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Costly communication and learning from failure in organizational coordination☆

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ABSTRACT

This paper investigates the coordination failure that arises from combining two small pre-existing groups and focuses on the reaction of group members to this change in environment. In an experiment, small groups were first able to establish a coordination history in a repeated minimum-effort game; in the second phase, two groups with different histories were combined into a larger group. Unlike most of the previous literature, subjects could endogenously choose to communicate in the newly formed group for a small fee. While communication proved to be necessary for preventing coordination failure in the newly formed group, only every second subject was willing to implement communication. Particularly, subjects from groups with a less efficient coordination experience in the first phase were more likely to realize the potential of coordination failure in the new group and were thus more likely to decide for communication. The results may be useful for understanding how groups coordinate in changing environments as they are common in economic contexts.

"Failure is always the best way to learn"
Kings of Convenience, "Failure" (2003)

1. Introduction

Coordination problems are central in many economic and organizational contexts (see e.g., March and Simon, 1958; Schelling, 1960; Lewis, 1969; Arrow, 1974; Skyrms, 2004). Because of the importance of coordination success for organizations and society, there are numerous studies on coordination problems, and laboratory experiments have illustrated the obstacles to successful coordination in large groups (for extensive overviews see Ochs, 1995; Camerer, 2003; Devetag and Ortmann, 2007). This experimental study investigates coordination problems that arise from a change in the composition of a group, which is common in many economic contexts in general and in organizational settings in particular. More specifically, the study is interested in how subjects deal with possible conflicts due to this change by allowing them to decide whether to install a pre-play communication device. The results show that a significant share of subjects was unwilling to facilitate coordination through communication despite the tiny implementation cost and its potential benefits. As a

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consequence, newly formed groups which failed to implement the communication device suffered from coordination failure.[1] In contrast, the opportunity to communicate allowed most groups to coordinate on the Pareto-efficient outcome.

The decision about communication is related to subjects' experience prior to the change in the group composition. Most notably, subjects with a successful coordination experience prior to the change were more likely to decide against communication, suggesting that they failed to recognize the potential benefits of pre-play communication and that they underestimated the coordination problem. This is particularly remarkable as subjects were informed about the differences in the coordination experiences of the new group members. In contrast, subjects who experienced less efficient coordination outcomes before the change were more willing to implement communication. These results highlight how learning from (coordination) failure can spark a necessary change and point to a novel and more nuanced view on coordination problems as they can emerge because individuals neglect mechanisms that improve coordination.

This paper is related to a large literature on coordination problems, which has mainly focused on the determinants for coordination failure or success.[2] Communication is obviously an important factor and some of the literature has provided important insights into how and when exogenously implemented communication is most effective (see e.g., Cooper et al. (1992), Blume and Ortmann (2007), and the studies discussed in the next section). This paper departs from the existing literature in two important ways. First, it deals with novel coordination problems emerging from a change in the environment, namely when two small groups with different coordination experiences are combined to coordinate their activities together. Second, it endogenizes the decision about communication and thus examines individuals' awareness of the potential conflicts that arise through this change. Addressing these issues is important for social groups and organizations or firms as its members have to continuously adapt to changing environments.[3] Therefore, it is of interest to understand (i) if individuals realize the benefits of communication in such situations and (ii) if previous inferences about exogenously implemented communication extend to a situation in which the choice of communication is endogenous.

In organizational settings, for example, novel coordination problems occur in firm mergers, in the restructuring of organizational units and in daily business when coordinating activities across units. On a smaller scale, coordination problems in changing environments can arise when teams have to work together for a limited time as is often the case with consulting firms, or simply when employees have to adapt to the new circumstances. In all these cases employees face strategic uncertainty about what actions to expect from each other as they, for example, lack a shared experience or are accustomed to different work routines. Small low-cost interventions such as communication in form of memos, meetings, jour fixes or committees may serve to align the expectations of employees in these novel situations and may be critical for organizational success.[4] Edmondson (2004), for example, points out how failures to communicate small problems in patient care can considerably impede coordination within nursing teams and between nurses and physicians, which can as a result accumulate to more serious coordination failures. Relatedly, the development of the Airbus A380 illustrates the pitfalls of conflicting work routines for coordination that were neglected by the management. The use of different construction software led to miscommunication and miscoordination between the different engineering teams and as a consequence to significant delays in the airplane's delivery schedule.[5]

The question how organizations learn from coordination problems is important for their success and is a recurrent topic in the literature on organizational learning (e.g., Blume and Franco, 2007; Blume et al., 2009; Levitt and March, 1988). It is commonly assumed that past success reinforces the status quo whereas experiencing failures paves the way for new ideas and solutions (Harford, 2011).[6] However, it is typically hard to disentangle how successful and unsuccessful experiences contribute to organizational performance. The experimental setup in this study provides a clear distinction between success and failure and offers the possibility to directly relate a subject's previous coordination experience to her costly choice to implement communication. The findings clearly underline that past coordination failure is crucial for the decision to implement communication and thus suggest that learning from failure is a critical piece for coordination success.

[1] Coordination failure typically refers to the inability of individuals to coordinate on one of the equilibria (miscoordination) or to achieve the efficient equilibrium in games with Pareto-ranked equilibria.

[2] Most of the research in this area has focused on fixed groups (see e.g., Camerer, 2003; Devetag and Ortmann, 2007). Coordination experiments with groups larger than two mainly use fixed groups, i.e., where group composition does not change during the experiment (fixed matching). Situations where the group composition changes (random matching) are more commonly investigated in two-player stag-hunt games (see e.g., Cooper et al., 1992; Schmidt et al., 2003).

[3] Changes to group boundaries or composition also emerge in other economic and social contexts, for example, when families split up and ex-partners start new families (e.g., patchwork families). Another example is when individuals move to another country, as foreign cultures and languages may impede integration. Governments often seek to facilitate the integration process, introducing for instance programs for language acquisition and opening information centers, among other measures.

[4] See, e.g., March and Simon (1958) or Lawrence and Lorsch (1967) for early accounts on mechanisms for facilitating coordination in organizations.

[5] Airbus relies on a decentralized production chain with facilities located in several European countries. While each facility is responsible for a specific procedure or part of an airplane, the final assembly takes place in Toulouse. This production process critically depends on the performance of each production step and therefore resembles a production function with complementarities. Coordination problems that arise from strategic complementarities are the focus of this study as such production functions are present in many organizations (see e.g., Knez and Camerer, 1994).

[6] There is indeed some anecdotal evidence that prior success causes firms to be inattentive to new problems or information. For example, some commentators reporting on the Airbus A380 crisis speculated that the problems originated in part from Airbus's prior success with its A320 model ("The Airbus Saga: Crossed Wires and a Multibillion-Euro Delay," *New York Times*, www.nytimes.com/2006/12/11/business/worldbusiness/11iht-airbus.3860198.html). A related phenomenon can be found in many team sports where leading by a small margin at halftime often results in losing the game (for evidence from Basketball see e.g., Berger and Pope, 2011).

Table 1
Payoffs for minimum-effort game.

		Minimum effort in group				
		0	10	20	30	40
Effort by subject *i*	**0**	200				
	10	150	230			
	20	100	180	260		
	30	50	130	210	290	
	40	0	80	160	240	320

Finally, the paper contributes to a recent theoretical literature on coordination in decentralized firms or changing environments (e.g., Hart and Moore, 2005; Dessein and Santos, 2006; Qian et al., 2006; Dessein et al., 2013). For example, Dessein and Santos (2006) emphasize the role of communication for coordination when organizations face a trade-off between adaption and coordination. In particular, they show that adaptiveness requires intensive communication to compensate for higher flexibility of work routines and tasks. The present study considers a setting where subjects have to decide how to deal with a changing environment for a given task. The results suggest that while communication is indeed important for coordination success, there can be too little communication as subjects underestimate its benefits and the coordination problem.

2. Game and related literature

The experiment implements a variant of the minimum-effort game (Van Huyck et al., 1990, VHBB in the following). This type of game captures many situations in organizational contexts where individual actions are strategic complements (Knez and Camerer, 1994). In the game n players simultaneously choose an effort level $e_i \in \{0, 10, 20, 30, 40\}$ and a player's payoff depends on his own effort e_i and the minimum effort in the group, $\min_{j=1,...,n}(e_j)$, see Table 1. All outcomes in which all players choose the same effort level are Nash equilibria, which are Pareto-rankable since all players are better off with a higher minimum effort. Efficient coordination requires that all players choose the efficient action, $e_i = 40$. However, since any symmetric outcome is an equilibrium there is strategic uncertainty about what other players will do. In particular, any player can secure himself the inefficient outcome by choosing $e_i = 0$. Note that the minimum-effort game is a potential game, i.e., there exists a potential function such that a change of decision in response to others' choices that increases a player's own payoff function also increases the potential function (Monderer and Shapley, 1996). The potential function of the minimum-effort game is

$$P(e_1, e_2, ..., e_n) = a \min(e_1, e_2, ..., e_n) - b \sum_{j=1}^{n} e_j,$$

where $a > b \geq 0$.[7] As illustrated below, it turns out that the maximization of the potential function is useful to organize most of the previous experimental results.

