Short Note

Speech Is Silver, Silence Is Golden

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Abstract: This paper experimentally investigates free-riding behavior on communication cost in a coordination game and finds strong indications of such free-riding. Firstly, the subjects wait for others to send a message when communication is costly, which does not happen when communication is costless. Secondly, the proportion of games where no communication or one-way communication takes place is much higher when communication is costly compared to when it is free.

Keywords: free-riding; communication; coordination

1. Introduction

Cheap-talk experiments suggest that communication is effective in achieving coordination in many situations (see Cooper *et al.* [1,2] and Blume and Ortmann, [3] for an overview). However, the bulk of this literature has dealt with games where the choice of communication has been exogenous and costless. From a real world perspective such choices can be challenged on several grounds. For example, it is not hard to argue that communication is usually endogenously and individually chosen. Moreover, in many situations communication is associated with a cost (e.g., the cost of a phone call or advertising costs). In a symmetric coordination game without a focal point all players would be willing to use a communication device to solve the coordination problem, if it is costless. If, on the other hand, the communication device is costly to use then a player would prefer that another player uses the communication device to solve the coordination issue. Of course, a player would be

willing to communicate if the gains from coordination outweigh the communication cost, but she would strictly prefer to remain silent herself and to let another player communicate. With a slight abuse of terminology one might call this free-riding on communication cost.[1]

We investigate this by way of economic experiments and find strong evidence of such free-riding attempts. To the best of our knowledge we are the first to document this type of behaviour. More specifically, we conduct a coordination game experiment without tacit coordination cues. A communication window is open pre-play where subjects can, at any time, choose to send a message (potentially at a cost) to solve the coordination issue. We observe considerable attempts to free-ride on the communication cost, by waiting for the opponent to send a message, but only when communication is costly. As a consequence, this leads to subsequent failure to coordinate in the underlying game.

Devetag and Ortmann [4] survey the literature of the effects of communication on coordination and conclude that communication is effective in achieving coordination. However and as noted above, this literature is concerned with costless communication, where all rational players have incentives to communicate to solve the coordination problem. When communication is costly and avoidable then a communication device will not solve the coordination issue as easily since the communication stage is itself a coordination game where a player prefers that the opponent sends a costly message to solve the coordination problem. Such a communication setup may lead to coordination failure in the same spirit as in a game of "Chicken" or "Hawk and Dove" game.

In a recent paper Kriss *et al.* [5] investigate the effect of endogenous costly communication on efficient coordination in the minimum-effort game. Like us they find that a cost of communication decreases use of the communication device and decreases (efficient) coordination.[2] Unlike in our setup the minimum-effort game contains tacit coordination cues, so the decrease in communication in their setup can come from both a free-riding effect and that subjects find some strategy profile salient and therefore deem the communication device unnecessary. Interestingly, in a post-experimental questionnaire they find responses supporting both explanations. We take this as further support of the existence of free-riding on communication.

It should be noted that what we observe is not just an instance of the well documented free-riding behavior in public goods games (see e.g., Isaac *et al.* [6] and Isaac and Walker, [7]). The reason is that our game is not a public good game which means that it is not straightforward to make analogies to this literature. Secondly, the two incentive structures are quite different. In most cases it is a dominant strategy to free-ride in a public goods game, but in the coordination game it is only an equilibrium to free-ride if the opponent communicates (and solves the coordination problem).

In light of the earlier literature we claim that our results contribute to the research of communication in games. The rest of the paper is organized as follows. Section 2 describes the game and the experimental procedures. Section 3 contains the results and section 4 concludes the paper.

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[1]   Free-riding often refers to public goods situations where it is optimal to not provide the public good. In this paper we use the term in the sense of not taking a costly action (*i.e.*, to communicate) that is beneficial for others while taking advantage of others' sacrificing actions.

[2]   They use a simultaneous one-shot communication device in each period whereas our setup is more akin to a dynamic communication device. This design difference makes is harder for them to directly study the intention to free-ride on the communication cost.

2. The Game and the Experiment

The underlying game is a market entry game that combines aspects of coordination and conflict of interest.[3] Two players, $i = 1,2$, choose one of four alternatives: enter market X or Y, both markets (B) or do not enter either market (N). Figure 1 gives the normal form representation of this game.

Figure 1. The coordination game in the experiment.

