cases}$$

where w_i is the initial endowment, $a_i < 1$ the marginal individual return of the investment, and $\bar{X}_i$ the maximum total investment above which further investments are no longer beneficial for party i. The values of these parameters are summarized in *SI Appendix, Table S2*. Total surplus is maximized if $\sum_{j=1}^{4} x_j = 300$. The investments can be interpreted as emission reductions or carbon prices. However, the experiment is framed neutrally without any reference to climate change.

Before investment decisions are made, parties can negotiate a binding contract as described above. At the negotiation stage all participating parties can make proposals and counterproposals for three minutes in real time. If a proposal is made, all parties see the proposal along with the payoff consequences implied by the proposal.

If a contract is agreed upon, each contracting party has to invest at least the amount it committed to in the contract. A party that did not participate in the negotiations can choose any investment level $x_i \in [0, x_i^{max}]$.

The **experiment with no enforcement** is identical to the experiment with enforcement with the only exception that the "contract" is called an "agreement" and that it is common knowledge that this agreement is not enforced. Thus, at the investment stage all parties can choose any investment level $x_i \in [0, x_i^{max}]$.

Finally, we conducted a control **experiment with symmetric parties** that has the exact same structure as the experiment with enforcement, but here all four parties have the same endowments and payoff functions that are the averages of the parameters of the asymmetric treatments (see *SI Appendix*, *Table S2*).

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Supplementary Information for

Focusing climate negotiations on a uniform common commitment can promote cooperation

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This PDF file includes:

Supplementary text
Tables S1 to S4
Figures S1 to S3
Preregistration
Ethics Approval
Instructions
SI References

Other supplementary materials for this manuscript include the following:

Dataset and Stata .do file available at https://doi.org/10.7805/climate-negotiations

Supplementary Information Text

S1. Summary statistics and parameters of the experiment

Table S1 displays the summary statistics on observations and demographics in the different treatments.

		Observations (absolute numbers)				**Demographics** (in percent)											
		Total				**gender**	**age**			**native lang.**	**field of study**						
			Sub-jects	Ses-sions	Matching groups	female	<20	20s	>30	german	econ	busi-ness	law	soc. sc.	huma-nities	natur. sc.	Other
1	**IC (enf)**	**360**	72	3	6	57	18	75	7	78	11	18	4	16	10	20	22
2	**CCC (enf)**	**360**	72	3	6	54	19	75	3	81	18	10	4	17	14	25	13
3	**UCC (enf)**	**340**	68	3	6	49	22	68	9	87	12	4	6	16	18	25	19
4	**IC (no enf)**	**180**	36	2	4	58	3	94	3	81	17	17	14	8	22	17	6
5	**CCC (no enf)**	**220**	44	2	4	59	23	75	2	75	16	11	5	11	5	27	25
6	**UCC (no enf)**	**360**	72	3	6	60	11	83	6	93	14	11	6	10	19	19	21
7	**IC (symm)**	**240**	48	2	4	58	8	81	11	77	10	13	10	6	15	31	15
8	**CCC (symm)**	**220**	44	2	4	70	16	80	2	84	7	16	7	16	25	14	16
9	**UCC (symm)**	**200**	44	2	4	70	16	84	0	82	32	16	5	9	7	14	18
	total	**2480**	**500**	**22**	**44**	**59**	**16**	**78**	**5**	**82**	**15**	**12**	**6**	**13**	**15**	**22**	**18**

Table S1. Summary statistics of all experimental sessions. Each session is divided in two matching groups. Subjects are randomly rematched after each round within a matching group, but there is no interaction across matching groups.

Table S2 displays the parameters of the asymmetric public good game.

i	w_i	a_i	x_i^{max}	$\bar{X}_i$
A	200	0.4	100	340
B	120	0.4	100	340
C	100	0.8	80	300
D	80	0.6	80	300

Table S2. Parameters of the asymmetric public good game in the enforcement and no enforcement experiment.

S2. Theoretical predictions and hypotheses

We analyze the game played in the **experiment with enforcement** by backward induction. If all parties are perfectly rational and only concerned about their own material payoff we get the following predictions for the outcome of the negotiation subgame (given the participation decisions at stage 1) in the three treatments.

Proposition 1 [Individual Commitment]: *In the IC treatment it is a dominant strategy for each party to commit to an investment of 0.*

Proof: At the commitment stage, the marginal return for each party $i \in \{A, \dots, D\}$ is given by

$$\frac{\partial U_i}{x_i} = \begin{cases} -1 + a_i & if\ x_i < \bar{X}_i \\ -1 & if\ x_i \geq \bar{X}_i \end{cases}$$

Thus, because $a_i < 1$ for all $i \in \{A, \dots, D\}$, it is a dominant strategy for each player to choose $x_i = 0$, no matter what had been proposed at the negotiation stage.

Proposition 2 [Complex Common Commitment]: *Let $S \subseteq \{A, B, C, D\}$ denote the coalition of participating parties. If $|S| \geq 2$ and if $S \neq \{A, B\}$, then every investment profile $x = (x_i, x_{-i})$ satisfying*

$$x_i \leq \frac{a_i}{1 - a_i} \sum_{j \neq i, j \in S} x_j$$

is a Nash equilibrium in the commitment subgame. If $S = \{A, B\}$*, the only NE is* $x_A = x_B = 0$.

Proof: In CCC the negotiation subgame admits multiple equilibria because each party is pivotal for the contract to become binding. It is always a Nash equilibrium that parties agree to the null contract (i.e., do not agree), but any contract that gives each party at least its outside option utility can also be sustained as a NE. In particular, many different efficient investment profiles can be sustained giving rise to different payoff distributions. □

Proposition 3 [Uniform Common Commitment]: *If |S|=4, there is a unique Nash equilibrium in undominated strategies in the commitment subgame with*

$$x_i = \begin{cases} 85, & if\ i = \{A, B\} \\ 75, & if\ i = \{C, D\} \end{cases}$$

giving rise to a minimum investment of 75 and the efficient total investment of 300.

If $|S| = 3$ *or* $|S| = 2$ *and* $A, B \notin |S|$*, then there is a unique Nash equilibrium in undominated strategies with* $x_i = x_i^{max}$*. If* $|S| = 2$ *and* $A \in |S|$ *or* $B \in |S|$*, then all Nash equilibria give rise to a minimum investment of 0.*

Proof: In UCC the negotiating parties have strong incentives to raise the proposed minimum investment, if enough parties participate in the negotiations. If $x_i \geq \min_{j \neq i}\{x_j\}$, then x_i does not affect the outcome. But if $x_i < \min_{j \neq i}\{x_j\}$, then party i can raise the investments of *all* parties by raising its proposed x_i. Thus, the marginal return of increasing x_i is $|S| \cdot a_i$ while the marginal cost is 1. Therefore, if $|S| = 4$, it is a weakly dominant strategy to raise x_i up to the level that is "socially" optimal from the perspective of party i. Note that parties A and B benefit from the investments up to a total investment of 340, so they would like to raise the minimum investment to 85, while C and D do not benefit from investments beyond a total investment of 300, so they will propose a minimum of only 75 (which maximizes total surplus). If $|S| = 3$, then $3 \cdot a_i > 1$ and $3 \cdot x_i^{max} < \overline{X_i}$, so it is a weakly dominant strategy for all participants to choose $x_i = x_i^{max}$. The same holds if $|S| = 2$ and the marginal return of each member of the coalition is greater than 0.5. However, if $|S| = 2$ and one member of the coalition has a marginal return smaller than 0.5 (which is true for types A and B), then these parties choose $x_i = 0$. □

These results make clear-cut and opposite predictions for IC and UCC. In CCC almost any outcome can be sustained as a Nash equilibrium, so coordination is an issue. Even if all parties want to coordinate on an efficient outcome, there are many efficient equilibria with different payoff distributions, none of which gives equal payoffs to all parties. This makes coordination difficult.

