CEPA DP No. 74

MARCH 2024

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CEPA Discussion Papers

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ISSN (online) 2628-653X

CEPA Discussion Papers can be downloaded from RePEc
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Published online at the Institutional Repository of the University of Potsdam
https://doi.org/10.25932/publishup-62936

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Does communication increase the precision of beliefs?*

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ABSTRACT

In this paper, we study one channel through which communication may facilitate cooperative behavior – belief precision. In a prisoner's dilemma experiment, we show that communication not only makes individuals more optimistic that their partner will cooperate but also increases the precision of this belief, thereby reducing strategic uncertainty. To disentangle the shift in mean beliefs from the increase in precision, we elicit beliefs and precision in a two-stage procedure and in three situations: without communication, before communication, and after communication. We find that the precision of beliefs increases during communication.

Keywords: prisoner's dilemma, communication, beliefs, strategic uncertainty, experiment
JEL Codes: C92, D83

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*We thank Max Andres and Juri Nithammer for very helpful discussions. This research is funded by the Volkswagen Foundation, which we gratefully acknowledge. Design and hypotheses were preregistered at the AEA registry before the data collection had started: Bruttel, Lisa and Vasilisa Petrishcheva. 2023. "Belief Precision and Communication." AEA RCT Registry. September 04. https://doi.org/10.1257/rct.11709-1.0.

1 Introduction

Communication is conducive to cooperation (Isaac, Ramey, and Williams, 1984; Davis and Holt, 1998; Fonseca and Normann, 2012; Engel, 2015; Cooper and Kühn, 2014; Dijkstra, Haan, and Schoonbeek, 2021; Freitag, Roux, and Thöni, 2021). This study improves the understanding of the role beliefs play in this effect. We study whether communication can help to form more *precise* beliefs about the interaction partner's willingness to cooperate. Such an increase in belief precision reduces the strategic uncertainty of the decision-making situation. Cooperation becomes less risky and thus more likely as beliefs have been shown to be important for cooperation (Dal Bó and Fréchette, 2018; Dvorak and Fehrler, forthcoming; Kartal and Müller, 2022; Battigalli and Dufwenberg, 2022; Andres, 2023). The aim of this study is to document whether this effect channel can be observed in the behavior of subjects in a laboratory experiment.

In a prisoner's dilemma, subjects decide whether they want to cooperate with an anonymous other subject or not. They make this decision twice: once without the possibility to communicate with each other and once with. An essential element of the experiment is that we ask the subjects three times – without, before, and after the communication – how likely they think it is that the other person will cooperate. For the belief elicitation, we introduce a two-stage procedure that first asks subjects whether they think the other subject will cooperate and then how certain they are about this belief. This procedure allows us to measure the precision of the belief separate from the belief itself.

We find that communication indeed increases the precision of beliefs, by about 12 percentage points in our setup. Reported precision is highest for subjects with a higher tolerance towards strategic uncertainty and a better knowledge about human behavior. Furthermore, we find that higher precision leads to lower cooperation rates for pessimistic beliefs both with and without communication, but to higher cooperation rates for optimistic beliefs only with communication. Finally, we use natural language processing to analyze of the communication protocols, illustrating a strong correlation between the text written by a subject and the beliefs of their partner.

There is a large literature on the incentive compatibility of different scoring rules for the elicitation of beliefs and their effect on the accuracy of stated beliefs (see, e.g. Gächter and Renner, 2010; Schotter and Trevino, 2014; Trautmann and van de Kuilen, 2015; Holt and Smith, 2016; Charness, Gneezy, and Rasocha, 2021; Burdea and Woon, 2022; Danz, Vesterlund, and Wilson, 2022), but the two-stage procedure we use in this study has, to the best of our knowledge, not yet been used in economic experiments. However, survey studies in related fields sometimes use an approach similar to ours, asking participants directly how certain they are about their belief (see, e.g. Yates, Zhu, Ronis, Wang, Shinotsuka, and Toda, 1989; Juanchich and Sirota, 2017). More often, precision is elicited using an interval method, (examples are Yaniv and Foster, 1997; Soll and Klayman, 2004; Haran, Moore, and Morewedge, 2010; Glaser, Langer, and Weber, 2013; Ren and Croson, 2013; Moore, Carter, and Yang, 2015).

In our theoretical framework, we model belief precision as the inverse of variance. This approach has been used in various applications, e.g., to study forecasts by financial analysts (Verrecchia, 1980; Friesen and Weller, 2006), determine optimal effort in a promotion contest (Miklós-Thal and Ullrich, 2015), or to capture how judges update their beliefs about defendants' recidivism risk (Ash and Marangon, 2023).

In the following, we provide the theoretical background in Section 2, describe our experimental design in Section 3, and develop hypotheses in Section 4. We then present the experimental results in Section 5 and conclude in Section 6. The Appendix complements the paper with a translation of the experimental instructions.