In their seminal paper, VHBB provide compelling evidence that large groups (14–16 persons) converge to the lowest minimum effort (secure equilibrium) within a few rounds, whereas two-player groups almost always achieved the highest minimum effort (Pareto-efficient equilibrium). Van Huyck, Battalio and Beil's results are consistent with the maximization of the potential function of the minimum-effort game.[8] Indeed, Goeree and Holt (2005) present a more systematic analysis of the predictions of (stochastic) potential maximization and show that play converges to high (low) effort levels if the marginal effort cost is below (above) a critical threshold as predicted by the potential-game approach in 2-player and 3-player minimum-effort games. Chen and Chen (2011) use potential game theory to provide a unifying framework for evidence that (social) identity can lead to more efficient coordination outcomes. They show theoretically how identity can change equilibrium selection in a potential game with multiple Pareto-ranked equilibria and present experimental results for a minimum-effort game in line with their predictions.

A number of studies have built on the original minimum-effort game parameterization of VHBB but have used different group sizes. For example, subsequent research shows that three-player groups frequently coordinated on either the secure equilibrium or the Pareto-efficient equilibrium, but also occasionally on the remaining equilibria in-between (e.g., Knez and Camerer, 1994; 2000; Weber et al., 2004), while groups with four and more players converge most of the time to the secure equilibrium (e.g., Knez and Camerer, 1994; Bornstein et al., 2002; Blume and Ortmann, 2007; Chaudhuri et al., 2009).[9]

[7] Note that the set of values maximizing P is a subset of the equilibria set of the minimum-effort game. For a common strategy profile e, the function P is maximized at the lowest effort when $b > a/n = b^*$, and is maximized at the highest effort when $b < b^*$ (see Monderer and Shapley, 1996). Thus outcomes are sensitive to the marginal cost of effort, the marginal benefit and group size. Given the parameters of the game used in the experiment (see Table 1), the marginal costs $b = 5$ are above the critical threshold $b^* = a/n = 8/3$ and thus play should converge to the least efficient effort level $e = 0$.

[8] The game parameters used by VHBB were $a = 0.2$ and $b = 0.1$. Thus with a group size of $n \geq 14$ groups should converge to the secure equilibrium as $b > b^*$ and with $n = 2$ any equilibria is possible including the most efficient (as $b \leq b^*$). In a third treatment they used $b = 0$ and group sizes of $n \geq 14$ which resulted in coordination on the efficient outcome as predicted (as $b < b^*$).

[9] Note that these results are consistent with potential maximization as well, as the marginal cost of effort is in all cases above the critical threshold (i.e., $b > a/n$). Recently, Engelmann and Normann (2010) report that even groups of four and six frequently coordinated on the Pareto-efficient equilibrium in

Weber (2006) demonstrates that large groups can often prevent inefficient coordination if they grow out of small, efficiently coordinated groups. A crucial factor for the observed efficient growth is that entrants are aware of the coordination history in the existing group.[10] In a related context, Salmon and Weber (2016) examine the effect of entry rules when subjects are able to move from a large, low-performing group to a small, high-performing group. They find that entry restrictions regulate the growth of groups without harming efficiency all that much and that the exact design of the regulation plays a less crucial role. While both studies are concerned with how a change in the group composition affects efficient coordination, they do not consider which institution subjects would implement themselves to prevent coordination failure.

Communication is one natural way to overcome coordination failure.[11] Several experimental studies have shown that even simple communication can substantially reduce the coordination problem. For example, allowing one player to send a non-binding signal about his intended action (one-way communication) in a two-player stag-hunt game improved coordination on the efficient equilibrium considerably more than tacit coordination (see e.g., Charness, 2000; Duffy and Feltovich, 2002). Comparing one-way and two-way communication (both players can send a message), Cooper et al. (1992) show that two-way communication is far superior to one-way communication (91 versus 53% coordination on the efficient equilibrium in the last 11 rounds). While all of these papers focused on two-player stag-hunt games, Blume and Ortmann (2007) also examine costless and simultaneous pre-play communication in a nine-player minimum-effort game. They find that in most groups "cheap talk" reliably leads to the Pareto-efficient equilibrium. Unlike the present paper, this and most other studies consider only exogenously implemented communication with subjects who had no prior coordination experience.

The paper closest to this study is Knez and Camerer (1994), who investigate how the shared experience of playing a coordination game is transferable to a new environment.[12] They demonstrate the difficulty of such transfers, even if subjects were aware of others' previous history.[13] By contrast, the focus of this paper is on how subjects solve coordination problems when facing a new environment. In particular, this study is concerned with the endogenous implementation of communication and thus with subjects' awareness of possible conflicts in newly-formed groups. Moreover, it is possible to draw inferences about the relationship between coordination experience and the use of communication.

3. Experimental setup and procedures

In each session there were twelve subjects who were randomly seated at separate computers in the beginning.[14] The experiment consisted of two parts and subjects received the instructions separately for each part.[15] In the first part of the experiment (Part I), subjects were randomly assigned to four groups with $n = 3$ subjects. The group composition was fixed throughout the first part. Subjects played 10 rounds of the previously described minimum-effort game (see Table 1). The payoffs in Table 1 were expressed by the experimental currency DM, which had a conversion rate of 200 DM = 1 Euro. At the end of each round subjects received aggregated feedback, i.e., the minimum effort in their group, along with their own effort and payoff. Note that Part I was the same in each session and the purpose was to let groups establish different precedents.

After round 10, subjects received new instructions for the second part (Part II), which involved a change in the group composition. As emphasized in the introduction, work in organizations and firms is often divided across several teams, which subsequently requires coordination among all team members to reintegrate their work. To capture this aspect of coordination two new groups of size $n = 6$ were formed. This group formation was done as follows. The four groups in each session were ranked according to their minimum effort in the last (10th) round of Part I (ties were broken randomly) and then a group of rank $r \in \{1, 2\}$ was combined with a group of rank $r + 2$. Subjects were not informed about the exact procedure; but they learned what minimum effort the new group members had chosen in the last round (round 10), i.e., group r was informed of the 10th round minimum effort (referred to below as the "pre-change minimum effort") in group $r + 2$ and vice versa. This information is a good proxy for past behavior in the other group and should highlight that the

the original minimum-effort game of VHBB. They attribute this result to their Danish subject-pool since they found a positive correlation of the minimum effort with the share of Danes in a group. Similarly, Feri et al., 2010) report higher efficiency in the original VHBB minimum-effort game with five-player groups where players are teams comprising three individuals each.

[10] McCarter and Sheremeta (2013) also find that information on history is important for efficient coordination when the group composition changes.

[11] Other factors that mitigate coordination failure are, for instance, group competition (Bornstein et al., 2002), simple cues such as a smile (Manzini et al., 2009), the saliency of the payoff-dominant equilibrium (e.g., Brandts and Cooper, 2006; Hamman et al., 2007) or the ability to choose interaction partners (Riedl et al., 2016). Most of these results can be reconciled with the potential game framework proposed by Chen and Chen (2011) who emphasize that identity has the potential to raise the critical threshold above the marginal cost of effort.

[12] A few papers have investigated how subjects transfer a precedent of efficient play between two similar games (e.g., Van Huyck et al., 1991; Knez, 1998; Knez and Camerer, 2000; Devetag, 2005; Duffy and Fehr, 2016). In these experiments, however, the same subjects interacted in both games.

[13] Weber and Camerer (2003) replicate the result of Knez and Camerer (1994) with an ingenious experimental design to demonstrate how conflicting corporate culture can be a pitfall for successful mergers. They find that two-player groups developed a unique code (a proxy for corporate culture) to complete a repeated picture-naming task faster but that this code became useless after merger because the subjects of the acquired group did not understand it. Related, Cremer et al. (2007) provide a theoretical contribution on the trade-offs between a specialized and a common language in organizations.

[14] There were two sessions with 24 subjects. In these sessions subjects were first randomly assigned to matching groups of 12.