	N	X	Y	B
N	12, 12	12, 24	12, 24	12, 36
X	24, 12	8, 8	24, 24	8, 20
Y	24, 12	24, 24	8, 8	8, 20
B	36, 12	20, 8	20, 8	4, 4

The set of pure strategy Nash equilibria consists of the diagonal elements starting at the bottom left corner.[4] Apart from the market sharing strategy pairs (X,Y) and (Y,X) this set also includes the market domination strategy pairs (B,N) and (N,B). In the experiment, however, we rarely observed the latter type of equilibria outcomes in either the communication stage or the action stage.[5] One reason for this might be that they seemed unfair or that players did not think that they could credibly implement them. Therefore, we abstract from these in the following discussion.

In the experiment the cost of communication was varied, so that communication was either costless ($c = 0$) or costly ($c = 3$ or $c = 5$).[6] The cost was set to be substantial, but low enough to give players an incentive to use the communication opportunity. Indeed, in the absence of communication the most plausible outcome is the mixed Nash equilibrium wherein both players earn 12. Hence coordination by communication would be profitable under both $c = 3$ and $c = 5$.

Both players were informed that they could send messages, for 90 s, to the other player through a "chat" function before they made their strategy choices in the game.[7] In treatments with $c > 0$,

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[3] We use data from an experiment described and motivated in detail in Andersson and Holm [8]. That paper is focussed on the resulting equilibria, welfare effects and the type of communication with a specific emphasis on market entry situations. It does not discuss the general phenomenon of free-riding in the communication stage.

[4] Let the probabilities of choosing strategies N, X, Y, B for a player be given by (p_N, p_X, p_Y, 1- p_N- p_X-p_Y). Then the symmetric mixed Nash equilibria are given by $\left(\left(1/4-a,a,a,3/4-a\right),\left(1/4-a,a,a,3/4-a\right)\right)$ for each $0 \leq a \leq 1/4$. More importantly, all of these equilibria give rise to the same payoff of 12 for both players. In Andersson and Holm [8] we investigate both a symmetric game and an asymmetric game. To avoid the complications with tacit coordination in the asymmetric game we concentrate on the symmetric variant where the only way to coordinate is through communication.

[5] The proportion of the (B,N) and (N,B) outcomes varied between 0 and 6 percentages of the coordinated outcomes. See Table 3 in Andersson and Holm [8].

[6] The difference in communication cost ($c = 3$ and $c = 5$) was motivated by the desire to study effects of variation in communication cost in Andersson and Holm [8]. We will not stress this treatment difference in the present paper since there were no substantial differences in free-riding between these treatments.

[7] Instructions are available in Appendix A.

the cost of communication was incurred by a player as soon as she sent her first message in the corresponding round.

When $c = 0$ a player is indifferent to whether she, her opponent, or both solve the coordination problem by sending a message. To the contrary, with $c > 0$ a player would prefer to free-ride and let the opponent solve it.[8] This game is hard to analyze theoretically in a stringent way since the communication stage is endogenous and dynamic. To get some understanding of the strategic aspects of the communication stage we note that when $c > 0$ it is optimal to remain silent until the very last seconds of the communication window. Once the players are at this stage the choice to send a message can be considered to be simultaneous and one may think of it as a normal form game where the choice is to communicate or not. Using this reduction we note that without communication the most likely outcome in the coordination game is the mixed Nash equilibrium payoff of 12. Furthermore, if any player communicates it is reasonable to expect the payoff of the equal split equilibria, *i.e.*, (X, Y) or (Y, X), that is 24 minus communication cost for the communicating player. Figure 2 shows this reduced game.

Figure 2. Reduced communication game.

	Communication	No communication
Communication	$24-c$, $24-c$	$24-c$, 24
No communication	24, $24-c$	12, 12

For positive communication costs c such that $0 < c < 12$ no strategy is dominant and there is no equilibrium in pure strategies attainable without coordination. In the symmetric mixed equilibrium of this simultaneous game "No communication" is played with a positive probability, which is increasing in c. Thus, the incentive to free-ride by choosing "No communication" is stronger when the communication cost is positive. The reduced game can be perceived as a variant of the "Chicken" game or the "Hawk and Dove" game.[9] Clearly in the case of zero communication cost the choice to communicate is a dominant strategy and hence we should expect no coordination failure. And even though it is hard to pin down exactly when players will communicate in this situation one might suspect that the distribution of communication times is less skewed towards the very last seconds of the communication window.