2 Theoretical background

In this section, we present theoretical considerations that motivate why the precision of beliefs is relevant for the cooperation decision. Assume that, from player i's perspective, each other player j has a defection risk R_j with $R_j \sim \mathcal{N}(\mu, \frac{1}{\rho_0})$, where ρ_0 is the precision.

Communication provides an informative signal $\widetilde{R}_j = R_j + \varepsilon_j$ on the individual defection risk of the other player, where $\varepsilon_j \sim \mathcal{N}(0, \frac{1}{\rho_{ij}})$.

The posterior defection risk after communication has mean

$$\hat{R}_j = \frac{\rho_0}{\rho_0 + \rho_{ij}} \cdot \mu + \frac{\rho_{ij}}{\rho_0 + \rho_{ij}} \cdot \widetilde{R}_j$$

and precision $\rho_0 + \rho_{ij}$.

Further assume that player i cooperates if the risk of being exploited is sufficiently low, i.e. if $\hat{R}_j < \bar{R}_i$, where $\bar{R}_i$ is the individual strategic uncertainty threshold. Then we can show the following:

1. A higher defection risk R_j of player j decreases the probability to be below player i's threshold, which means that the chance that player i cooperates decreases:

$$\frac{\partial \hat{R}_j}{\partial \widetilde{R}_j} = \frac{\rho_{ij}}{\rho_0 + \rho_{ij}} > 0$$

2. A higher posterior precision ρ_{ij} increases the chance that player i cooperates for below-mean defection risk $\widetilde{R}_j$ and vice versa:

$$\frac{\partial \hat{R}_j}{\partial \rho_{ij}} = \frac{\rho_0}{(\rho_0 + \rho_{ij})^2} \cdot \left(\widetilde{R}_j - \mu\right)$$

3 Experimental design

General setup Our experiment is based on a prisoner's dilemma game which subjects play once without and once with communication, with random rematching between the two games. Each subject can choose between actions X (cooperation) and Y (defection). We use the following calibration of the game:

	X	Y
X	$(50, 50)$	$(10, 80)$
Y	$(80, 10)$	$(20, 20)$

Table 1: Stage-game payoffs in the prisoner's dilemma.

This experiment contains two stages. In Stage 1, two subjects are randomly matched to play a prisoner's dilemma without communication. Before they make a decision whether to cooperate or defect, we elicit their beliefs and the precision of their beliefs. We describe the details of the elicitation procedure below. In Stage 2, subjects are rematched to play a prisoner's dilemma with communication with a new partner. We elicit their beliefs and belief precision before and after their communication. Afterwards, they make a second decision about cooperation or defection. Feedback about the actions of the partner in both games is provided only after the second game. Figure 1 summarizes the timeline of the experiment.

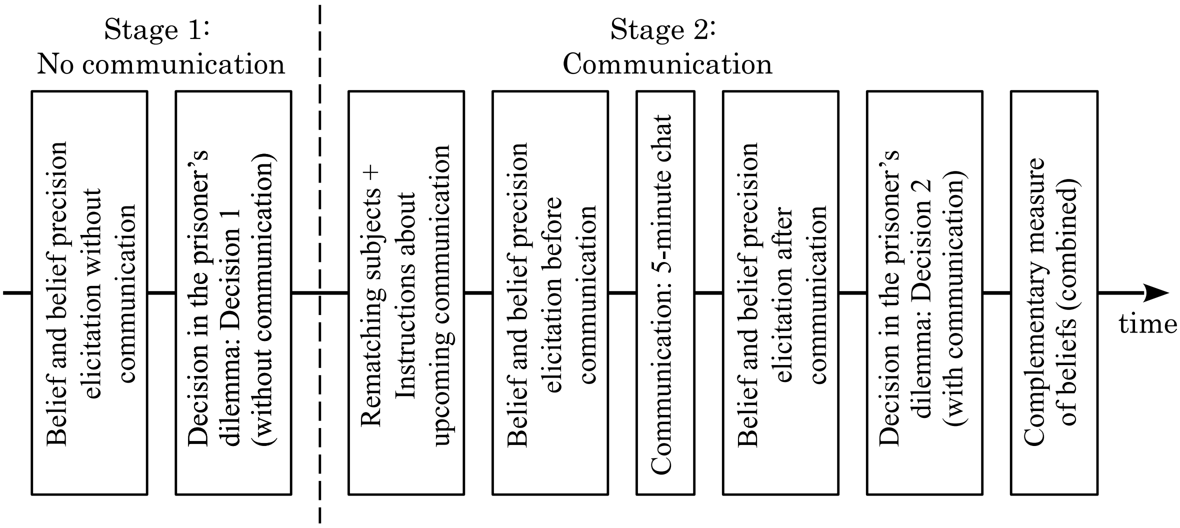


Figure 1: Timeline of the experiment.