[15] Subjects were aware that the experiment consisted of several parts. However, since subjects received the instructions separately for each part, they could not strategically condition their behavior to influence outcomes in later parts. The instructions were framed as a working task to ease subjects' understanding and also included control questions regarding the payoff function and other procedural details. The experiment started only after all subjects had answered all questions correctly (see the appendix for sample instructions).

Table 2
Overview of treatments in Part II.

Treatment	Communication	#Subjects	Rounds	#Groups Part 1 / 2 / 3
End	Available (voted yes)	54	20 or 25	18 / 9 / 6
	Not available (voted no)	42	20 or 25	14 / 7 / 4
Base	Not available (exogenous)	60	20	20 / 10 / –
ExCom	Available (exogenous)	48	20	16 / 8 / –

Notes: In treatment End, the voting decision refers to the vote of a randomly drawn subject in a newly-formed group. In five sessions of End, subjects played five additional rounds (Part III) with a voting decision before round 21.

other group had a different experience in a simple and transparent way. The group formation procedure was expected to create two large groups in each session, each formed from two small groups with different coordination experiences. As such, the focus is not on whether communication is more effective for groups with different or similar experience, but whether subjects realize that communication may be helpful when experiences differ.

The study consists of three treatments in order to investigate this question. In the main treatment subjects could decide endogenously on the implementation of a pre-play communication stage, which will be explained in detail below. In the pre-play communication stage, subjects had to send a non-binding message $m_i \in \{0, 10, 20, 30, 40\}$ to all group members before actual play. The instructions explicitly stated that subjects could use these numerical signals to inform the other group members about their planned effort e. Thus the instructions provided a suggestive interpretation of messages (see e.g., Blume and Ortmann, 2007). Before making their effort decision, subjects received an overview of the distribution of messages and they were able to observe for each possible message m the number of sent messages in their group.

Additionally, there were two control treatments in which the institution (communication or no communication) was imposed exogenously to check whether and how the endogenous implementation of communication affected behavior in the coordination game. All three treatments have in common the number of rounds (10), the group size ($n = 6$), and the feedback after each round (distribution of individual effort in their group, minimum effort and own payoff). Depending on the treatment, subjects had to answer a few questions relating to communication after round 20 (see the appendix for the questions). Table 2 provides an overview of the details of the treatments.

In the main treatment End(ogenous communication) subjects had to decide on the implementation of a pre-play communication stage. More specifically, subjects had to vote on communication after learning about the formation of a new group, the pre-change minimum effort of the new group members, and the details of the communication technology in round 11. After voting, they had to state their beliefs about the other group members' voting decision, for which they received 0.15 cent if their statement was correct. In each group the voting decision of one randomly selected subject was then implemented. That is, if the randomly selected subject voted for communication, the whole group communicated in each round before they made their effort decision. (This endogenous implementation of communication is referred to as EndCom.) If the randomly selected subject voted against communication, there was only the effort decision and no communication was possible. (This case is referred to as EndNoCom.) Importantly, subjects were not informed of the distribution of votes in their group.

The purpose of this procedure to implement communication was to elicit subjects' true preferences for communication and to abstract away from strategic issues.[16] In addition, this procedure avoids that subjects learn about others' communication preferences, which may affect a subject's expectation about behavior in the group in the game stage. For example, knowing that the majority of the group voted for communication may provide a strong signal to coordinate on the Pareto-efficient equilibrium. Such inferences from the voting stage are minimized by disclosing only the decision of the randomly selected subject.

The crucial feature about the choice of communication is the small cost $c = 20$ (equal to 10% of the secure payoff) for the implementation. Importantly, the cost c had to be paid in each period by each subject in a group when communication was available, irrespective of her vote. The implementation cost was deducted from each subject's earnings, i.e., all payoffs in Table 1 were reduced by $c = 20$. There was no cost for subjects when communication was not available, i.e., subjects faced the payoffs depicted in Table 1. The communication cost reflects that agents are less productive when communicating as they are, for example, engaged in meetings, calls or writing emails. Notice also that the implementation cost avoids an indifference between communication and no communication. Thus it is possible to discriminate between the anticipation of a possible conflict due to the group formation and a pure preference for communication.

As the decision about communication in the beginning of Part II was irreversible, i.e., groups could either communicate in each of the 10 rounds or not, some sessions involved a third part (Part III). That is, in five randomly chosen sessions of

[16] Other voting rules, for example, may introduce strategic considerations (e.g., expectations about others' voting behavior may play a role) such that (voting) behavior likely varies with the specific voting rule. The random dictator procedure ensures that all subjects in a group are pivotal with the same probability $1/N$, where N is the group size, and have strong incentives for truthful revelation of their most preferred institution.

Table 3
Distribution of effort and minimum effort in Round 1 and Round 10.

	Individual effort		Minimum effort	
	Round 1	Round 10	Round 1	Round 10
0	6%	30%	16%	35%
10	8%	13%	19%	12%
20	31%	26%	52%	28%
30	17%	10%	9%	6%
40	38%	21%	4%	19%
Median	30	20	20	20
Mean	27.2	17.9	16.4	16.2
N	204	204	68	68

treatment End, subjects had the possibility to play the game in the same group for another five rounds.[17] Importantly, they had to vote again on communication before they played these additional five rounds. Therefore, it is possible to see whether subjects from less successful groups in Part II would revise their previous voting decision.

In the minimum effort game in Table 1 an equilibrium consists of all outcomes in which players select the same strategy. Adding costless pre-play communication to the stage game preserves its equilibria, but messages may serve as a selection device if all messages announce the play of the same strategy that constitute an equilibrium outcome of the stage game.[18]

Should subjects vote for communication? Notice first that the implementation cost is smaller than the difference in payoffs between two equilibria. Therefore, if a subject expects coordination on the same equilibrium with and without communication she has no incentive to vote for communication as payoffs in the game with communication are strictly lower. In contrast, if a subject expects that communication leads to a higher equilibrium than in the game without communication, she should vote for communication.

In any case, the voting decision of a subject may carry a signal about expected behavior in the coordination game. That is, voting for communication may signal an expectation that all will choose $e = 40$ because all other equilibrium outcomes in the subgame with communication yield a lower payoff than in the subgame without communication. Applying this reasoning further, voting against communication can signal an expectation that all will choose $e = 40$, too, as all other equilibria without communication result in lower payoffs than the most efficient equilibrium with communication (all choose $e = 40$).[19] However, the signaling value of the voting decision in the present setup is minimal because only the decision of the randomly selected subject is revealed. It is, however, likely that previous experience in Part I affects subjects' voting decision. For example, subjects with a history of coordination failure before the change in environment, might be more aware of the difficulty to coordinate on the efficient outcome. Thus, if they believe that communication can ease this difficulty and lead to a higher equilibrium, they are more likely to vote for communication than subjects who experienced better outcomes before the group formation.

4. Results

In total, 204 students participated in the experiment, which was run at the Technical University Berlin using the software toolkit z-Tree (Fischbacher, 2007). Students were recruited from various fields of study (economics, engineering, sciences) using ORSEE (Greiner, 2015). The earnings of subjects were publicly determined by randomly selecting four out of 10 rounds each from Part I and II and two additional rounds (out of five rounds) if there was a Part III (only treatment End). The experiment lasted about one hour and subjects were paid in private and they earned on average € 12.50 (including a show-up fee of € 3).[20]

4.1. Establishing different precedents

Part I of the experiment served to establish a variety of precedents among groups. Table 3 gives an overview of the distribution of the two outcomes of main interest: individual effort (hereafter "effort") and group-level outcome (or "minimum

[17] All subjects were recruited for 90-minute sessions, but session were typically finished well before this limit (in about 60 minutes). Subjects in these five sessions were told that there was time left to play for another five rounds. They learned about the details of Part III and were asked for their consent. It was made clear that Part III was the final part and that afterwards they would receive their earnings from all three parts. Given the duration of the two finished parts of the experiment and the remaining time, this announcement seemed credible and all subjects gave their consent.

[18] Communication in games of complete information and a common language has been analyzed theoretically by Farrell (1987, 1988), Rabin (1990); 1994), and Farrell and Rabin (1996). For a survey of the theoretical literature on cheap talk and early experimental studies, see Crawford (1998) as well as Blume and Ortmann (2007).

[19] For a theoretical literature on forward induction see e.g., Van Damme (1989) and for experimental evidence see e.g., Blume et al. (2016), Brandts and Holt (1992), Cachon and Camerer (1996), Cooper et al. (1993) Huck and Müller (2005) Van Huyck et al. (1993).

[20] Note that total earnings are multiple of five euro cents and that earnings were rounded to the nearest 50 cent increment. Subjects learned this only before they received their payment in private.