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[8] Clearly, with $c > 0$, the game allows for many equilibria, but these do not necessarily imply free-riding. For instance, in the following equilibrium profile both players bear the same communication cost: I.) The Row player sends the initial message that they should play (X,Y) and then plays X if he gets a confirmation from the Column player that she will play Y. If Row does not get this confirmation, he plays a mixed strategy consistent with Nash-equilibrium. II) The Column player initiates communication, but if she receives the suggestion to play "(X,Y)" she sends a confirming message and acts according to the message. If she does not get this message, she will play a mixed Nash-equilibrium. Still, even if this profile shows that some equilibrium behaviour excludes free-riding in communication, there may be an incentive to free-ride since many probably consider the confirmation message to be redundant.

[9] This game differs slightly from the typical Chicken and Hawk Dove games, where it is normally assumed that it is somewhat better to communicate when the other player also does so, compared to communicate when the other player does not.

All subjects took part in one session only. Each such session consisted of three subsessions. In each subsession, ten rounds of each game were played where subjects were re-matched with a new co-player (*i.e.*, a strangers' matching protocol was used).[10] Subjects were informed about the outcome after each round. In total the experiment consisted of three sessions (with 18–24 subjects) and three treatments in each. A session took between 75 and 90 min. Subjects were recruited from introductory and intermediate Economics courses at the School of Economics and Management, Lund University. The subjects' total average earning was SEK373 (about USD57 when experiments were conducted). Table 1 presents the sessions relevant for this paper.[11]

Table 1. Treatment Design.

Session	Treatment	Treatment	Treatment
(# subjects)	(subsession code)	(subsession code)	(subsession code)
3(18)	No comm. (SS31)	$c = 0$ (SS32)	$c = 5$ (SS33)
4(24)	$c = 0$ (SS41)	$c = 3$ (SS42)	No communication (SS43)
5(20)	$c = 3$ (SS51)	$c = 0$ (SS52)	No communication (SS53)

Note: Subsession code SSnm denotes session n and subsession m.

3. Results

It is reasonable to interpret hesitation in sending the first message as a sign of intent to free-ride on communication cost. We measure this by the time from which communication was possible until a player in a pair sent the first message.[12] In line with the theoretical discussion in Section 2, one should expect the average time of the first message to be shorter when communication is costless compared to the case when communication is costly.
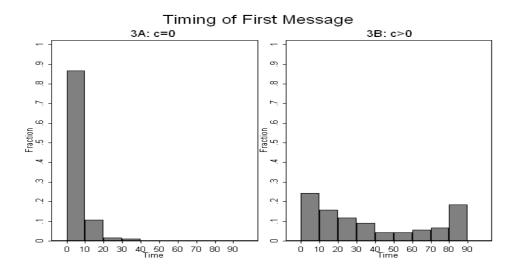
As a first crude evidence of this free-riding effect Figure 3 shows the distributions of times to the first message in a pair. There is a clear difference in the distribution of time to the first message between costly and costless communication. With costless communication the distribution is unimodal with a peak in the very beginning of the communication window and half-way through the communication window all pairs have communicated. To the contrary, with costly communication the distribution is u-shaped and much more spread out over the entire communication window.

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[10] With subsequent subsessions it is justified to worry about potential order effects. However, there is no clear evidence of order effects for the sessions analyzed in this paper. The reader is referred to section 5.4 in Andersson and Holm [8], where this issue is thoroughly discussed.

[11] It should be noted that the original design consisted of several other sessions and that the original experiment was not primarily designed to study free-riding of communication.

[12] Other issues relating to the timing in communication have received some interest. This is the case for the so called "deadline" effect (see e.g., Roth *et al.* [9], and Roth [10]).

Figure 3. Distributions (in seconds) of the times to the first message. (**3A**) uses data from zero cost treatments; (**3B**) uses data from treatments with strictly positive communication cost.

We have pooled data from treatments with $c = 3$ and $c = 5$ in Figure 3. However, not much variation in the data is masked by such pooling.[13] We now turn to analyzing the data of message timing. To save space we let SSnm denote session n and subsession m (see subsession code in Table 1). In Table 2 we present averages from each subsession. The largest differences are observed between treatments with zero communication cost and those with positive communication cost. In situations with costless communication the timing of the first message is on average in the interval of $1-7$ s whereas the corresponding number for costly communication treatments is 34–42 s.