Beliefs and belief precision Beliefs and, in particular, belief precision are the main outcomes we are interested in. We elicit individual beliefs and their precision at three points in time: once before the decision without communication and twice for the decision with communication, namely before and after communication takes place. The advantage of this procedure is that we can disentangle the increase in mean beliefs with and without communication from the increase in precision we are mainly interested in. If subjects correctly anticipate the cooperation-enhancing effect of communication on average, the shift in mean beliefs *without* and *before* communication will fully capture this effect. The shift in precision *before* and *after* communication then provides a clean estimate for an increase of belief precision due to communication among the two subjects. All three belief elicitations have the same format.

We elicit subjects' point beliefs b by asking the question: "Do you think it is more likely that the other person you are about to interact with will choose X or Y, respectively?". Subjects' answer to this question is binary, X or Y. For the analysis, we code X as 1 and Y as 0. We elicit subjects' belief precision p by asking the question: "How certain are you in your assessment?" They can answer on a continuous scale from "blind guess" to "absolutely sure." The scale is represented by a slider with no default value. For the analysis, we convert subjects' answers on this scale to a linear score between 0 and 1. The elicitation of beliefs and belief precision is jointly incentivized using the binarized scoring rule, i.e., the closer the subjects' guess is to the action of their partner, the higher the probability of receiving the higher of two bonuses is, where the low bonus is equal to 30 and the high bonus is equal to 60. Subjects can access detailed explanations of the incentive scheme by clicking a button in the belief elicitation screen.

Complementary measure of beliefs To be able to compare beliefs elicited in this two-stage format to standard measures of beliefs, we additionally elicit the belief about the partner's cooperation in the standard format, i.e., by asking subjects how likely they think it is that their partner played X, after the cooperation decision with communication. There, the question reads: "Please tell us again how likely you think it is that the person you last interacted with has chosen X or Y in the decision. You can see a line that starts at Y and ends at X below. The more certain you are that the other person has chosen Y, the closer to Y you should click. Conversely, the closer you click to X, the more certain you are that the other person has chosen X."

Re-interpreting the confidence elicited with the precision measure p as the degree of optimism (or pessimism) that the other player has chosen according to the belief b, we can derive a combined measure that we can compare to the standard "percentage" belief. We obtain this combined measure as $(1-p)/2$ if $b = 0$ and as $(1+p)/2$ if $b = 1$. Comparing the two measures will allow us to document residual differences that one can attribute to belief precision but not to the subject's degree of optimism.

Before-after within-subject design The experimental design is before-after within-subject. We made this choice based on two key arguments. Firstly, this design allows us to observe individual effects in addition to the aggregate comparisons of the main outcomes without, before, and after communication. Thus, we can observe a potential change in belief precision at the individual level. Secondly, in the context of our experiment, randomizing the order of Stages 1 and 2 (without and with communication) is not particularly useful. Placing Stage 2 (with communication) first would create, in expectation, strong spillover effects on the outcomes of Stage 1 (without communication). As the changes in the baseline belief about cooperativeness in the population without communication are not the main focus of our study, we aim to focus on the benchmark belief without *any* communication. Furthermore, randomizing the order of the belief elicitations before and after communication does not make sense for obvious reasons.

Communication After subjects have entered their "before" belief, a chat window opens for five minutes. Subjects cannot skip the chat stage. They also cannot extend or shorten the communication time. The chat is free-form, i.e., there are no predefined messages subjects can exchange, and we do not prime or nudge them to communicate about any particular topic. There are no restrictions on the chat content except that the subjects are not allowed to reveal their identity.

Feedback and payment To prevent hedging, we randomly select only one decision or one belief for payout, and this is common knowledge for all subjects ex-ante. We provide feedback about the decisions taken in both games and the decision or belief selected for payout only at the end of the experiment.

Procedures The sample size is 144 participants. We collected the data between September and November 2023 at the Potsdam Laboratory for Economic Experiments at the

University of Potsdam. The participants were invited to the sessions through the regular invitation procedures of the laboratory. No specific rules have been used to restrict participants who are registered in the database from participating in the experiments other than that they have not participated in this experimental study before. We programmed the experiment in z-Tree (Fischbacher, 2007) and invited participants using ORSEE (Greiner, 2015). On average, each participant earned 17 euros in the experiment, including a 5 euros show-up fee. Sessions lasted less than one hour.

4 Hypotheses

Given the consistent evidence that communication facilitates cooperation, we expect that communication leads to higher cooperation rates in our setup. We specify this expectation as our first hypothesis.

Hypothesis 1. *Cooperation rates with communication are higher than without communication.*

Regarding beliefs, we consider two comparisons: without vs. before communication (Update 1) and before vs. after communication (Update 2). Update 1 captures subjects' belief updating in anticipation of communication. Subjects learn about having a chance to deliver their arguments to their matched partner and try to convince them to cooperate. Hence, one can think of this shift as a measure of how convincing subjects expect *their argument* to be.