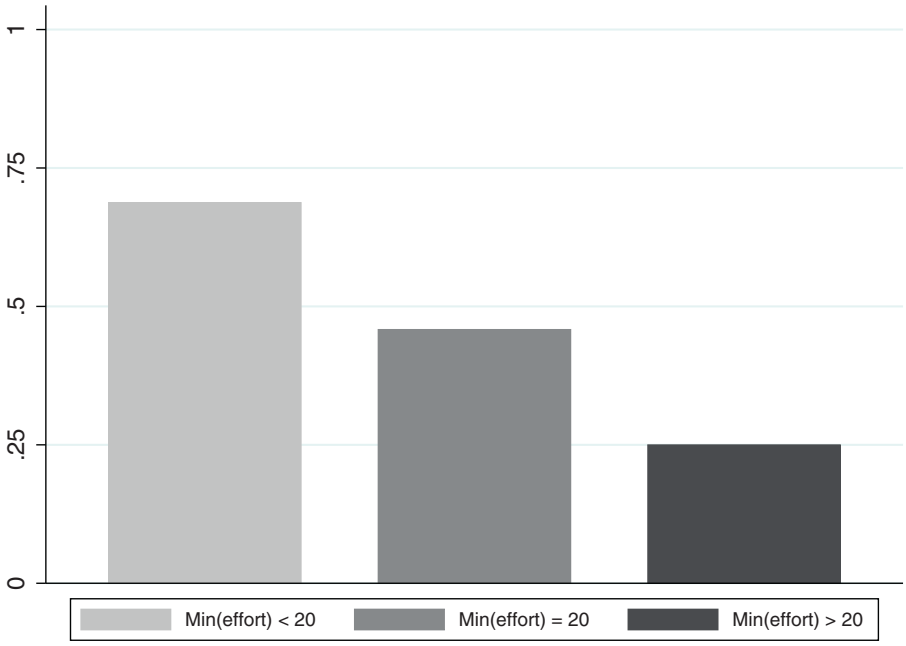

Fig. 1. Share of yes-votes and minimum effort in round 10.

effort"). The focus here is on these two outcomes in round one and round 10, respectively. Note that the data is pooled over all sessions, as the experimental conditions are the same in Part I.

As one can observe, the vast majority (86%) of effort choices in the first round were above 10. By round 10, however, there was a substantial shift to lower effort choices. For instance, the share of zero choices increased to 30%. The shift from higher effort in round one to lower effort in round 10 is statistically significant (Wilcoxon signed-rank test, $z = 4.811,\ p < 0.01$). While the minimum effort in the majority of groups (52%) was 20 in round one, in round 10 there was a shift toward a higher share of groups with a minimum effort of 0 (35%) and with a minimum effort of 40 (19%). Most of the dynamics occurred in the first rounds. Looking at the minimum effort in the last five rounds (6–10) reveals that in 56 out of 68 groups the minimum effort stayed the same. In round 10 about 88% of effort choices match the minimum effort in a group. Thus, as intended, there was a variety of minimum effort levels in the first part, which were mostly set early on.[21]

The following analysis focuses on the main treatment (End) where subjects had the option to implement a pre-play communication stage. Section 5 presents additional analyses to address possible concerns raised by the endogenous implementation of communication in treatment End.

4.2. Voting on communication

In treatment End, subjects were able to endogenously implement communication through a voting stage at the beginning of round 11. About 52% of subjects voted for communication. In particular subjects from lower-ranked groups (third and fourth), indicating a lower pre-change minimum effort, were significantly more likely to vote for communication than subjects from the two top-ranked groups ($\chi^2_{(1)} = 4.2,\ p = 0.04$). Looking at the relation of pre-change minimum effort and voting behavior in detail provides a more convincing picture about the relationship of experience and subjects' voting decisions (see also Fig. 1). Of the subjects in groups where the pre-change minimum effort was 20 – the median minimum effort in round 10 – only 46% voted for communication. Subjects in groups with a pre-change minimum-effort above the median voted for communication in only 25% of cases. That is in strong contrast to subjects in groups with a pre-change minimum effort below the median, who voted in 69% of cases for communication.

While these findings are only descriptive, there is some evidence suggesting that experience shapes voting behavior. A substantial share of subjects in treatment END chose an effort $e \geq 30$ in the first round (56%, see also Table 3 for aggregated behavior in all three treatments). Whether these *high-effort* subjects experienced high or low minimum-effort levels in Part I depended *only* on the first-round decision of the other two group members, which basically set the precedent for subsequent rounds. That is, a *high-effort* subject who was matched with at least one other subject who chose a first-round effort

[21] The variety of minimum effort levels in round 10 is also evident by looking at the ranking of groups within a session. The minimum effort of first-ranked groups in a session was on average 33 and for second-ranked groups it was 20. Third- and fourth-ranked group achieved on average a minimum effort of 9 and 2, respectively.

Table 4
Voting behavior in Round 11.

Dependent variable:	voting decision			
	(1)	(2)	(3)	(4)
Individual avg. effort in rounds 1–10	−0.015*** (0.004)	−0.011*** (0.003)	−0.011*** (0.003)	−0.009*** (0.003)
Expectations about others votes		0.671*** (0.099)	0.675*** (0.098)	0.693*** (0.095)
Round 10 minimum of others			0.003 (0.002)	
Effort in round 1* lower-ranked groups				0.004* (0.002)
Pseudo R^2	0.10	0.30	0.31	0.31
N	96	96	96	96

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Average marginal effects from probit regressions with robust standard errors clustered on pre-change group level. The dependent variable is a subject's voting decision, which equals one if a subject voted for communication. "Individual avg. effort in rounds 1–10" is the individual effort averaged over round 1 to 10. "Expectations about others votes" is the share of group members expected to vote for communication and ranges from 0–1. The variable "Round 10 minimum of others" is the minimum effort in round 10 of the new group members. "Effort in round 1 * lower-ranked groups" indicates first-round effort in groups ranked third or fourth.

$e \leq 10$ experienced coordination on low effort levels throughout Part I. In contrast, a *high-effort* subject who was matched with other *high-effort* subjects, $e \geq 30$, experienced coordination on high effort levels throughout Part I.[22] Focusing on these *high-effort* subjects reveals that only a small share (22%) voted for communication when they were placed in a successful group. In contrast, 75% of the *high-effort* subjects voted for communication when they were placed in an unsuccessful group. The difference is significant according to a Fisher's exact test ($p = 0.014$). This finding suggests that experience has a strong impact on subjects' voting decisions and, in particular, that bad experience induces subjects to enact a change by voting for communication.

While own groups' pre-change minimum effort proved to have an impact on the voting decision, other factors may have played a role, too. For example, the voting decision is likely to be affected by information on the past experience of new group members or by a subject's belief about other individuals' voting decisions.

To control for these factors and to check the robustness of individual experience prior to the change of group composition, Table 4 presents the results (average marginal effects) from probit regressions. The dependent variable in all four regressions is the voting decision of a subject in round 11 and standard errors are clustered at the pre-change group level to account for possible dependencies of individual behavior within groups in Part I. To capture individual experience in Part I more precisely, the regression in the first column includes only the subjects' own average effort in rounds 1–10.[23] The negative coefficient indicates that subjects with a higher average effort level in the first 10 rounds have a lower likelihood of voting for communication. A one-point increase in the average effort in Part I is associated with a 1.5-percentage-point drop in the likelihood of voting for communication. This supports the result above that a lower minimum effort in round 10 is associated with a higher likelihood of voting for communication.

The result from column (1) is robust to the inclusion of other controls (see columns 2–4). Beliefs about other group members' voting decision are positively correlated with a subject's voting decision, which suggests that subjects assume that most group members share their view on how to respond to the change in environment. This is despite the fact that subjects received information about the pre-change minimum effort of the new group members. The pre-change minimum effort of others (observed information) should, in principle, be as relevant for the voting decision as the history of the subjects' own group (experienced information). This is because both observed and experienced information are revealing signals about future behavior. Interestingly, though, this is not the case, as the coefficient estimate on the minimum effort of the new group members in round 10 is small and statistically insignificant (column 3).

This suggests that subjects neglected information about the previous behavior of new group members and thus put little weight on observed information.[24] Subjects who chose a lower effort in the first 10 rounds may have ignored this

[22] If a *high-effort* subject was matched with other *high-effort* subjects, the minimum effort in these groups in Part I was in 93% of cases high as well, i.e., the minimum effort was 30 or 40. In contrast, if a *high-effort* subject was matched with at least one subject who chose a first-round effort $e \leq 10$, the minimum effort was in 95% of cases 10 or 0. Note that the focus here is only on groups that started out with either a low (0 or 10) or a high minimum effort (30 or 40) as in other cases experience also depended on the behavior of *high-effort* subjects in later rounds (though the results are robust to including these subjects).