We now turn to the participation stage. In IC, given the predicted outcome of the negotiation game, parties are indifferent whether to participate, because there will be no contract with positive investment levels anyway.[4] In CCC and UCC, the more a party expects others to invest if it does not participate, the stronger is the incentive to free-ride on others' commitments. If $|S| > 2$, then in the negotiation subgame of UCC there is a unique Nash equilibrium in undominated strategies giving rise to the efficient outcome, while in the negotiation subgame of CCC there are many (efficient and inefficient) equilibria and coordination failure is possible. Thus, free-riding is less of a problem in CCC than in UCC. Therefore, we expect that parties participate with a higher probability in CCC. This is summarized in the following hypothesis:

Hypothesis 1 [Enforcement Treatments]:

a) There is more participation in CCC than in UCC; participation in IC is undetermined.

b) For any given number of participants contracts are more efficient in UCC than in CCC, and least efficient in IC.

In the **experiment with no enforcement**, the game theoretic analysis is straightforward. Regardless of what the parties agreed to at the negotiation stage, at the investment stage parties face a standard public good game in which it is a dominant strategy to invest nothing (see Proposition 1). However, it is a well-known fact that many people keep their promises. [5] If the parties expect that some fraction of the participants will stick to the agreement, they have similar incentives at the negotiation stage as in the main treatments.

[4] Because parties are indifferent in equilibrium, even small deviations from selfishness and rationality may serve as a tie-breaker. If, for instance, parties believe that non-participation makes them look uncooperative, might lower others' willingness to cooperate or is more boring than participation, those parties would participate.

[5] Abeler, Noszenzo and Collin (2019), Vanberg (2008)

Hypothesis 2 [No Enforcement Treatments]:

a) If all parties are only interested in their own material payoff, each party chooses an investment of zero in all treatments independent of what happened at the negotiation stage.

b) If some parties experience a disutility from promise breaking, then these parties stick to the agreement made at the renegotiation stage while others cheat, so that, overall, (non-binding) commitments are positively correlated with investments. As a result, the outcome is qualitatively similar to the outcome with enforcement (see Hypothesis 1), yet investment levels are lower.

Finally, consider the Symmetry treatments. Here, all parties have the same payoff functions with the average parameters of the asymmetric experiments, i.e., $w_i = 125$, $a_i = 0.55$, $x_i^{max} = 90$ and $\overline{X_i} = 320$. The game theoretic analysis is a straightforward adaptation of the analysis of the main experiment with very similar results. However, symmetry offers a natural (symmetric) focal point in the CCC treatment. Thus, we hypothesize that in CCC parties will agree to a common commitment more often. Therefore, we expect the difference between UCC and CCC to be smaller. However, because a common commitment in CCC is more likely, parties have a stronger incentive to free-ride by not participating in the negotiations.

Hypothesis 3 [Symmetry Treatments]:

a) *The symmetric, efficient outcome with $x_i = 75$ for all $i \in \{A, B, C, D\}$ is a natural focal point for agreement in CCC. Because no such focal point exists in the Main treatments, it is more likely that the negotiating parties will come to an efficient agreement in Symmetry. This reduces the difference between CCC and UCC compared to the Main treatments.*

b) *More efficient negotiations reduce the incentive to participate. Thus, the participation rate in CCC is lower compared to the Main treatments.*

S3. Additional experimental results and statistical analyses

Enforcement treatments, non-parametric tests: We first compare the participation, commitment and investment decisions in the main treatments with enforcement. Fisher's exact test does not reject the hypothesis that the participation decisions in IC and UCC are drawn from the same distribution ($p=0.365$), but it does reject this hypothesis comparing IC and CCC ($p=0.044$) and UCC and CCC ($p=0.017$). A pairwise comparison of the commitments between the three treatments using the Wilcoxon signed rank test rejects the hypothesis that they are drawn from the same distribution ($p<0.001$). Similarly, comparing investments in UCC to those in IC and CCC rejects the hypothesis that they are drawn from the same distribution ($p<0.001$), while the hypothesis that investment decisions in IC and CCC are drawn from the same distribution cannot be rejected ($p=0.4026$).

Regression analysis: Table S3 shows an OLS regression analysis of participation, commitments, investments and payoffs in the main treatments with enforcement. In comparison to the IC treatment, there are no significant differences in CCC, but highly significant and substantial differences in UCC. Commitments and investments are 25 (and 28, respectively) percentage points higher in UCC, and subjects earn 33 points more on average. However, there is no significant difference in the participation decision. Subjects played the experiment five times in a stranger matching condition. There is a statistically significant decline of the participation rate of about 2 percentage points per round and a corresponding small reduction of commitments, investments and payoffs.

VARIABLES	(1) Participate	(2) Commit	(3) Invest	(4) Payoff
CCC	0.0472	-5.222	2.508	3.011
	(0.0441)	(4.325)	(4.160)	(4.968)
UCC	-0.0127	25.03***	28.69***	33.09***
	(0.0565)	(4.362)	(4.022)	(4.558)
Round	-0.0231***	-3.000**	-3.825***	-4.508***
	(0.00618)	(1.182)	(0.846)	(1.005)
Type B	-0.0830	-14.87***	-16.40***	-63.60***
	(0.0619)	(3.779)	(3.492)	(3.492)
Type C	0.0264	-2.336	-0.321	-31.18***
	(0.0548)	(2.662)	(3.519)	(5.397)
Type D	-0.0491	-13.35***	-14.71***	-71.31***
	(0.0524)	(3.920)	(3.993)	(4.090)
Constant	0.929***	46.60***	52.75***	220.1***
	(0.0517)	(5.026)	(4.628)	(4.392)
Observations	1,060	1,060	1,060	1,060
R-squared	0.027	0.192	0.235	0.456
Sample	IC; CCC; UCC	IC; CCC; UCC	IC; CCC; UCC	IC; CCC; UCC

Table S3. OLS regression analysis of the participation, commitment and investment decisions and of the payoffs in the main treatments (asymmetric with enforcement). Robust standard errors in parentheses, clustered at matching group level. *** p<0.01, ** p<0.05, * p<0.1.