Table 2. Summary of message data.

		Message time in seconds		Communication structure in percent		
SS	Cost	Mean	Std. Dev	No	One-way	Two-way
32	0	5	5	0	1	99
33	5	42	35	4	57	39
41	0	2	3	0	0	100
42	3	37	31	4	56	40
51	3	34	26	1	52	47
52	0	7	7	0	2	98

Using the fact that the first period message timing data of SS41 and SS51 are independent observations we can perform a valid statistical test of the hypothesis that the incentive to free-ride on communication is stronger when the cost of communication is positive. Indeed a

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[13] When comparing $c = 3$ and $c = 5$ a Wilcoxon-Mann-Whitney test shows a weak difference between SS33 and SS42 ($n = 21$, $p = 0.0632$) but not between SS33 and SS51 ($n = 19$, $p = 0.2828$) when only considering period 1 choices. For choices at period 10 there is no difference ($p = 0.1764$ and $p = 0.6823$ respectively). When it comes to the difference in proportions of one-way communication between $c = 3$ and $c = 5$ in period 1 a proportions test reveals no difference ($p = 0.2320$ and $p = 0.4302$ for the above comparisons). For period 10 the corresponding proportions test p-values are ($p = 0.6426$ and $p = 0.1719$).

Wilcoxon-Mann-Whitney test strongly rejects the hypothesis that communication-initiation times comes from the same distribution ($n = 22$, $p= 0.002$). With the cautionary note that the observations are not independent we also report the p-values at the very last period in the same subsessions. In both cases we can strongly reject that they come from the same distribution ($p = 0.0001$).

A second indication of free-riding is the fraction of communication rounds that is one-way.[14] In the game it is possible for the player who sends the first message to achieve coordination without any response from the other player, who may then free-ride. The latter player may of course want to send a message to the former player to reassure her that they have an agreement.[15] However, since this is costly in the treatments with communication cost, we should expect a higher proportion of one-way communication in treatments with costly communication compared to those with costless communication. As the second column from the right of Table 2 shows, the results strongly support this conjecture. When communication is costly one-way communication is potentially more efficient than two-way communication and hence an increase in communication cost might be welfare improving if it leads to a sufficient increase in the proportion of one-way communication.[16] Table 3 presents average per period profits.

Table 3. Average profit.

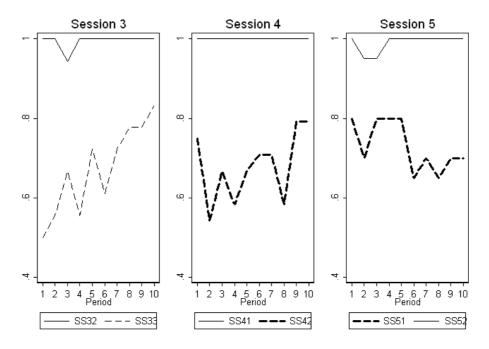| Subsession	SS31	SS32	SS33	SS41	SS42	SS43	SS51	SS52	SS53
Cost	NC	0	5	0	3	NC	3	0	NC
Profit	11.4	23.4	18.4	23.6	19.5	13.2	20	21.5	12.3

As can be seen from Table 3 profits are decreasing in the communication cost, implying that the increase in one-way communication does not fully mitigate the increase in communication cost. The most relevant treatments to compare in this respect are $c = 3$ (SS42 and SS51) and $c = 5$ (SS33). Here, the average payoffs are higher when the communication cost is lower (*i.e.*, $c = 3$), which suggests that the potential gain of the increase in one-way communication when $c = 5$ is dominated by the cost of communication and coordination failures. In addition, as can be seen in Figure 4 the fraction of subjects choosing to communicate is in general not decreasing over time so this phenomenon is not likely to disappear. From Table 3 it can also be noted that in subsessions without communication (*i.e.*, SS31 and SS52) the average profit is close to the mixed Nash equilibrium profit of 12.

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[14] Since it is also efficient that only one subject sends a message when it is costly one can argue that this is "coordination" on the efficient outcome rather than free-riding. However, this coordination also implies voluntary or involuntary free-riding since it is essential that at least one take the communication cost. Thus, even if this indication not only involves free-riding, we argue that there is an element of it to motivate us using the concept.

[15] As noted by Crawford [11], reassurance may have a strong effect on coordination success.

[16] For a more elaborate account of the welfare effects of communication, see Andersson and Holm [8].