[23] Using the average minimum effort in Part I as independent variable yields qualitatively the same results.

[24] A possible concern here is that subjects neglect this information because of its asymmetry. More precisely, subjects naturally have complete information on their own group history (experienced information) whereas they observe only others' behavior in the last period (observed information) and thus may place little weight on this piece of information. However, the information before the voting stage focused subjects' attention on the minimum effort in round 10 in both their own group and the group they are combined with. Thereby the behavior in the last period before the group formation was particularly salient. Moreover, subjects do not neglect the information on others' behavior in general. The analysis in Section 5.1 shows that observed

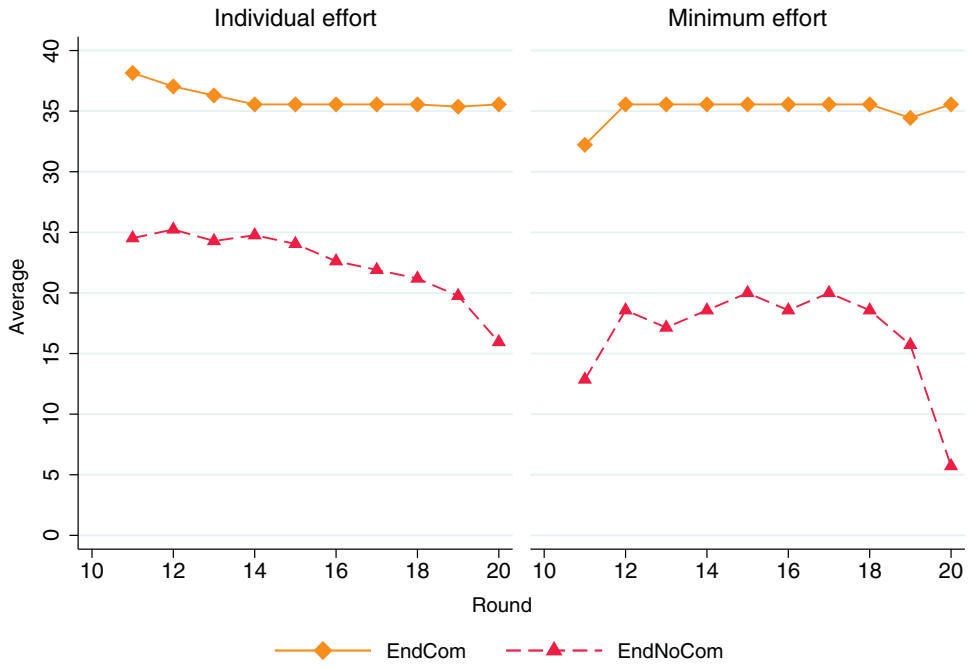

Fig. 2. Evolution of individual effort and minimum effort in end.

information because their own experience shaped their awareness of coordination failures, thus their vote for communication. Conversely, more successful subjects – those from groups with a higher minimum effort - lacked the experience of inefficient outcomes (or had only little experience with it) and thus may have never been aware of the difficulty of coordination on a more efficient outcome.[25] So, successful subjects not only seemed to underestimate conflict potential from interacting with other subjects who possessed a different level of experience; they also seemed to ignore information suggesting this potential.

The regression in the last column controls for initial effort choices. The previous analysis showed that some subjects chose a high effort in the first round (*high-effort subjects*) but ended up in a group experiencing coordination failure because of a low first-round effort of another subject. These subjects are potentially more aware of the difficulty of coordination on a high minimum effort and as a result are more willing to pay the small cost of communication to avoid coordination failure. The regression in column (4) provides additional evidence in favor of this observation. The variable "Effort in round 1 * lower-ranked groups" captures the first-round effort choice of all subjects in an unsuccessful group by round 10 (third or fourth ranked group in a session). The positive coefficient points to a higher likelihood of voting for communication for subjects with higher first-round effort in less successful groups. This is consistent with the previously presented evidence that *high-effort* subjects who experienced coordination failure in Part I are more likely to vote for communication than *high-effort* subjects who coordinated on high equilibria in Part I.

4.3. Coordination outcomes with choice of communication

The random-dictator decisions in treatment End led to the implementation of communication in nine groups (referred to as EndCom). The remaining seven groups had no communication available (referred to as EndNoCom). Fig. 2 displays how the average effort and minimum effort of groups evolves over time in groups with communication (EndCom) and without communication (EndNoCom). Table 5 shows summary statistics for effort, messages, minimum effort, and payoffs in Part II for all treatments as well as for groups with and without communication in treatment End.

It is apparent that in all 10 rounds, subjects in groups with the possibility to send a message $m_i \in \{0, 10, 20, 30, 40\}$ to all other group members chose higher individual effort, resulting in subsequently higher minimum effort than when this possibility was absent. The average effort was never below 35 throughout round 11 to 20 in EndCom, whereas the average effort steadily declined in EndNoCom from round 11 onwards (see Fig. 2). Comparing the average effort from round 11 to

information is positively associated with effort choices in round 11 when communication is not available (while observed and experienced information play no role if communication is available).

[25] A somewhat similar observation was made by Guarino et al. (2006), who studied a stochastic stag-hunt game where efficient coordination also depended on a chance move and where players could not observe the other players' choice and payoff. They found that subjects with good experience failed to realize that other subjects might have had a bad experience (due to bad luck).

Table 5
Summary statistics: Part II.

	Average					
Treatment	#Groups	Effort	Messages	Min(e)	Net pay	Coordination
End (communication endog.)	$N = 16$	30.1	37.5	27.0	254.4	0.81
Groups w/ communication (EndCom)	$N = 9$	36.0	37.5	35.1	280.8	0.95
Groups w/o communication (EndNoCom)	$N = 7$	22.4	–	16.6	220.4	0.63
Base (no communication exog.)	$N = 10$	19.4	–	13.4	210.1	0.62
ExCom (communication exog.)	$N = 8$	30.6	36.8	25.9	254.0	0.79

20 in EndCom (36) to EndNoCom (22), the hypothesis of equal effort can be rejected (Mann–Whitney test, $z = 2.719$, $p < 0.01$).[26] The differences in effort are, of course, reflected in the differences in minimum effort between EndCom and EndNoCom. In EndCom, one group always coordinated on the secure outcome whereas the other eight groups coordinated on the Pareto-efficient outcome in 96% of cases. On average, the minimum effort from round 11 to 20 was 35 when communication was possible. In contrast, when communication was not available groups coordinated in 60% of cases on a minimum effort of 20 or less and in only 20% of cases on the efficient outcome. The average minimum effort over all 10 rounds was 17 in EndNoCom. The hypothesis of equal minimum effort with and without communication can be rejected using a Mann–Whitney test ($z = 2.619$, $p < 0.01$). Notice that the coordination rate, i.e., the proportion of effort decisions coinciding with the minimum effort in a group, is substantially higher in EndCom (0.95) than in EndNoCom (0.63) (see last column in Table 5). The difference is statistically significant (Mann–Whitney test, $z = 2.830$, $p < 0.01$). Therefore, groups with communication not only achieved higher individual effort, but they are also more coordinated than groups without communication.

The higher individual and minimum effort in groups with communication resulted in substantially higher payoffs than in groups without communication. As evidenced in Table 5, the payoff in groups with communication was 301 and accounting for the implementation cost the net payoff was, on average, 281. In contrast, the average payoff in groups without communication was only 220. The hypothesis that the payoffs are the same in groups with and without communication can be rejected (Mann–Whitney test, $p < 0.075$).

As indicated by the average minimum effort in EndCom, communication was effective in helping to coordinate on the Pareto-efficient outcome in eight out of nine groups. An important prerequisite for this result is that subjects announce the efficient action (89% in round 11) and follow this announcement (90% in round 11). Two distinct patterns led to coordination on less efficient outcomes or made communication meaningless in later rounds. First, in round 11 a small share of subjects (9%) sent a message indicating a high effort, but instead chose a lower effort level.[27] Second, from round 12 onwards some subjects switched to announcing and playing the secure action in the group which always coordinated on the secure outcome. Section 5.1 provides more detailed results on the use of messages and how it relates to subjects' initial preferences for communication.