We also include the types of the players in the regression. Types have no significant effect on the participation decision. Type C has only half the initial endowment of type A, but he benefits twice as much from contributions to the public good. These two effects cancel each other out, so there is no significant difference in the behavior of types A and C. Type B is poorer than A, but enjoys the same marginal benefit from contributions to the public good. This type commits and invests significantly less than A. The same holds for type D, who has a slightly higher marginal benefit, but who is much poorer than A. The different wealth and behavior of the different types is also reflected in their payoffs. Adding demographic controls (gender, age, field of study,

political and religious orientation) does not affect significance levels and has little impact on the regression coefficients.

Overall, our laboratory data strongly confirm Hypothesis 1. Moreover, the data show that, because more efficient negotiations only marginally hamper participation (if at all), the overall cooperation level in UCC is much higher than in CCC and IC.

No Enforcement treatments, non-parametric tests: Fisher's exact test does not reject the hypothesis that the participation decisions in the three treatments are drawn from the same distribution ($p=0.249$). However, a pairwise comparison of the (non-binding) commitments between the three treatments using the Wilcoxon signed rank test rejects the hypothesis that they are drawn from the same distribution ($p<0.001$). Similarly, comparing investments in UCC to those in IC and CCC rejects the hypothesis that they are drawn from the same distribution ($p<0.001$), while the hypothesis that investment decisions in IC and CCC are drawn from the same distribution cannot be rejected ($p=0.86$).

Comparing the investment decisions in the UCC treatment of the No Enforcement experiment to the investment decisions in the IC and CCC treatments of the Enforcement experiment by using a Wilcoxon ranksum test rejects the hypothesis that they are drawn from the same distribution ($p<0.001$).

Symmetry Treatments, non-parametric tests: Fisher's exact test rejects the hypothesis that the participation decisions in the three treatments are drawn from the same distribution ($p <0.001$). A pairwise comparison of commitment decisions using the Wilcoxon signed rank test rejects the hypothesis they are drawn from the same distribution in UCC and IC ($p=0.0039$) and in UCC and

CCC ($p=0.0086$), while this hypothesis cannot be rejected comparing IC and CCC ($p=0.7073$). A pairwise comparison of investment decisions rejects the hypothesis that they are drawn from the same distribution in IC and CCC ($p<0.001$) and IC and UCC ($p<0.001$), but this hypothesis cannot be rejected comparing CCC and UCC ($p=0.7374$).

Regression analysis (all treatments): Table S4 shows OLS regressions of participation, commitment and investment decisions and of payoffs for all treatments. In the No Enforcement treatments, commitments are significantly higher, but investments and payoffs are lower than in the main treatments. Commitments, investments and payoffs are also somewhat lower in the Symmetry treatment. When we look at the interaction of CCC (UCC) and No Enforcement, the coefficients of CCC*NE (UCC*NE) show that the positive effect of No Enforcement on commitments is restricted to the IC treatment. Furthermore, the negative effect on investments is particularly strong in CCC. The interaction of Symmetry and UCC shows that the participation rate is significantly lower with symmetry which results in lower commitments, investments and payoffs. There is the same negative time trend as in the main treatments. Types differ only in the asymmetric treatments (main and No Enforcement). This is why types are interacted with "asymmetric". The pattern is very similar to what we have seen in the main treatments. Adding demographic controls (gender, age, field of study, political and religious orientation) does not affect significance levels and has little impact on the regression coefficients.

VARIABLES	(1) Participate	(2) Commit	(3) Invest	(4) Payoff
CCC	0.0472	-5.222	2.508	3.011
	(0.0433)	(4.250)	(4.087)	(4.882)
UCC	-0.0127	25.03***	28.69***	33.09***
	(0.0556)	(4.287)	(3.952)	(4.479)
No Enforcement	-0	18.92***	-7.658*	-9.097*
	(0.0606)	(3.473)	(3.854)	(4.623)
Symmetry	-0.0133	-7.685	-5.557	-49.27***
	(0.0543)	(4.889)	(6.103)	(6.999)
CCC*NE	0.0104	-25.13***	-2.438	-2.982
	(0.0689)	(7.258)	(5.439)	(6.519)
CCC*S	-0.131*	8.900	9.900	11.20
	(0.0656)	(7.348)	(8.330)	(9.721)
UCC*NE	0.0489	-15.26**	-15.66***	-17.64***
	(0.0763)	(5.893)	(5.214)	(6.058)
UCC*S	-0.180**	-15.49**	-16.68**	-18.98**
	(0.0689)	(6.502)	(6.985)	(8.305)
round	-0.0270***	-2.617***	-4.656***	-5.571***
	(0.00425)	(0.729)	(0.555)	(0.663)
B*Asym	-0.0440	-10.38***	-8.209**	-68.27***
	(0.0429)	(2.961)	(3.423)	(3.971)
C*Asym	0.0615	0.0242	4.429	-40.89***
	(0.0388)	(2.374)	(3.193)	(5.011)
D*Asym	-0.0374	-10.57***	-8.536**	-76.78***
	(0.0381)	(3.015)	(3.371)	(4.925)
Constant	0.919***	43.04***	50.47***	228.3***
	(0.0425)	(3.784)	(3.824)	(4.340)
Observations	2,480	2,480	2,480	2,480
R-squared	0.052	0.179	0.158	0.392
Sample	all	all	all	all

Robust standard errors in parentheses, clustered at matching group level.
*** p<0.01, ** p<0.05, * p<0.1

Table S4. OLS regression analysis of the participation, commitment and investment decisions and of the payoffs in all experiment. The interaction terms are constructed as follows: CCC*NE is a dummy variable that takes the value of 1 if we have a treatment with CCC and no enforcement. The variable B*Asym is a dummy variable that takes the value of one if a subject is of type B and if one of the asymmetric experiments is considered. Robust standard errors in parentheses, clustered at matching group level. *** p<0.01, ** p<0.05, * p<0.1.