We expect that subjects in the experiment correctly anticipate that communication increases cooperation, e.g. by activating social preferences (see Zultan, 2012). Therefore, we hypothesize that mean beliefs b about the partner's cooperation are higher with communication. This increase in beliefs should happen before communication has taken place. Our second hypothesis formulates this expectation.

Hypothesis 2. *Beliefs before communication are higher than without communication.*

It is important to note that we expect no change in the precision of the beliefs without and before communication. This is because subjects receive no new information about their partner in between these two belief elicitations. Therefore, the degree of uncertainty about the other's choice, and, thus, their belief precision, would remain, in expectation, unchanged.

Now consider Update 2 that contains a precision shift when communication realizes. Based on law of iterated expectations, the belief, on average, does not shift anymore. At this point, subjects can judge how convincing they find their partners' arguments and update their belief precision according to the new information. We expect that communication reduces strategic uncertainty, i.e. it makes subjective beliefs about the partners' likelihood of cooperation more precise. This effect can work into both directions: exchanging credible promises about cooperative choices can make subjects more certain about the likelihood that their partner will cooperate if they already held a rather optimistic belief, but communication can also turn an optimistic initial belief into a precise pessimistic belief. According to the law of iterated expectations, these shifts should cancel out each other on average across the population of subjects making the mean belief before and after communication the same. However, the belief about the own partner's cooperation should be more precise after the communication. We formulate this expectation as our third and main hypothesis.

Hypothesis 3. *Belief precision after communication is higher than before communication.*

5 Results

This section is organized as follows. First, we present our main results in Section 5.1. We provide additional insights with respect to individual controls and test our theoretical framework in Section 5.2. Lastly, we analyze the communication content in Section 5.3.

5.1 Main results

We summarize our main results in Figure 2. We present three main outcomes: cooperation rates without and with communication, beliefs and their precision elicited at the three stages in the left, middle and right sections of Figure 2, respectively.

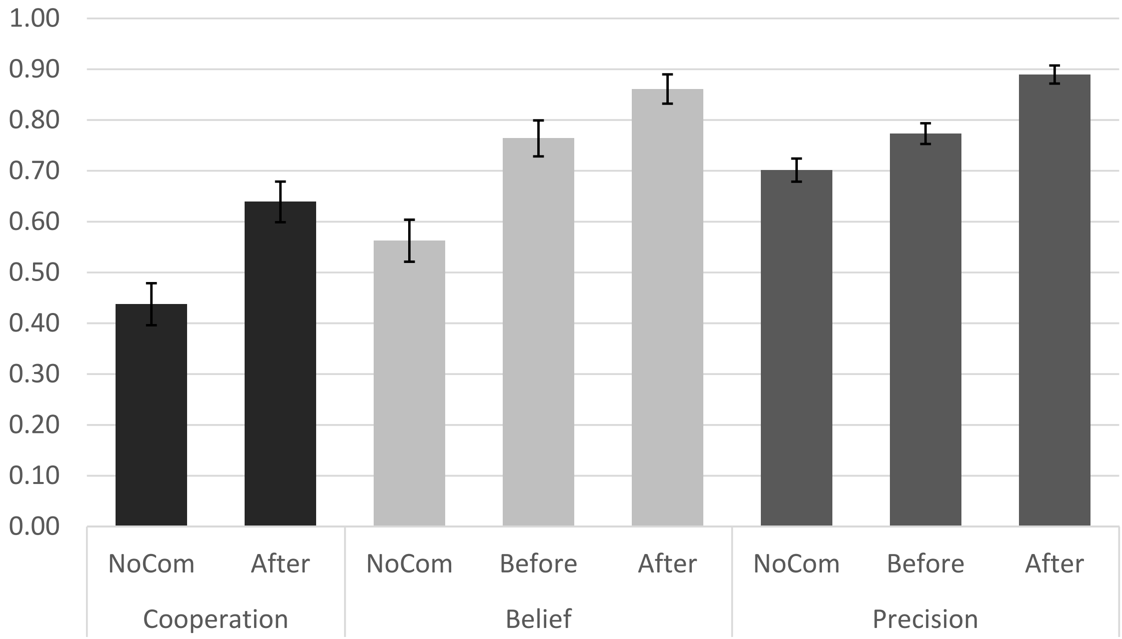


Figure 2: Mean cooperation rates, beliefs, and precision, including error bars.

Cooperation Without communication, the cooperation rate is 44%. Introducing communication results in a substantial increase shifting the average cooperation rate to 64%. In line with Hypothesis 1, we document that cooperation rates are significantly higher with than without communication ($p < 0.01$, McNemar's test).