4.4. Revisiting the communication decision

After experiencing coordination failure in the newly-formed groups in Part II, one may expect that subjects reconsider their voting decision and try to implement communication if they are given a second chance. In order to investigate this conjecture, there was a third part in five randomly selected sessions in treatment End. These sessions involve six groups in EndCom and four groups in EndNoCom. Two groups in EndNoCom coordinated in 70% of cases on the Pareto-efficient equilibrium (the average minimum effort was 35.5), whereas five groups in EndCom always coordinated on the Pareto-efficient equilibrium. These seven groups were classified as successful. The remaining three groups (one in EndCom and two in EndNoCom) almost always coordinated on the secure equilibrium and are thus classified as unsuccessful. One would thus expect that subjects in the unsuccessful groups are more likely to vote for communication so as to reverse the coordination failure.

While every second subject in these groups (30 out of 60) voted for communication in the first voting decision in round 11, this number dropped to every fifth subject (12 out of 60 subjects) in round 21. This drop is statistically significant (McNemar's $\chi^2_{(1)} = 13.5$, $p < 0.01$) and from the viewpoint of successful groups not entirely surprising as they can be expected to continue coordinating on the Pareto-efficient outcome. Nevertheless, 17% of subjects (7 out of 42) from successful groups were willing to incur the cost of communication. Surprisingly, only 28% of subjects (5 out of 18) from unsuccessful groups were willing to implement communication. Subsequently, none of the three unsuccessful groups managed to implement

[26] In the following, all non-parametric tests use the average of the variable of interest in a group as an independent observation. Note that this is a very conservative test to detect treatment differences, because the data is pooled over all rounds and over all individuals in a group, yielding one observation for each group.

[27] Note that in the used minimum-effort game a player has a weak preference over others actions. That is, if a player, for example, intends to choose $e = 20$, he may send a message $m > 20$ to induce high efforts from all other players to secure the payoff for a minimum effort of 20. However, overstatements ($m_{it} > e_{it}$) need not be an intent, but can simply be a reaction to observing a low message in the group.

Table 6
Voting behavior in round 21.

Dependent variable:	Voting decision			
	(1)	(2)	(3)	(4)
Individual avg. effort in rounds 11–20	−0.003* (0.002)	−0.003 (0.002)	−0.003* (0.002)	−0.008 (0.018)
Difficulty of coordination		0.015 (0.052)		
Importance of communication			0.128*** (0.043)	0.161*** (0.058)
Pseudo R^2	0.02	0.02	0.25	0.23
N	60	60	60	18

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Average marginal effects from probit regressions with standard errors clustered at the group level. The dependent variable is a subject's voting decision, which equals one if a subject voted for communication. "Individual avg. effort in rounds 11–20" is the individual effort averaged over round 11–20. "Importance of communication" is a categorical variable ranging from 1 to 5 and indicates subjects' rating about the importance of communication. Analogously, "Difficulty of coordination" indicates subjects' perception of the difficulty of coordination. See footnote 28 for the two questions.

communication and they continued to coordinate on the secure equilibrium in all five rounds, whereas the other seven (successful) groups always coordinated on the Pareto-efficient equilibrium.

To shed more light on the voting decision in round 21, Table 6 presents the results of probit regressions with the voting decision in round 21 as a dependent variable. The first column shows that a higher average effort in rounds 11–20 lowers the likelihood of voting for communication. But the effect is very small and only marginally significant.

Recall that after round 20, but before subjects learned about the third part, they had to answer questions relating to communication, in particular they had to assess the difficulty of the coordination problem and to rate the importance of communication for coordination both on a five-point scale.[28] Subjects who rate the coordination problem as more difficult (higher rating) are more likely to vote for communication, though not significantly so (column 2). The voting decision is, however, related to how subjects rate the importance of communication. A one-point higher rating, meaning that communication is perceived as (more) important, is associated with a 13 percentage point higher likelihood of voting for communication. This relationship also holds when the sample is restricted to the unsuccessful groups only (column 4). It seems that the continued experience of coordination failure in Part II deteriorated subjects' view on communication as a device to facilitate coordination, so that subjects in unsuccessful groups were unwilling to incur the implementation cost in Part III.[29]

5. Robustness analysis

The previous results demonstrate that communication improves coordination substantially. However, the endogenous choice of communication raises some concerns. First, since subjects could choose their preferred institution (communication or no communication) a straightforward question is how subjects' decisions about communication affect messages and effort choices. Second, it is important to see how the option of implementing communication affects behavior in the coordination game and whether exogenously implemented communication also alleviates the coordination problem. Third, it is conceivable that the implementation procedure of communication conveys some informational content about expected play in the minimum-effort game. This section addresses these concerns by utilizing procedural details of the implementation of communication and with the help of two control treatments, in which the implementation of communication and no communication was exogenous.

5.1. The impact of the voting decision on effort

While the groups with communication achieved better coordination outcomes than the groups without communication, the previous analysis ignored how subjects' decisions about communication (voting) influenced their subsequent decisions in the coordination game. To investigate this question, the following analysis exploits the fact that all 16 groups in treatment End consisted of a mix of subjects who decided for and against communication.[30] It is thus possible to see whether subjects

[28] The two questions were the following: What do you think, how difficult is it to coordinate on the same effort level in your group? The scale was from 1 (easy) to 5 (difficult). What do you think, was the possibility to send messages to your co-subjects important? (Scale: 1 (not important) to 5 (important))

[29] This is similar to the findings of Kriss et al. (2016), where subjects could unilaterally decide on sending a costly pre-play message in each round of nine-person minimum-effort game. Messages were rare in the beginning, however, and later attempts to reverse the inefficient outcome by communication were infrequent despite the resulting coordination failure.

[30] While all groups in End consist of a mix of yes and no-voters, it is the case that groups in EndCom have on average a higher share of subjects who voted for communication (61%) than groups in EndNoCom (38%). Note that the average minimum effort in round 10 does not differ between groups in EndCom (15.6) and EndNoCom (16.4).

Table 7
Individual effort and messages in Round 11.

Dependent variable:	Individual message	Individual effort		
	EndCom (round 11)	End (round 11)	End (round 11–20)	No Com. (round 11)
Individual avg. effort in rounds 1–10	0.112	0.891***	0.920***	0.651***
	(0.121)	(0.120)	(0.149)	(0.136)
Round 10 minimum of others	−0.092	0.349***	0.453	0.354***
	(0.076)	(0.110)	(0.260)	(0.094)
Voting for communication (d)	5.816	0.166	−1.554	
	(4.292)	(3.469)	(2.757)	
EndNoCom (d)				−2.309
				(2.019)
EndCom (Communication) (d)		39.053***	39.860***	
		(6.038)	(13.248)	
EndCom * Individual avg. effort in rounds 1–10		-0.896***	−0.845***	
		(0.130)	(0.197)	
EndCom * Round 10 minimum of others		−0.297**	−0.364	
		(0.120)	(0.280)	
EndCom * Voting for communication (d)		1.207	1.005	
		(3.790)	(2.858)	
Constant	33.373***	−2.476	−6.323	5.514
	(4.688)	(5.382)	(11.146)	(4.499)
R^2	0.12	0.63	0.41	0.36
N	54	96	960	102

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
OLS regressions with robust standard errors clustered on pre-change group level (and on level of merged groups in column 3, respectively). Column (1) uses data from EndCom only, column (2) uses data from End, column (3) uses data from round 11–20 in End, and column (4) uses data from EndNoCom and Base. "Individual avg. effort in rounds 1–10" is the individual effort averaged over round 1 to 10 and "Round 10 minimum of others" is the information about the new group members before the voting stage. "Voting for communication" indicates a vote for communication in round 11 and "EndCom (Communication)" is a dummy variable indicating groups in which communication was implemented. (d) denotes a dummy variable.

who voted for communication send higher messages and choose different effort levels than subjects who voted against communication within the same institution. Table 7 shows regression results, which provide evidence for the impact of individuals' voting decision on game behavior. Notice that the focus is on round 11, because behavior in later rounds typically depends on the group performance in earlier rounds (as the results from Part I show, see Section 4.1).

The first regression in column (1) of Table 7 looks at groups with communication (EndCom) and examines how subjects' voting decisions relate to the sent messages in round 11. Although the fraction of messages $m < 40$ was higher for subjects who voted against communication (20%) than for subjects who voted for communication (6%), the coefficient for the voting decision is not statistically significant. Accordingly, subjects' initial preferences for communication have no bearing on the use of messages.

The second regression sheds light on the question of whether voting for communication leads to different effort decisions in round 11 (column 3 reports the results considering rounds 11 to 20). The first two coefficients describe the impact of individual experience and information on others' experience on individual effort in groups without communication (EndNoCom). They show that a higher effort in the rounds before the change as well as a higher pre-change minimum effort of new group members have a significantly positive impact on subjects' efforts in round 11 in EndNoCom. This suggests that observed information is just as relevant for effort decisions as experienced information. The third coefficient indicates that individual voting decisions in groups without communication have no significant effect on effort in round 11. In fact, the average effort in round 11 was 23.8 for subjects who voted for communication and 25 for subjects who voted against communication.