S.4 Supplementary Figures

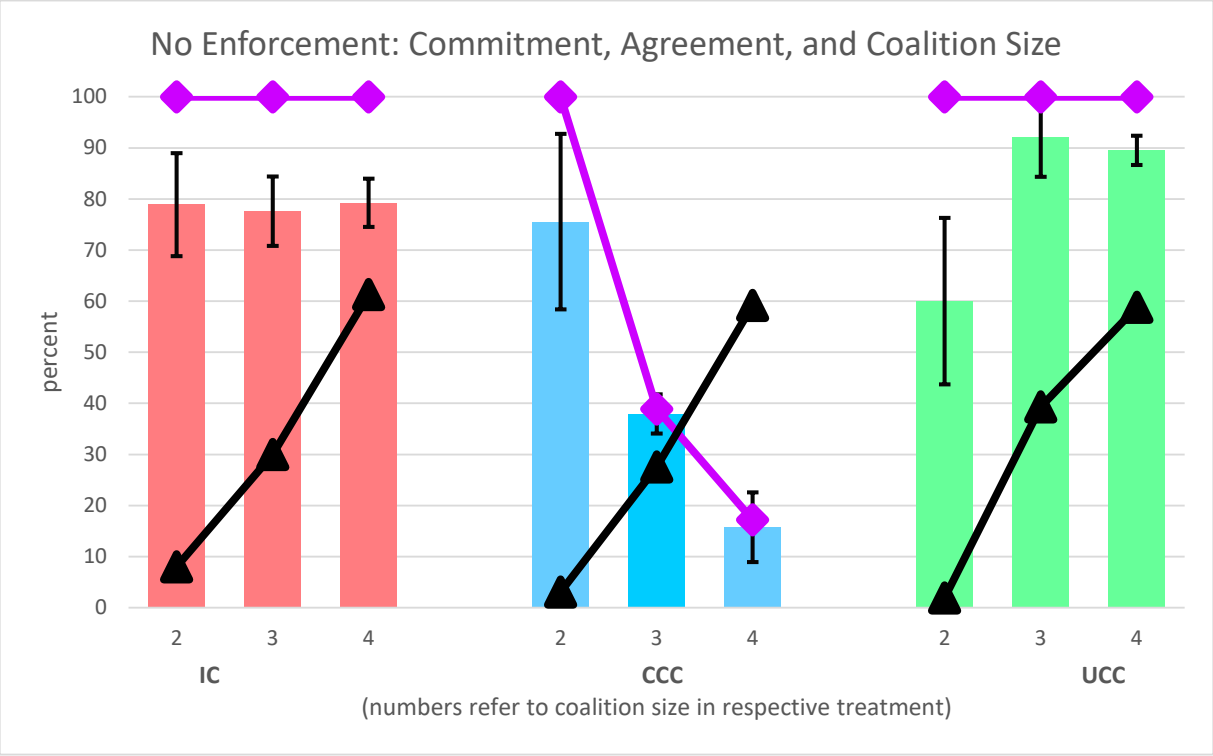

Fig. S1. No Enforcement treatments, inside negotiations: Commitment, agreement, and coalition size when contracts are not enforced. The bars show average (non-binding) commitments conditional on participation (in percent of the socially optimal investment level) as a function of coalition size in each treatment. Error bars represent SE of the mean clustered at the matching group level. The commitment levels in UCC are significantly larger than the individual commitment levels in IC and CCC for coalition sizes of 3 and 4. There are very few observations for a coalition size of 2. The black triangles show the distribution of the number of participants in negotiations ("coalition size"). In all treatments, larger coalitions are much more frequent than smaller coalitions. The purple diamonds show the frequency of agreements as a function of coalition size. CCC negotiations fail in more than half of all cases, while full agreement is built into IC and UCC.

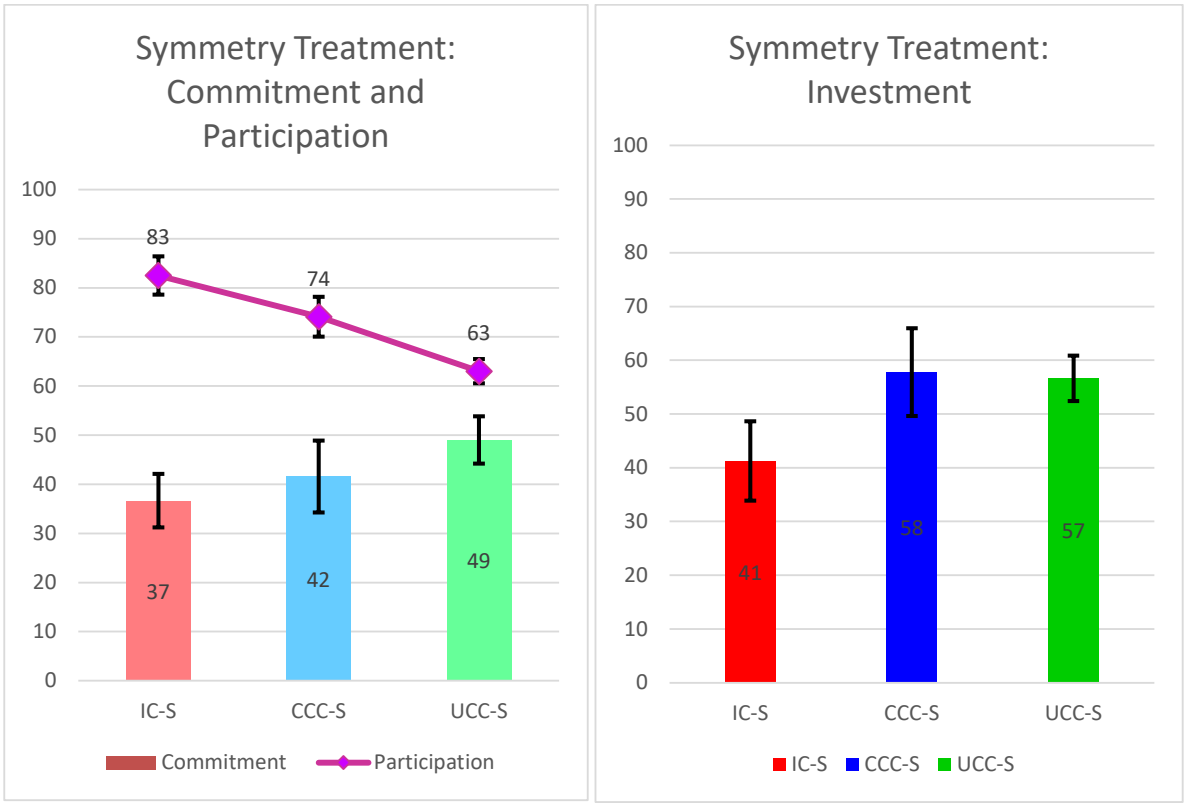

Fig. S2, Symmetry treatments: Cooperation measured by participation, commitment, and investment decision across negotiation treatments when parties are symmetric. The bars display the average commitments (left diagram) and investments (right diagram) in percent of the socially optimal investment level in the three treatments. The averages are calculated with respect to the whole group of subjects, regardless of whether subjects participated in the negotiation or not, thus illustrating the groups' overall cooperation level. The violet diamonds above the bars in the left diagram display the participation rates. Error bars represent SE of the mean clustered at the matching group level. The results are based on 660 observations of commitment, investment and participation decisions of 136 individuals. Each individual participated in one treatment only and took decisions in five anonymous and randomly re-matched groups.