Beliefs Hypothesis 2 stated that we expect the anticipation of communication to increase the belief about the partner's cooperation. The middle set of bars in Figure 2 illustrates mean beliefs without (56%), before (76%), and after (86%) communication. The increase by 20 percentage points from the decision without communication to the elicitation before communication ($p < 0.01$, McNemar's test), which is exactly as large as the increase in cooperation rates, suggests that subjects indeed anticipate the cooperation-enhancing effect of communication in line with Hypothesis 2.

Figure 2 also shows that beliefs increase further, by another 10 percentage points, from before communication to after communication ($p < 0.01$, McNemar's test). This indicates that subjects on average update their belief about the other's cooperation positively during the communication.

Precision The right set of bars in Figure 2 shows the perceived belief precision subjects report. In line with Hypothesis 3, belief precision increases from before (77%) to after (89%) communication ($p < 0.01$, Wilcoxon signed rank test, two-sided).[1] This indicates that communication increases subjects' confidence in their ability to predict their partner's choice and thereby reduces strategic uncertainty.

There already is a smaller increase in reported precision from the decision without communication (70%) to the elicitation before communication takes place ($p < 0.01$, Wilcoxon signed rank test, two-sided). Thus, the anticipation of communication not only increases optimism of beliefs, but subjects also become more certain that their optimistic belief is accurate.

Combined Belief Measure The two-stage belief elicitation procedure aimed at disentangling the increase in belief precision due to communication from the belief itself becoming more optimistic. Based on the data presented so far, we cannot rule out that the precision shift also reflects an increase in optimism that the other player cooperates after communication. This would be the case if subjects interpreted the question "How certain are you in your assessment?" in terms of their degree of optimism or pessimism rather than as confidence in their ability to make an accurate prediction.

In an attempt to disentangle the two interpretations, we complement our analysis with a comparison to the standard percentage belief elicited after communication. In their response to that question, subjects on average report a 79% probability that their partner plays X. The mean of the combined measure of the belief b and precision p is

[1] As the precision elicited after communication is no longer independent across individuals, we complement the nonparametric test using individual subjects as the unit of observation with a regression analysis accounting for the interdependence of individual observations after communication. In a plain OLS regression on the shift in precision before and after communication, the constant term has the value 0.116 (standard error clustered by group = 0.025, $p < 0.01$).

83%, which is significantly higher than the mean percentage belief ($p < 0.01$, Wilcoxon signed rank test, two-sided). Thus, even if we assume that the shift in precision contains an optimism shift, there still remains a 4 percentage point residual. This residual provides a natural lower bound for the true increase in precision due to communication.

5.2 Additional Results

Individual Characteristics Belief precision may depend on individual characteristics, in particular subjects' attitude towards risk or strategic uncertainty and their confidence in making predictions about others' behavior. In the questionnaire, we elicited these characteristics.[2] The regression analysis in Table 2 allows us to analyze the effect of these exploratory control variables on precision after communication in an OLS regression.

	Precision after communication (1)	(2)
Risk seeking		-0.001
		(0.006)
Strategic uncertainty tolerant		0.016**
		(0.006)
Knowledge human nature		0.024**
		(0.011)
Precision before communication	0.157	0.106
	(0.096)	(0.080)
Constant	0.768***	0.567***
	(0.080)	(0.116)
Observations	144	144
R-squared	0.033	0.117

Table 2: OLS regressions on precision after communication. Standard errors clustered by group. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Note first that belief precision before and after communication are not significantly correlated. This result suggests that communication shifts the belief precision to a universally high level for all subjects independent of whether their belief precision before communication was high or low.

[2]The variables for willingness to take risks, strategic uncertainty, and knowledge of human nature have been elicited on a Likert scale from 0 to 10.

The second regression adds the control variables, indicating that elicited precision after communication is higher for subjects who are more tolerant to strategic uncertainty and those who claim to have a better knowledge of human nature. At the same time, risk tolerance does not play a significant role in the context of our experiment. Intuitively, subjects' interaction in the experiment involved strategic uncertainty rather than mechanical risk.

Theory Test Table 3 shows the results of a Probit regression testing the underlying theory of how beliefs and their precision influence cooperation. The regressions use the cooperation decisions without or after communication as the outcome variable.