As expected, the dummy variable for EndCom indicates that effort in round 11 is higher with communication than without communication in EndNoCom. Looking at the interaction with the voting decision reveals that how subjects vote has no influence on effort in EndCom, either. Moreover, the coefficients for the interaction variables of pre-change effort and information on others' minimum effort in round 10 are negative and statistically significant. But since the magnitude of these two coefficients is of similar size and of opposite sign than in EndNoCom, the effect in EndCom is negligible (almost zero). The regression in column (3) basically confirms these results by extending the focus to all rounds in Part II (11–20).

These findings suggest that it is not so important to get into his preferred institution, but rather that the presence or absence of communication alone is the driving force behind behavior in round 11. It seems likely that once subjects are assigned to an institution (communication or no communication) they update their beliefs about the behavior of others. In EndNoCom, subjects adjust their behavior in response to their own behavior in round one to 10 and the information on others' minimum effort in round 10. That is, precedents are an important factor for round 11 behavior when communication

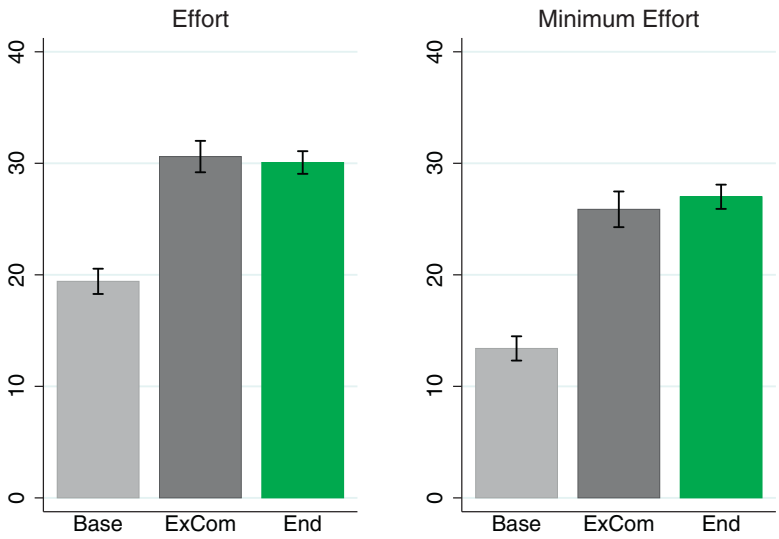

Fig. 3. Average individual effort and minimum effort in the 3 treatments..

is not possible. In EndCom, however, precedents play no role and both yes- and no-voters use messages in a similar way to facilitate coordination.

5.2. Two treatments with exogenous implementation of communication and no communication

This section introduces two control treatments, in which the decision about communication was exogenous to address possible concerns about the endogenous choice of communication such as selection. To be more precise, there was no communication in treatment Base and the only difference to groups in EndNoCom is that the absence of communication was exogenously imposed, whereas in EndNoCom the absence of communication was the decision of a randomly selected subject. In treatment ExCom, communication was imposed exogenously and groups had to communicate by sending a message $m_i \in \{0, 10, 20, 30, 40\}$ to all group members as in EndCom. All other details of the two control treatments were identical to treatment End, except that there was no implementation cost in ExCom as there was no choice involved in this treatment.

5.2.1. The value of the option to implement communication

Fig. 3 displays average individual effort and minimum effort in Part II in all three treatments. The figure highlights two important results. First, looking at the coordination outcomes of the two control treatments – Base and ExCom – reveals that higher effort with the possibility to send messages is not an artifact of the endogenous choice of communication in treatment End. As evidenced in Fig. 3, effort was substantially higher with exogenously imposed communication (ExCom) than without communication (Base). On average, effort was about 19 in Base and about 31 in ExCom. Subsequently, minimum effort is about twice as high in ExCom (26) than in Base (13). Second, it is apparent that the option of implementing communication (End) results in higher individual and minimum effort compared to Base as well. Moreover there is virtually no difference between exogenously implemented communication (ExCom) and the option to implement communication (End). However, there are underlying differences. While in ExCom the average minimum effort was low because some groups failed to utilize communication, it was low in End because some groups have chosen to not communicate.

Table 8 presents regression results that support these observations. The dependent variable in these regressions is one of three outcome variables of interest in rounds 11 to 20: effort, minimum effort and net payoffs. The independent variables include dummies for treatments ExCom and End, while Base serves as the benchmark. Note that treatment End contains groups with and without communication and thus the comparison with Base measures the causal effect of having the option to implement communication (intent-to-treat estimate). The regression also controls for time effects and includes the average of the pre-change minimum efforts of two combined groups ("Avg. pre-change minimum effort") to control for the different experiences prior to change of the group composition.

The regressions show three key results. First, the positive and significant coefficient estimate on ExCom indicates that exogenously imposed communication leads to higher individual effort, minimum effort and payoffs than when communication is not possible (Base). Second, individual and minimum effort as well as net payoffs are significantly higher in End than in Base, indicating that having the choice of communication leads to better outcomes. Third, there is no difference between ExCom and End for all three outcomes despite that all groups in ExCom but only about half of the groups in End could communicate.

The last result suggests that communication is more effective when subjects can choose communication than when it is exogenously imposed. Indeed, as Table 5 shows, individual effort is higher in groups with endogenously implemented

Table 8
Treatment effects.

Dependent variable:	Individual effort (1)	Minimum effort (2)	Net Payoff (3)
End (d)	11.644**	14.652***	47.802**
	(4.374)	(5.140)	(19.150)
ExCom (d)	12.923**	14.324**	50.073*
	(5.180)	(6.400)	(25.558)
Round	−0.812***	0.141	5.186***
	(0.265)	(0.249)	(1.376)
Avg. pre-change	0.479*	0.510*	1.713
minimum effort	(0.247)	(0.287)	(1.026)
Constant	23.386***	2.037	98.890***
	(5.041)	(6.438)	(32.062)
R^2	0.18	0.19	0.14
N	2040	340	2040

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
OLS regressions with standard errors clustered at the group level. "ExCom" is a dummy variable for treatment ExCom and "End" is a dummy variable for treatment End and includes groups with and without communication. "Round" indicates a linear time trend. The variable "Avg. pre-change minimum effort" is a lagged variable for the average minimum effort of the two combined groups in round 10. Net payoff is payoff minus cost for communication. (d) denotes a dummy variable.

communication (EndCom, 36.0) than in groups with exogenously implemented communication (ExCom, 30.6). The lower effort in ExCom also translates into a lower minimum effort. Two groups always coordinated on the secure outcome and another three groups coordinated on effort levels below 40 in at least some rounds. Subsequently, the average minimum effort in ExCom was about 26 compared to 35 in EndCom. Accordingly, the differences for both the minimum effort (Mann–Whitney test $z = 2.472$, $p < 0.01$) and effort (Mann–Whitney test $z = 2.465$, $p < 0.01$) are statistically significant. This is consistent with a democracy premium, i.e., that a democratically instated institution lead, for example, to more cooperation than the same, but exogenously imposed institution (see e.g., Dal Bo et al., 2010; Sutter et al., 2010; Markussen et al., 2014).[31]

An obvious explanation for the observed differences in groups with endogenously and exogenously implemented communication is a different use of messages. A crucial factor for successful communication is the mapping of messages into actions and, in particular, whether subjects announce and play the same action. There are pronounced differences between the two treatments. About 89% announced an effort choice $e = 40$ in EndCom, whereas 77% intended to choose $e = 40$ in ExCom. The fraction of subjects who followed their messages was also higher in EndCom than in ExCom. About 80% of subjects in EndCom played their announced effort in round 11 and overall rounds the fraction was 93%. This is independent of subjects' preferences for communication. That is, subjects who voted for communication are not more likely to follow their announcements than subjects who voted against communication (Fisher' exact test, $\chi_1^2 = 1.82$, $p = 0.18$ in round 11 and $\chi_1^2 = 1.69$, $p = 0.19$ for all rounds). In contrast, in ExCom only 69 (77) percent of subjects followed their announcement in round 11 (over all rounds).[32]

Interestingly, while in EndCom all subjects who sent a message $m < 40$ increased their effort to $e = 40$ in round 11, only 27% of subjects in ExCom increased their effort to $e = 40$ after sending a message $m < 40$. Moreover, subjects who sent a message $m = 40$ less likely decreased their effort in round 11 in EndCom (10%) than in ExCom (19%). Therefore, the likelihood that a subject chose $e = 40$ is higher in EndCom than in ExCom (t-test, $t = 3.1124$, $p < 0.01$). Thus, subjects tend to be more inclined to stick to their announcements and are more likely to choose $e = 40$ if they see a message $m < 40$ when communication was endogenously implemented. Importantly, this does not depend on subjects' initial preferences for communication.