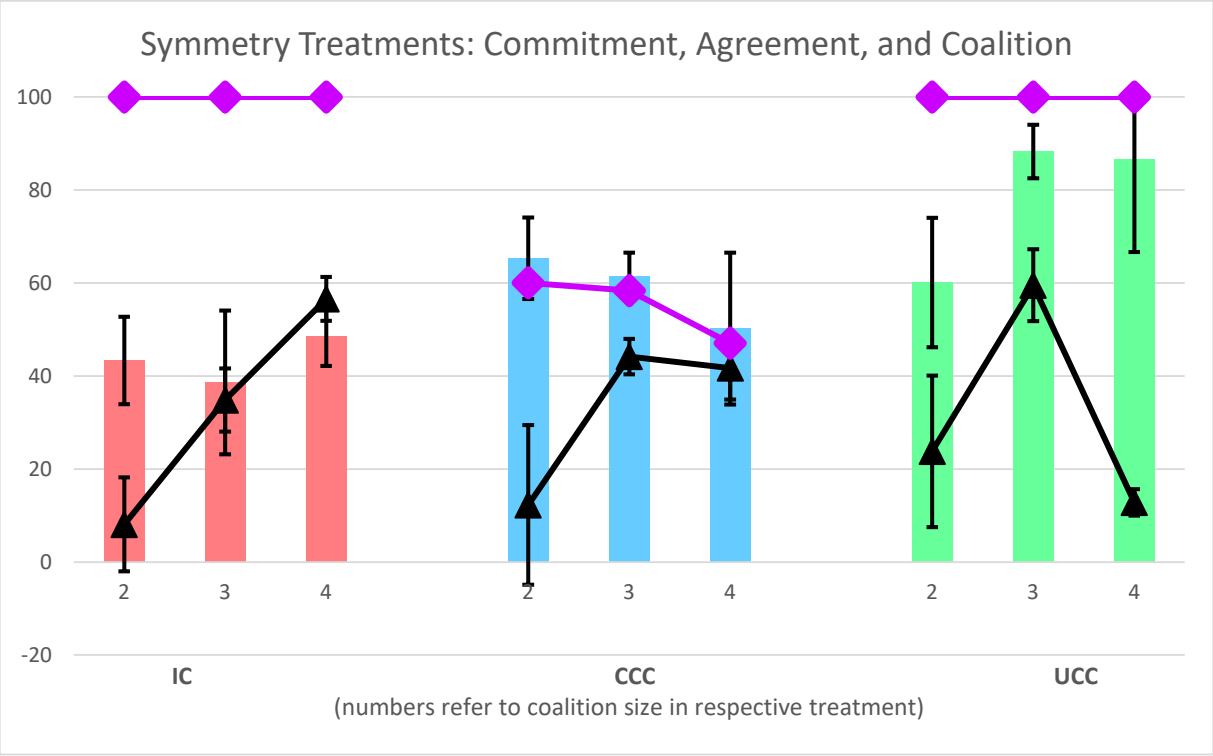

Fig. S3, Symmetry treatments, inside negotiations: Commitment, agreement, and coalition size when parties are symmetric. The bars show average commitments conditional on participation (in percent of the socially optimal investment level) as a function of the coalition size in each treatment. Error bars represent SE of the mean clustered at the matching group level. The commitment levels in UCC are much higher than the commitment levels in IC and CCC if there are three or four participants. The black triangles show the distribution of the number of participants in negotiations ("coalition size"). Because the participation rate is lower in the symmetry treatments than in the main treatments, the coalition sizes tend to be smaller as well. The purple diamonds show the frequency of agreements for different coalition sizes. Full agreement is built into IC and UCC, while CCC negotiations fail in about half of all cases.

S5. Preregistration

AsPredicted CONFIDENTIAL - FOR PEER-REVIEW ONLY

How to Design Climate Change Negotiations – An Experimental Study (#7089)

Created: 12/01/2017 05:44 AM (PT)
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This pre-registration is not yet public. This anonymized copy (without author names) was created by the author(s) to use during peer-review. A non-anonymized version (containing author names) will become publicly available only if an author makes it public. Until that happens the contents of this pre-registration are confidential.

1) Have any data been collected for this study already?
No, no data have been collected for this study yet.

2) What's the main question being asked or hypothesis being tested in this study?
For more than 20 years, international climate negotiations basically failed to generate ambitious international cooperation. Recently, an increasingly number of scholars attribute the failure to a flawed design of climate negotiations. Paris-style "pledge-and-review" negotiations do not acknowledge that cooperation based on "individual commitments" must rely on altruism, which is unlikely to effectively promote cooperation. Kyoto-style "quantity" negotiations tried to reach a common commitment, which involves reciprocation and thus a much more powerful motivation to cooperate. Yet Kyoto failed to acknowledge that it is extremely difficult for asymmetric countries to agree on a global cap-and-trade scheme, because there is no 'focal' distribution of caps across countries that can be easily agreed upon. An increasing number of scholars suggests that a common price-commitment is a better candidate for a reciprocal common commitment in climate negotiations, because many would agree that a uniform price is a focal outcome. Focusing on carbon pricing would thus facilitate international negotiations and enforcement, and in this way help to more efficiently and effectively fight climate change (see Cramton et al., 2017, Global Carbon Pricing, MIT Press for more on the motivation for our study). That said, such arguments and proposals ultimately rely on assumptions about human cooperation. Our study is a first step in testing the effectiveness of different climate negotiation styles.

3) Describe the key dependent variable(s) specifying how they will be measured.
1. Stated negotiation goal (elicited before negotiation, not incentivized)
2. Negotiation behavior/coordination (participation decision, offers made)
3. Cooperation (investment in public goods game)

4) How many and which conditions will participants be assigned to?
We study the role of negotiation design for the effectiveness and the efficiency of negotiations by comparing three negotiation mechanisms in a controlled laboratory experiment:
1. Pledge and Review (Paris) = Individual Commitment (IC)
2. Quantity commitments (Kyoto) = Common Quantity Commitment (CQC)
3. Minimum price = Common Price Commitment (CPC)
We use a between-subject design with three factors:
1. Negotiation format (IC, CQC, or CPC)
2. Enforcement of negotiation result (with or without)
3. Symmetry of parties (symmetric or asymmetric)
We are mostly interested in the impact of the negotiation format in case of enforcement and with asymmetric players, to emphasize our hypothesis that full enforcement power is not sufficient to obtain ambitious results, but that enforcement rather needs to be complemented by an appropriate negotiation mode. The treatments without enforcement and symmetric players serve as robustness checks. Treatments with enforcement will use strangers matching, treatments without enforcement partners-matching (to allow reciprocation).

5) Specify exactly which analyses you will conduct to examine the main question/hypothesis.
Our null hypotheses are derived from standard-theoretical predictions that assume that all parties are rational and purely self-interested. We will focus on the following prediction, which constitutes a symmetric pure strategy equilibrium in all treatments: No party participates in the negotiation, and no party cooperates.
Our alternative hypotheses are mostly directional:
(i) Regardless of enforcement, negotiating common commitments (CPC/CQC) is more effective than negotiating individual commitments (IC) with respect to cooperation and efficiency. (This is not saying that common commitments perform better than individual commitments with respect to participation in the negotiation.)

(ii) CPC leads to a stronger focal point for cooperation than CQC, which will have two behavioral implications:

a. If there is Enforcement of the contract, CPC facilitates coordination and thus also increases cooperation compared to IC and CQC

b. If there is No Enforcement of the contract, CPC facilitates cooperation through more ambitious reciprocal self-enforcement and thus increases cooperation compared to IC and CQC

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Version of AsPredicted Questions: 2.00

Wharton CREDIBILITY LAB

(iii) As a result, with respect to dynamics, we expect that – with individual commitments – there will be a "ratchet down" effect, whereas with common commitments the ratchet down will be less pronounced, or there might even be a "ratchet up" effect towards stable coordination and cooperation.

(iv) All effects get stronger as the payoff functions induce larger asymmetries, starting with no difference between CQC and CPC in the fully symmetric case.