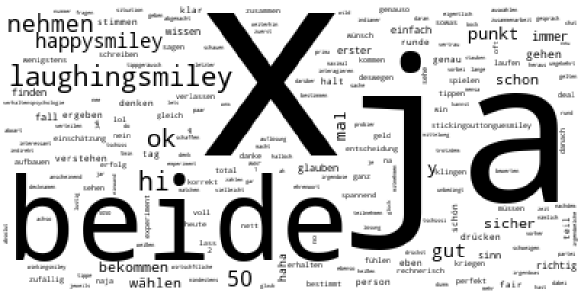
	Cooperation without communication		Cooperation after communication	
	(1)	(2)	(3)	(4)
Belief	1.397***		1.882***	
	(0.238)		(0.419)	
Precision if optimistic		0.159		1.006**
		(0.420)		(0.500)
Precision if pessimistic		-1.808***		-1.116
		(0.488)		(0.709)
Constant	-1.000***	0.264	-1.282***	-0.301
	(0.190)	(0.300)	(0.395)	(0.458)
Observations	144	144	144	144

Table 3: Probit regressions on cooperation after communication. Standard errors after communication clustered by group. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Models (1) and (3) explain cooperation decisions with beliefs indicating that cooperation rates are higher when beliefs are optimistic. Models (2) and (4) test whether a higher precision of beliefs leads to more cooperation if the belief is optimistic and less cooperation if the belief is pessimistic. We find evidence for the latter in the data without communication and the former in the data after communication. While the effect of precision if the belief is pessimistic after communication is likely insignificant due to the small number of observations (there are only 14% pessimistic subjects after communication), the null effect of precision if the belief is optimistic without communication needs further explanation.

One likely explanation is the moderating effect of social preferences that is more pronounced after communication (see Heinrich and Mayrhofer, 2018). For a pessimistic belief to lead to less cooperation, the risk that the other individual defects suffices to make their own defection optimal. However, the individual has to care about the other's payoff additionally for an optimistic belief to lead to more cooperation. Without communication, this does not seem to be the case on average.

5.3 Communication



(a) pessimistic before, optimistic after

(b) optimististic before and after

(c) optimistic before, pessimistic after

(d) pessimistic before and after

Figure 3: Word clouds

In an attempt to discover not only whether but how communication affects beliefs, we use natural language processing to analyze the content of the chats. Figure 3 depicts the most frequent tokens the partner wrote in the chat, split up by the own belief before and after the chat, in a word cloud where the font size of a token corresponds to its relative frequency.[3] Of all 144 subjects, 21 switch from a pessimistic to an optimistic belief, 7 switch from an optimistic to a pessimistic belief, 13 are pessimistic before and after, and 103 are optimistic before and after.

The token frequencies illustrate that subjects who clearly state that 'both' ('beide') subjects should choose the cooperative action 'X' and confirm their willingness to do so ('yes'/'ja') are successful in inducing an optimistic partner's belief. In cases where subjects entered the chat with an optimistic belief already, we additionally see many expressions of happiness. Subjects who write more about about 'Y' in addition to 'X' lose their partner's optimism during the chat. Furthermore, 'ok' and 'alright' ('gut') seem to transmit such skepticism. Those who even talk about 'taking' ('nehmen') 'Y' confirm their partner's already pessimistic belief.

6 Conclusion

In a laboratory experiment, we studied the effect of communication on the precision of beliefs about others' cooperation in a social dilemma. To this end, we introduced a two-stage belief elicitation procedure that disentangles belief precision from the belief itself. Using this procedure, we find evidence in favor of the idea that communication makes beliefs not only more optimistic – which facilitates the coordination of conditionally cooperative players – but also more precise.

Furthermore, we find that those subjects who have better knowledge about human nature and are less averse to strategic uncertainty report higher precision after the communication. Thus, our findings contribute an important missing piece for understanding how communication affects cooperation, showing that it reduces strategic uncertainty and hence facilitates cooperation.

Finally, we observe an interaction between belief precision, cooperation, and communication. For pessimistic beliefs, higher precision leads to less cooperation with and without communication. However, for optimistic beliefs, higher precision leads to more

[3] During pre-processing, we replaced smileys by their verbal translation, removed any other punctuation, lemmatized words to their base form, converted all letters to lowercase, and deleted stopwords.

cooperation only with communication while it has no effect on cooperation without communication. We attribute this to a moderating effect of social preferences: only with communication, individuals care enough about others' payoffs to make them respond positively to a more precise optimistic belief.

Future research is needed to test the robustness of these findings and the channels we propose. Firstly, our approach to disentangle beliefs and their precision could be developed further to isolate precision from optimism in the cleanest possible way. Our comparison between the standard belief elicitation in percent and the combined measure derived from our two-stage procedure may provide a path into this direction. Secondly, the suggested moderating effect of social preferences on the interaction of belief precision, communication, and cooperation calls for more research.

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Appendix: Instructions

A Paper instructions

Welcome to this experiment!

Today you will take part in a decision experiment. You will receive an allowance for participating in this experiment. The amount you receive depends on your decisions and the decisions of other people participating in this experiment. It is therefore important that you read the instructions on the following pages carefully.

These instructions are identical for all participants.

For the entire duration of the experiment, you are not allowed to communicate with other participants unless you are explicitly asked to do so as part of the experiment. We therefore ask you not to talk to each other. Violation of this rule will result in exclusion from the experiment and payment.