Taken together, these results document that communication facilitates coordination in situations where groups with different coordination histories have to coordinate their activities together, i.e., when they lack some shared experience. Importantly, this is irrespective of whether communication is imposed exogenously or whether communication is optional.

5.2.2. *Information and signaling*

As previously noted, it is possible that the voting procedure conveys a signal about which equilibrium strategy to play. For example, while the decision against communication can be perceived as a signal to coordinate on the Pareto-efficient

[31] A possible concern is that the random implementation of communication in EndCom is biased, and thus that groups disproportionately consist of yes-voters. However, as the previous analysis has shown a subject's voting decision had no effect on effort choices in round 11 (and also not on choices in rounds 11–20, see Section 5.1). Therefore, it is unlikely that higher effort in EndCom is due to selection of subjects into groups with communication.

[32] The difference in following one's message can, in part, be explained by the higher share of groups which coordinated on the secure outcome in ExCom. Subjects in these two groups continued to send messages $m = 40$ in 72% of the cases. In contrast, in the single group in EndCom which coordinated always on the secure outcome only 43% of messages indicate an effort $e = 40$ and 48% indicate the secure effort $e = 0$ as it was played in each round.

equilibrium, it can also be interpreted as a signal for coordination on a lower or the secure equilibrium.[33] If such signaling plays a role, then one should observe that effort in EndNoCom is different from effort in Base where such a signal is ruled out by design. Again, the focus is primarily on round 11 in order to not confound the signaling effect with feedback about previous play.

Column (4) of Table 7 presents the results from comparing round-11 behavior in EndNoCom and Base.[34] The results show that a higher effort in round 11 is associated with a higher effort in Part I as well as a higher pre-change minimum effort of the new members, but not with a decision against communication. The latter is indicated by the insignificant dummy variable for EndNoCom.

Further evidence is presented in Table 5, which shows summary statistics for behavior in all rounds after the change in group composition. Across rounds 11 to 20 the average minimum effort in Base was 13, compared to 17 in EndNoCom. Only three out of 10 groups in Base managed to consistently coordinate on either 30 or 40, all other groups predominantly coordinated on the secure outcome. Accordingly, the difference in minimum effort between groups that selected to have no communication and groups that had no choice is not statistically significant (Mann–Whitney test, $z = 0.098$, $p > 0.92$). Similarly, the average effort in round 11 to 20 (19) is not statistically different from an average effort (22) in EndNoCom (Mann–Whitney test $z = 0.195$, $p > 0.84$). In summary, it is unlikely that the implementation procedure conveys some meaningful information about which effort to choose.

6. Conclusion

This experiment investigated how groups deal with conflicts that arise from combining two groups with different experiences. The results demonstrate that while communication could ease these conflicts, a substantial fraction of subjects decided against communication, even though the implementation cost was low. This suggests that these subjects did not realize that the different pre-change experiences can cause conflicts in the newly formed group and that a larger group size increases strategic uncertainty. Subsequently, groups without communication typically found themselves in less inefficient equilibria, while almost all groups with communication coordinated on the highest effort level.

The inefficient coordination of groups without communication raises the question whether subjects in these groups would revise their initial decision about communication. The results from Part III indicate that this was not the case and that the unwillingness to revise their voting decision was related to subjects' perception that communication is unessential for coordination. If subjects decided against communication because they did not believe in its benefits, information regarding the benefits of communication could present a valuable remedy for the unwillingness to implement communication. While the current setup does not provide direct evidence of such an information intervention, it illustrates that observing behavior of others is not necessarily helpful. In fact, subjects placed more weight on information they experienced themselves than on information they observed in others when deciding about communication. This is consistent with findings that subject neglect information about others' past experience in a minimum-effort game (Simonsohn et al., 2008).

The kind of experience subjects had prior to the change was critical for the decision on communication. Initially successfully coordinated subjects most likely decided against communication, suggesting that they were unaware of the higher strategic uncertainty in the larger group. They ignored information about others' past experience and seemed to project their view of the coordination task onto other subjects, mistakenly believing that coordination was easy to achieve. In contrast, subjects with bad experience in Part I were more likely to decide for communication. While they ignored observed information too, their own experience may have contributed to an awareness that the coordination is difficult and that communication may be useful.

The results also indicate that communication in large groups is not always successful as evidenced by a few groups which never managed to coordinate efficiently despite the ability to communicate. This could be due to the higher potential for miscommunication in large groups and because the communication stage itself is characterized by strategic uncertainty in the setup of this experiment. This is in line with Feltovich and Grossman (2015), who provide some evidence that communication becomes less effective with increasing group size. If subjects are aware of such a loss in effectiveness, it may dampen the impact of experience on the decision to implement communication in larger groups as communication is not worth its cost.[35]

Notwithstanding these obstacles of communication, the results clearly illustrate that communication in the form of signaling intentions is in most cases sufficient to reduce strategic uncertainty and that learning from failure plays a critical role for implementing communication. Although caution is warranted when extrapolating results from the laboratory to the field, the examples below illustrate that the failure to implement communication and, in particular, the importance of experience for realizing the benefits of communication for coordination have some relevance in the real world.

[33] Blume et al. (2016), for example, demonstrate that foregoing costly communication in a two-player stag-hunt game can indeed facilitate coordination on the Pareto-efficient equilibrium. Arguably, their two-player game is more conducive for such an effect than larger n-player games. Indeed, there is no evidence for such reasoning in the six-player groups and the random-dictator decision used in this study.

[34] Recall that the previous analysis in Section 5.1 revealed that effort choices do not differ between no-voters and yes-voters in EndNoCom as well, suggesting that selection into groups without communication is unlikely.

[35] Similarly, the impact of experience may be less pronounced under other implementation rules for communication. For example, experience may get less decision weight if a rule gives, for example, room for strategic considerations.

The failure to implement communication is akin to what Heath and Staudenmayer (2000) termed "coordination neglect", a tendency to underestimate the difficulty of coordination. If organizations underestimate coordination problems, they may, for example, not realize how important effective communication between different work teams or departments is. This is particularly the case when shared experience within groups hinder communication across groups and may explain why Airbus failed to use the same construction software across facilities in the development process of the Airbus A380 and why firms often fail to turn innovative projects into profitable products (e.g., Christensen, 1997).[36] A particular severe case of a coordination failure due to the use of incompatible communication was the shot down of two U.S. Army Blackhawk helicopters by the U.S. Airforce over the Iraq no-flight zone in 1994. One reason for this incident was that specific keywords were not understood in the same way by all involved units, i.e., they lacked shared experience. For example, for the Airforce the word "aircraft" included helicopters, while this was not the case for the Army. Therefore the Airforce pilots expected to see no U.S. helicopters in the no-flight zone, whereas the Army thought they were allowed to fly in the zone (Snook, 2000). This example also stresses the importance of learning from failure for coordination success. While successful experience before the incidence may have obscured the incompatibility of codes, the incident (and thus failure) induced a change of codes and routines.

The prevalence of task differentiation in organizations and firms suggests that "coordination neglect" is a common problem in organizations, as differentiated tasks have to be reintegrated in a coordinated fashion and the integration process is prone to conflicts due to frictions, such as different routines, experience or culture. Even if these problems are small scale or require only low-cost interventions, they can accumulate to more serious failures if they are not addressed (see e.g., Lawrence and Lorsch, 1967; Heath and Staudenmayer, 2000; Knez and Simester, 2001; Staats et al., 2012). While awareness for low-cost interventions that ease coordination problems seem to be key for organization success, the results of this study demonstrate that subjects often lack such awareness, which can have substantial negative implications. This is particularly the case when they did not experience failure. Thus the study provides valuable insights for avoiding coordination failure based on an inadequate understanding of the coordination problem.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.euroecorev.2017.01.006.

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[36] Illustrative examples are Xerox's failure to introduce the first personal computer (Smith and Alexander, 1988) or Nokia's failure to capitalize on smart phone or tablet prototypes long before Apple launched its iPhone or iPad ("Nokia's Bad Call on Smartphones," *Wall Street Journal*, www.wsj.com/articles/SB10001424052702304388004577531002591315494).

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