To address our hypotheses, we will apply standard non-parametric tests to compare differences in negotiations (coordination) and cooperation behavior. Moreover, we will also use standard regression methods, predicting the dependent variables (coordination and cooperation) with dummies for experience, negotiation format, enforcement, and symmetry, and interaction effects. In secondary analyses, we also plan to study in more detail the determinants of negotiation behavior (participation decision, negotiation goals and coordination success).

6) Describe exactly how outliers will be defined and handled, and your precise rule(s) for excluding observations.

-

7) How many observations will be collected or what will determine sample size? No need to justify decision, but be precise about exactly how the number will be determined.

Because our experiment uses a new design, so that there is little guidance from the literature regarding the choice of parameters, we will run a pilot experiment to test the functionality of the coding, to fine-tune the time we give subjects to conclude their negotiations, and to decide on the number of rounds the game is played (based on the time needed for negotiations and how fast behavior settles). The pilot will include one independent observation for each negotiation mode with asymmetric players and full enforcement only. The data from the pilot experiment will not be further used.

We plan to then collect six independent observation (based on matching groups) for IC, CQC and CPC with asymmetric players and full enforcement. If the experiment is successful and finds main effects of negotiation style, we will add robustness checks with respect to symmetry and without enforcement as outlined above.

8) Anything else you would like to pre-register? (e.g., secondary analyses, variables collected for exploratory purposes, unusual analyses planned?)

-

S6. Ethics Approval

LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

VOLKSWIRTSCHAFTLICHE FAKULTÄT
ETHIKKOMMISSION

Prof. Dr. J. Winter, LMU München, D-80539 München

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Ihr Zeichen, Ihre Nachricht vom | Unser Zeichen | München, 12. Januar 2018

Project 2018-01, "Climate Change Negotiations", submitted January 12, 2018

Dear Klaus M. Schmidt,

Your project proposal has been received by the Ethics Commission, Department of Economics, University of Munich. The commission has determined that the project poses no more than minimal risk of harm to participants, researchers and others affected.

It is hereby approved without full review.

Sincerely yours,

Prof. Dr. Joachim Winter
Chairman of the ethics committee

Besuchsanschrift
Ludwigstr. 33, Raum 345
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Öffentliche Verkehrsmittel:
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Bayerische Landesbank München
Kto. 24 868 BLZ 700 500 00
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S7. Instructions

In the following, we provide instructions for the UCC treatment (with enforcement), translated from the original German instructions. The instructions of the IC and CCC treatments and of the No Enforcement and Symmetry treatments are adapted from the UCC treatment (with enforcement) only to reflect the change in rules, but are otherwise identical.

The instructions are followed by an English translation of the information sheet, which summarizes all parameters for the asymmetric treatments and which was provided to participants on a separate handout. The information sheet for the subjects in the symmetric treatments is constructed analogously.

We then present translations of the screenshots of the exercises that subjects in the UCC treatment (with enforcement) had to answer before the experiment started in order to become familiar with the rules of the game. Subjects in other treatments answered analogous questions, adapted to the rules in the respective treatment.

Finally, we present the Questionnaire that all subjects had to answer after the experiment (translation from German). The Questionnaire was the same for all subjects in all treatments.

The instructions, information sheets, and exercises of all other treatments in the original German version and translated into English are available upon request from the authors.

[Instructions for UCC treatment (with enforcement)]

Welcome to our experiment!

Please read these instructions carefully. If you have a question, please raise your hand or press the red button on your computer. We will then come to you and answer your question. Private communication between participants is not allowed during the experiment. You are also not allowed to use your mobile phone during the experiment. Please keep it in your bag.

For showing up to the experiment, you will receive 6 Euro. In addition, you can earn additional payments depending on your decisions and the decisions of other participants. The currency in this experiment is called ECU ("Experiment Currency Unit"). At the end of the experiment, all ECUs will be converted into Euro and paid out to you in cash. The exchange rate is: 12 ECU = 1 Euro. All decisions and payments in this experiment will be treated confidentially and evaluated anonymously. All participants in this experiment received the same instructions.

Procedure of the experiment

The experiment consists of 5 identical rounds. In each round, you will be assigned to a group of 4 participants. The group will be randomly reassembled in each round. Each group consists of a participant of type A, B, C and D. Which type you are (A, B, C or D) will be displayed on your computer screen at the beginning of the experiment. Your type remains the same for all 5 rounds.

At the beginning of each round, you will receive an *endowment* (in ECU) depending on your type. The richest type A gets 200 ECU in each round, the poorest type D only 80 ECU. You can *invest* any amount of your endowment (up to a *maximum amount* depending on your type) into a group project. The rest of your endowment that you do not invest is yours. It will be paid out to you at the end of the experiment.

Every ECU you invest in the group project is lost to you but will generate additional payments *for all four* group members. The amount of the additional payment for each ECU invested in the group project (*the rate of return*) depends on the type of the group member. If an additional ECU is invested in the group project by any participant, then participant A receives an additional payment of 0.4, participant B also of 0.4, participant C of 0.8 and participant D of 0.6. Thus, for the group,

a total of 2.2 ECU (= 0.4 ECU + 0.4 ECU + 0.8 ECU + 0.6 ECU) is generated by the investment of one ECU (see information sheet).

> Example 1: You are a type D participant. If you invest 10 ECU in the group project, you lose these 10 ECU, but you get 0.6 x 10 ECU = 6 ECU back from the group project. In total you have lost only 4 ECU. Participant A wins 4 ECU because of your investment, Participant B also wins 4 ECU and Participant C wins 8 ECU.

Please note that you will only receive payments from the group project as long as the sum of the

> Example 2: You are a type D participant again. Now not only you, but each participant invests 10 ECU in the group project. You lose 10 ECU again, but now you get 0.6 x 40 = 24 ECU back from the group project, because *all four* participants have invested 10 ECU. In total you have won 14 ECU (0,6 x 40 – 10 = 14). Participant A wins a total of 6 ECU (0.4 x 40 - 10 = 6), participant B also wins 6 ECU (0.4 x 40 – 10 = 6) and participant C wins 22 ECU (0.8 x 40 – 10 = 22).

investments of all four group members does not exceed a *maximum investment amount.* For each ECU invested beyond the maximum investment amount, there will be no return from the group project. This maximum investment amount also depends on your type.

> Example 3: For Type C, there is a return from the group project only up to a maximum investment amount of 300 ECU. Assume that each participant invests 75 so that the investment amount is exactly 300 (= 4 x 75). If all four participants would then invest an additional ECU in the group project, C would not draw any additional profit from it. He or she would only lose the ECU that he or she invested additionally.

The enclosed information sheet summarizes this information and all numerical values in a table. Please place the information sheet on your desk in such a way that you can always look at this information.

The task of the group members is to decide in each round how much they want to invest in the group project. The investments can be negotiated.

Negotiation

During the negotiation, the group members can agree on a *common commitment* that determines the investment of each of the four group members. The negotiation process consists of three stages: Participation, negotiation and commitment.

Participation. In the first stage, the group members decide independently whether they wish to participate in the negotiation. Members who do not wish to participate do not participate in further stages of negotiations and wait until the negotiation process is completed. Their investments are not subject to negotiation. After the participation decision, all members are informed about who is taking part in the negotiation.