If there is something you do not understand, please look again at these experiment instructions or give us a hand signal. We will then come to you and answer your question personally.

During the experiment we do not talk about euros, but about points. So your income will first be calculated in points. Your points will then be converted into euros at the end of the experiment, using the following conversion rate:

$$4 \text{ points} = 1 \text{ euro}$$

At the end of today's experiment, you will be paid in cash the points you have achieved from the experiment converted into euros. In addition, you will receive 5 euros today for showing up on time for the experiment.

You will interact with two different other persons in this experiment. You will not learn from us who these other persons are, nor will the other persons learn your identity from us. Any information you disclose in this experiment and the decisions you make will be kept confidential and anonymous by us. The payout procedure is organized in such a way that participants will not see what amount the other participants receive.

On the following pages we will explain the basic procedure of the experiment. You will learn about the sequence of decisions in detail bit by bit, either directly here on paper or later on the screen.

Overview of the experiment procedure

This experiment consists of several parts in which you will either make decisions or be asked for your assessment of another person's decision. For the first two parts, the instructions will be explained to you on the following pages. The instructions for the later parts will be shown to you on the computer screen immediately before each part.

At the end of the experiment, only one of the parts will be randomly selected to determine your final payoff. In doing so, each of the parts has an equal chance of being selected. Consequently, only one decision or estimate will have an effect on your final payoff, but it could be any of your decisions or estimates.

The decision situation is always the same; you are interacting with another person in it. In the course of the experiment, this will be two different other persons. You and the other person will each be asked simultaneously to choose one of two possible decisions X and Y. You will be asked to choose one of two possible decisions Y and X, respectively. Depending on your two choices, your payoffs will then be determined according to the following table:

My Decision	Decision of the other person	My payoff	Payoff of the other
X	X	50	50
Y	Y	20	20
X	Y	10	80
Y	X	80	10

When we ask you for your assessment of another person's decision, you are each asked to give two statements:

- Do you think it is more likely that the other person will choose X or Y?
- How certain are you in your assessment?

Immediately after the experiment, we will ask you to fill out a short questionnaire on the computer.

Only at the very end will you find out which part of the experiment was determined to pay off and how the other two persons decided. You will also find out how many points you will receive in total. Your points will be converted into euros and paid to you in cash. On the following pages we explain the first two parts of the experiment in detail.

Part 1: Assessment

First, you are asked to tell us whether you think it is more likely that the other person with whom you will interact in the next part will choose X or Y, respectively. You will also be asked to tell us how certain you are in your guess (on a scale from “blind guess” to “absolutely certain”).

If part 1 determines your final payoff, it will depend on how accurate your guess was. If your guess of the other person’s decision in part 1 was correct and you also indicated that you were absolutely sure, you will receive 60 points for the correct guess. In the case of an incorrect assessment where you were absolutely sure, you will receive 30 points. If you indicated that you were not sure, you will receive either 60 points or 30 points. The probability of receiving the higher payout of 60 points depends on your guess and how sure you were about it. If your guess is correct, the more sure you were about it, the higher the probability of getting 60 points. Conversely, if your decision is wrong, but you were unsure, the probability of getting 60 points is also higher. This mechanism ensures that it is in your best interest to state your true estimate. Later in the experiment, when you click the “Information” button on the screen for your estimate, you will be shown exactly how the computer program calculates your payoff.

You will only be informed at the end of the experiment whether your assessment in part 1 determines your final payout.

Decision

You and the other person will be asked simultaneously to choose one of two possible decisions X and Y. Depending on your two choices, your respective payoff is then determined according to the following table:

My Decision	Decision of the other person	My payoff	Payoff of the other
X	X	50	50
Y	Y	20	20
X	Y	10	80
Y	X	80	10

- If you and the other person both choose X, you each get 50 points.
- If you and the other person both choose Y, you each get 20 points.
- If one of you chooses X and the other chooses Y,
  - the person who chose X gets 10 points and
  - the person who chose Y gets 80 points.

You will not be informed if your decision in part 2 determines your final payoff until the end of the experiment. You will also not know the other person's decision until the end of the experiment.

After part 2, the computer program assigns you a new person for the further experiment. From part 3 onwards, you interact with a different person than before. Your assessments in the further parts also refer to this new person.

Now please turn to the screen. We will ask you there to answer some quiz questions. This is to make sure that all participants have understood the instructions well. Only when all participants have answered these questions correctly will the experiment begin. If something is unclear to you, please give a clear hand signal. We will then come to your place.

Good luck!

B On-screen instructions

Welcome to the experiment!

Before we start, please answer the following quiz questions.

Only when all participants have answered correctly, the experiment will begin.