Figure 4. By period fraction of subjects communicating. Solid lines show *c* = 0, thick dashed lines *c* = 3 and thin dashed lines *c* = 5.

It can finally be noted that at least some subjects understand and explicitly express the intent to free-ride in their messages. Admittedly, this is not any hard evidence of free riding. However, the following dialogue nicely illustrates that while some subjects understand the free-riding opportunities, this may not be the case for all subjects:

Player 1: "I can pick X or Y"
Player 2: "you take X then I will take Y"
Player 1: "ok"
Player 2: "well done, you got me to write as well… nice work! :P"

4. Conclusions

This paper finds robust evidence of free-riding on communication cost. It is important to take this tendency into consideration when designing institutions and contracts where there are costs associated with communication since free-riding motives may obstruct efficient coordination even if the communication costs are small relative to the communication gains. It should be noted that whereas the mere direct (technical) cost of communication today is often negligible, the indirect expected cost can be substantial. For instance, a firm that wants to collude with its competitors takes the risk that the initiation of such communication can be used against it in a future trial. The policy implication here is that making the intent to collude illegal and subject to penalties may effectively prevent such coordination, not only for reasons of deterrence but also because of the free-riding mechanism.[17]

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[17] Of course one should always be careful when extrapolating results to the policy domain. The effect of costly communication has been shown in the different context of infinitely repeated Bertrand games, to facilitate collusion (Andersson and Wengström [12]).

In a recent survey of the literature on coordination failure, Devetag and Ortmann [4] maintain that communication can be seen as a successful solution to coordination failure. They also conclude that since communication is often observed in real life, coordination failure should be seen as an exception rather than a rule both inside and outside the lab. Although we agree with this conclusion our results suggest that the exception might be more prevalent than we first thought.

Acknowledgments

Conflicts of Interest

The authors declare no conflicts of interest.

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Appendix

A. Experimental instructions

This is a translation of the instructions given to the subjects in the experiment. Our comments are given in *italics*.

B. General Information

You are going to participate in an economic experiment. You will receive SEK 100 for your participation and you can earn additional money based on the choices you make during the experiment. The amount you earn depends on your and your co-players' choices. In this experiment you will earn experimental "daler", which will be converted to Swedish crowns when the experiment is finished according to the exchange rate 1 daler = SEK 0.45. We ask you to be silent during the experiment. If you have any questions please raise your hand so that the experimenters can come to you to answer your questions.

You can make your choices by clicking on your computer screen. It is important that you understand the structure of the game, you are therefore asked to carefully read through the instructions to make sure that you fully understand them before the experiment starts.

You will be asked to make choices in three different strategic situations. Each strategic situation will be repeated 10 times.

C. Strategic Situation

The choice you are about to make concerns entry into two markets. This situation will be repeated 10 times. In each round you will be paired with a new co-player. You will not receive any information about who you have been matched with.

You are asked to choose one out of four possible strategies in this situation:

- Stay out
- Only enter market x
- Only enter market y
- Enter both markets

Below you will find information on the amount you can earn from each possible strategy (the amount earned by your co-player is given in parenthesis):

The co-player:	stay out	enters x	enters y	enters both
Your strategy:				
stay out	12 (12)	12 (24)	12 (24)	12 (36)
enter x:	24 (12)	8 (8)	24 (24)	8 (20)
enter y:	24 (12)	24 (24)	8 (8)	8 (20)
enter both:	36 (12)	20 (8)	20 (8)	4 (4)

Before you choose a strategy you and your co-player have the opportunity to communicate via the computer terminal. To open your side of the communication channel you will pay an initial fee of *c*

daler.[18] When you send your first message the fee will be deducted automatically from what you earn. However, neither you nor your co-player are required to stick to the strategy you might have discussed in your messages. On the following page there is an illustration of the communication procedure. Note: It is forbidden to write messages where you identify yourself, for example, by name, sex, or appearance. Violation against this rule will result in the entire payment being withdrawn.

Computer screen (above). Translation of the text in the boxes:

- Top box: Here you are able to see the messages that you and your co-player have sent. Note that it does not cost anything to read your co-player's messages.
- Middle box: You can write the messages you want to send here. You send the message by pressing Enter.
- Bottom box: You have the opportunity to communicate with the other participant for 90 s. It costs 0 daler to open your side of the communication channel.

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[18]   *c* was set to 0,3 or 5