Negotiation. At the beginning of the negotiation process, each participant specifies a negotiation goal that he or she would like to achieve. This negotiation goal is not communicated to the other negotiation participants and has no influence on the actual negotiation or the payoffs of the participants. The negotiators then have three minutes to exchange proposals for a joint commitment. Note: A proposal must specify a minimum investment which is the same for all negotiators and cannot exceed the lowest maximum of ECU 80. Proposals are immediately visible to all negotiators and can be changed at any time within the negotiation period of three minutes.

Commitment. After the three minutes have elapsed, negotiators will be invited to make a final proposal independently of each other. The proposal with the lowest minimum investment becomes binding for all negotiating members, i.e. all members must invest at least as much as the lowest minimum investment.

Note: The higher the mandatory minimum investment, the more all negotiators have to invest, which benefits *all* negotiators (including yourself). If you have proposed the lowest minimum investment, your proposal will result in a low investment commitment for *all* negotiators, which will harm all negotiators (including yourself). A higher proposal increases the commitment of *all* participants, which benefits all participants (including yourself). You also never have to worry

about having to invest more than the other negotiators in a high proposal: You will never be obliged to invest more than the negotiator with the lowest proposal in that negotiation.

Example 4: All four participants participate in the negotiation and have proposed the following minimum investments: 100 (A), 60 (B), 80 (C) and 40 (D). The proposal of participant D is the lowest and is therefore binding for all participants. So each participant only has to invest 40 - even the participants who have proposed a higher minimum investment.

Note: If participant D increases his proposal from 40 to 50, *all* negotiators will have to invest 10 more. This increases the payment to D by 14 ECU. The payments to *all* other participants also increase. If D, on the other hand, reduces the lowest minimum investment to 30, then all participants only have to invest 30. But if all participants invest only 30 instead of 40, the payment to D is reduced by 14 ECU. The payments to all other participants also decrease.

The payments to participants A and B are highest when the minimum investment of 80 becomes binding. The payments to participants C and D are highest when a minimum investment of 75 becomes mandatory. The reason for this difference is the different maximum investment amount from which investments no longer pay off. If all four participants invest 75, a total investment of 4 x 75 = 300 is achieved. Investments exceeding the maximum investment of 300 will not pay off for C and D (see information sheet).

Note: Participants A and B can increase their payment without risk by increasing their proposed minimum investment to 80. Participants C and D can increase their payment without risk by increasing their proposed minimum investment to 75.

Investment decision

The result of the negotiations, i.e. the lowest minimum investment that has become binding, is communicated to all four group members. The negotiators must honor their commitment and choose an investment that is at least as large as the agreed minimum investment. The group

members who have not negotiated decide freely on their respective investments in the group project.

Result of this round

Now the payments for this round can be calculated. Your payment consists of your endowment minus your investment in the group project plus your profit from the group project (i.e. the sum of all investments up to your maximum investment sum multiplied by your rate of return per ECU from the group project).

After each round, all participants are informed about the investments and payments of all group members. Then the next round begins, in which you are matched with *three new, randomly selected, other participants.* At the end of the experiment, one of the five rounds will be randomly selected. The result of this round is paid out to the participants, the other four rounds do not play a role for the final payoff.

Information sheet [asymmetric treatments]

Participant of type	**Equipment** in each round	**Rate of return** for each ECU invested in the group project, the participant will receive	**Maximal amount** maximal possible investment in each round	**Maximal investment sum**, from which further investments no longer bring a return for the participant
A	200 ECU	0,4 ECU	100 ECU	340 ECU
B	120 ECU	0,4 ECU	100 ECU	340 ECU
C	100 ECU	0,8 ECU	80 ECU	300 ECU
D	80 ECU	0,6 ECU	80 ECU	300 ECU

Exchange rate: 12 ECU = 1 Euro

Calculation of the payment of participants i, i = A, B, C, D:

$$\text{Payment of participant i} = \text{equipment of i} - \text{investment of i} + \text{rate of return of i x} \begin{cases} \text{sum of investments} & if \ \text{sum of investments} \leq \text{max. sum of investments for i} \\ \text{max. sum of investments} & if \ \text{sum of inbestments} > \text{max. sum of investments for i} \end{cases}$$

Please note:

- You will be brought together in each round with a new, randomly selected group of other participants.
- One of the rounds is randomly selected and paid out.

1. Exercises – UCC (with enforcement)

In the following we replicate the screens that the subjects had to go through when when they solved the exercises. The numbers that the subjects had to enter are indicated in red. Black numbers are provided by the computer.

Exercises

In the following exercises, you can try out different scenarios to become more familiar with the decision situation. The scenarios should not be seen as suggestions. They have been selected by us to cover as wide a range of possible situations as possible. Below you will find an input mask in which you can enter how much each of the four participants invests in the group project.

You can use the tab key to conveniently jump back and forth between the input fields.

Once all the investments have been entered, the bottom line will show the payments that would result from these investments to the four participants. Please try it out.

When you are done, press “Next”.

	Investment of				
Participant	A	B	C	D	Sum
Investment	30	50	80	40	210
Payment	230	150	180	160	740

Next

Exercise 1

You are participant C. In the following table you are marked in blue.

Participants A, B and D invest 20, 80 and 30, respectively, into the group project. Enter these investments in the input mask.

	Your proposal				
Participant	**A**	**B**	**C**	**D**	**Sum**
Investment	20	80	80	30	210
Payment	264	124	188	176	752

What is your payoff, …

… if you invest 0? 204

… if you invest 40? 196

… if you invest 80? 188

Next

Exercise 2

You are participant D. In the table you are marked in blue.

Participant	Investment of A	Investment of B	Investment of C	Investment of D	Sum
Investment	30	20	40	25	115
Payment	216	146	152	124	638

What is your payoff …

- if A invests 30, B 20, C 40, and D 25? 124
- if everybody invests twice as much? 168
- if everybody invests 0? 80

Next

Exercise 3

You are participant B. In the table you are marked in blue.

This screen shows you how the negotiation works when all four participants participate in the negotiation. You are participant B. In the upper table you can see the suggestions that participants A, C and D have already made. You can enter your own proposal in the input mask below. If you enter a minimum investment for a negotiation participant, it will be adopted for all participants. As soon as you have made a proposal for a common minimum investment, you will see the resulting payments to the participants in the bottom row, if all negotiation participants make this minimum investment.

Proposal of participant	Minimum investment A	B	C	D	Sum
A			80		320
B					
C			65		260
D			15		60

Participant	Your proposal for the minimum investment of all participants A	B	C	D	Sum
Minimum investment			80		320
Payment	248	168	260	180	856

Participant A has proposed a common minimum investment of 80. Please, type this proposal into the input mask. If all participants make this minimum investment, what is the payment received

- by you (participant B)? 168
- by participant D? 180

Next

Now enter the following proposal into the input mask: 40.

You are participant B. In the table you are marked in blue.