Which payout do you get if you and the other person both choose Y? [Enter number 0-100, correct: 20]

What payoff do you get if you choose Y and the other person chooses X? [Enter number 0-100, correct: 80]

What payoff do you get if you choose X and the other person Y? [Enter number 0-100, correct: 10]

What payoff do you get if you and the other person both choose X? [Enter number 0-100, correct: 50]

Please tell us your assessment of how likely you think it is that the other person in the decision will choose X or Y, respectively.

Do you think it is more likely that the other person with whom you are about to interact will choose X or Y? [Select X or Y, radio buttons in vertical order]

How certain are you in your assessment? [slider, ranging from "blind gues" to "absolutely sure"]

You will be informed only at the end of the experiment whether your guess in this part determines your final payoff. If you want to know exactly how your possible payout will be determined, please click the "Information" button.

Behind the "Information" button:

First, the computer translates your guess into a number between 0 and 10. The number is 10 if you were absolutely sure the other person would choose X, and 0 if you were absolutely sure the other person would choose Y. The values in between are translated linearly into numbers between 0 and 5, respectively. If you indicate that you guessed blindly, the number is 5 in both cases. The values in between, when you were a little more or a little less sure, are translated linearly into numbers between 0 and 5 or between 5 and 10.

Then the computer calculates a value that we call DIFF: The difference between your answer and the correct answer. The correct answer is 10 if the other person chooses X, and 0 if the other person chooses Y.

Then the computer determines the squared value; DIFF2=DIFF*DIFF.

Next, the computer randomly draws an integer between 1 and 100 (each realization is equally likely).

If the value of DIFF2 is less than this random integer, you get 60 points, otherwise you get 30 points.

You and the other person now choose one of the possible decisions X and Y. As a reminder, here are the rules for the payoff:

- If you and the other person both choose X, you each get 50 points.
- If you and the other person both choose Y, you each get 20 points.
- If one of you chooses X and the other chooses Y,
  - the person who chose X gets 10 points and
  - the person who chose Y gets 80 points.

Please make your decision here: [Select X or Y, radio buttons in vertical order]

You will be informed only at the end of the experiment whether your decision in this part determines your final payoff. You will also learn about the other person's decision only at the end of the experiment.

The computer program assigned you a new person for the rest of the experiment. From now on, you interact with a different person than before. Your assessments in the further parts also refer to this new person.

You and the other person will be asked again asked at the same time to choose one of two possible decisions X and Y.

Depending on your two choices, your payoff is determined. The same rules apply as for the first decision:

- If you and the other person both choose X, you each get 50 points.
- If you and the other person both choose Y, you each get 20 points.
- If one of you chooses X and the other chooses Y,
  - the person who chose X gets 10 points and
  - the person who chose Y gets 80 points.

Unlike the first decision, however, this time you can communicate with the other person for five minutes before making the decision. For this purpose, a chat window will open right away on the computer screen, where only you two can exchange messages with each other. The window remains open for five minutes and then closes automatically. You may write whatever you want in the chat, with the only restriction being that you must not give any hint about your identity.

Before you can chat with the other person, please share your assessment of how likely you think it is that the other person will choose X or Y in the decision after the chat.

Do you think it is more likely that the other person you are about to interact with will choose X or Y? [Select X or Y, radio buttons in vertical order]

How certain are you in your assessment? [slider, ranging from "blind guess" to "absolutely sure"]

Your payoff for this guess will be calculated the same way as the first time. You will be informed only at the end of the experiment whether your guess in this part determines your final payoff.

If you want to know exactly how your possible payout will be determined, please click the "Information" button.

You can immediately chat for five minutes with the person you will subsequently interact with. For this purpose, a chat window opens on the next screen, where only the two of you can exchange messages with each other. The window stays open for five minutes and then closes automatically. You are allowed to write whatever you want in the chat, with the only restriction that you are not allowed to give any hint about your identity.

Now that you have chatted with the other person, please share again your assessment of how likely you think this person is to choose X or Y in the decision.

Do you think it is more likely that the other person you are about to interact with will choose X or Y? [Select X or Y, radio buttons in vertical order]

How certain are you in your assessment? [slider, ranging from “blind guess” to “absolutely sure”]

Your payoff for this guess is calculated the same as before. You will be informed only at the end of the experiment whether your guess in this part determines your final payoff.

If you want to know exactly how your possible payout will be determined, please click the “Information” button.

You and the other person now choose one of the possible decisions X and Y. As a reminder, here are the rules for the payoff:

- If you and the other person both choose X, you each get 50 points.
- If you and the other person both choose Y, you each get 20 points.
- If one of you chooses X and the other chooses Y,
  - the person who chose X gets 10 points and
  - the person who chose Y gets 80 points.

Please make your decision here: [Select X or Y, radio buttons in vertical order].

You will be informed only at the end of the experiment whether your decision in this part determines their final payoff. You will also learn about the other person's decision only at the end of the experiment.