Proposal of participant	Minimum investment A	B	C	D	Sum
A			80		320
B					
C			65		260
D			15		60

Participant	Your proposal for the minimum investment of all participants A	B	C	D	Sum
Minimum investment			40		160
Payment	224	144	188	136	788

If all participants make the minimum investment of 40, what is the payment received …

- by you (participant B) 144
- by participant D 136

Next

Exercise 4

You are participant B. In the table you are marked in blue.

Proposal of participant	Minimum investment A	B	C	D	Sum
A			80		320
B					
C			65		260
D			15		60

Participant	Your proposal for the minimum investment for all participants A	B	C	D	Sum
Minimum investment			60		240
Payment	236	156	232	164	788

Make a proposal

Enter the following proposal into the input mask: 60

Then click on "Make a proposal". Your proposal will now appear as a proposal from participant B in the table above. You can replace your proposal with a new one at any time within the negotiation time of 3 minutes. Please replace your proposal with any other proposal and then click "Next".

Next

Exercise 5

The time for negotiations has expired. Please make your final proposal now.

You are participant A. In the table you are marked in blue.

Here you can see the screen for your final proposal. In the table above you can see the last suggestions made by the four participants during the negotiation phase. You (and the other participants) now have the possibility to confirm your proposal or change it one last time.

Proposal of praticipant	Minimum investment A	B	C	D	Sum
A	30				120
B	80				320
C	80				320
D	60				240

Participant	Your proposal for the minimum investment for all participants A	B	C	D	Sum
Minimum investment					
Payment					

Suppose that all participants made the following final proposals: 30 (A), 80 (B), 80 (C), 60 (D). Which minimum investment is now binding for all participants?

- Binding minimum investment: 30

Please enter the binding minimum investment as your proposal into the input mask. If all participants make this minimum investment, what is the payment received …

- by you (participant A)? 218
- participant D? 122

Suppose you (participant A) raise your proposal to 70, while all other proposals remain the same. What minimum investment is now binding for all negotiators?

- Binding minimum investment: 60

If all participants make this minimum investment, what is the payment received …

- by you (participant A)? 236
- by participant D? 164

Next

Exercise 6

Here you can see how the negotiation works when only two participants participate in the

The following participants decided not to participate in the negotiation: B, C

You are participant D. In the table you are marked in blue.

negotiation. Participants B and C did not participate in the negotiation. You are participant D. In the table you can see the proposal that participant A has already made. You can enter your own proposal in the input mask below. In addition, you can enter what you expect participants B and C to invest. Once you have specified all the investments, you will see the payoffs for the participants in the bottom row.

Participant	Minimum investment A	Minimum investment D	Sum
A	80		160
D			

Participant	Your proposal for the minimum investment for all negotiators A	Your proposal for the minimum investment for all negotiators D	Expected investment of B	Expected investment of C	Sum
Investment	80		20	0	180
Payment	192	108	172	244	716

Participant A proposed 80 as the common minimum investment. Type this proposal into the input mask. You expect that participant B will invest 20 and participant C 0. What is the payment received

- by you (participant D)? 108
- by participant A? 192

Next

Exercise 7

The following participants decided not to participate in the negotiation: B, C

You are participant D. In the table you are marked in blue.

Here you can see the screen for the final proposals. In the upper table you see last proposals made in the negotiation phase by participant A and by yourself. You (and participant A) have now the opportunity to confirm your last proposal or to change it one last time.

Proposal of	Minimum investment A	Minimum investment D	Sum
A	80		160
D			

Particiant	Your proposal for the minimum investment for all participants A	Your proposal for the minimum investment for all participants D	Expected investment of B	Expected investment of C	Sum
Minimum Investment					
Payment					

Suppose the two negotiating parties have entered the final proposals 80 (A) and 40 (D). Then a minimum investment of 40 is binding for the negotiating parties. How much has to be invested …

- by you (participant D)? 40
- by participant A? 40
- by participant C? 0

Suppose you (participant D) have increased your final proposal to 60, while A's proposal remains unchanged. Then the minimum investment is 60 for the negotiating parties. How much has to be invested…

- by you (participant D)? 60
- by participant A? 60
- by participant B? 0

End of Exercises

You have now completed the exercises. The experiment starts shortly. Please think for a second about what negotiation result you would like to achieve, if you would participate in the negotiations.

2. Questionnaire

Questionnaire

Please answer the following questions:

Your age?

Your gender?

- male
- female

Your subject of study?

- Economics
- Business Administration
- Other Social Sciences
- Psychology
- Humanities
- Law
- Natural Science/Technology
- Other

Your nationality?

- Germany
- EU without Germany
- Non-EU

How is your mood today in general?

- Very good
- Good
- Neutral
- Bad
- Very bad

How was your mood during the experiment?

- Very good
- Good
- Neutral
- Bad
- Very bad

How often did you participate in experiments?

- Never
- Once or twice
- Three to five times
- More than five times

Your mother tongue?

- German
- Other

How many participants in the experiment are personally known to you?

Did you ever attend a lecture on „Game Theory“?

- Yes
- No
- Not sure

On a scale from 1 ("do not agree at all") to 7 ("fully agree"): If the negotiation led to no or only small investment commitments, it was because of...

...a lack of time for the negotiation.
1 7
...some negotiators not understanding the decision situation enough.
1 7
...unfair payments resulting from the negotiations.
1 7
...unfair investment commitments resulting from the negotiation.
1 7

...the following participant not being willing to compromise enough:

- A
- B
- C
- D
- No type stood out particularly

Which party would you vote for if there was a Bundestag election next Sunday?

- CDU/CSU
- SPD

- FDP
- Grüne
- Die Linke
- AfD
- Other

How serious do you estimate the dangers of climate change are?

- Very serious
- Rather serious
- Rather insincere
- Very insincere
- Not sure

Which religious community do you belong to?

- Roman-catholic
- Protestant
- Other Christian religious community
- Non-Christian religious community
- None

Our everyday actions are influenced by basic principles we belief in. Little is known about this in science. Here are different characteristics a person can be described with. Probably, some characteristics personally apply to you fully and others do not at all.

On a scale from 1 ("Not applicable at all") to 7 ("Fully applicable"): I am someone who...

...works carefully.
1 7
...is communicative, talkative.
1 7

...is sometimes a bit coarse/rough.
1 7
...is inventive and comes up with own ideas.
1 7
...worries a lot.
1 7
...is able to forgive.
1 7
...is rather lazy.
1 7
...opens up, is sociable.
1 7
...appreciates artistic experiences.
1 7
...becomes nervous easily.
1 7
...processes tasks efficiently.
1 7
...is reserved.
1 7
...is considerate and kind towards others.
1 7
...has a vivid imagination.
1 7
...is relaxed and knows how to cope well with pressure.
1 7

On a scale from 1 ("Very bad") to 7 ("Very good"): How do you rate the graphical implementation of the experiment?
1 7

On a scale from 1 ("Very difficult") to 7 ("Very simple"): How easy to handle did you find the experiment?
1 7

How can we improve the next experiment?

On a scale from 1 ("very unlikely") to 7 ("very likely"): Would you advise a friend to participate in another experiment?
1 7

Would you like to tell us anything else? [optional] :

Next

SI References

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