Chapter 52

THE PROBLEM OF COMMON CHOICE IN SYMMETRIC N-PERSON COORDINATION GAMES

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An apocryphal story is told that in 1897 there were exactly two automobiles (horseless carriages) in the State of Nebraska. Traffic laws regulating these new contraptions were generally lacking and the law was especially silent on how motorized vehicles should pass one another when approaching from opposite directions. Sure enough, as soon as these autos found themselves on the same road, they crashed head-on. The problem confronting these drivers was not that of "chicken" but rather "coordination," in which there were two Pareto-superior equilibria from which to choose. Despite the simplicity of the problem, one or both drivers made the wrong choice.

Coordination problems, such as the one facing our Cornhusker motorists, can be simply and easily solved provided an appropriate institutional remedy is at hand. Markets, for example, with frictionless transaction costs and complete information, constitute one way of quickly coordinating supply and demand. The evolution of social norms constitute another way of coordinating human action. Central to both of these solutions is the presence of a clear, unambiguous signal about what actions individuals should take. Where such a signal is present, the problem of coordination is easily solved; where absent, the problem of coordination can be extraordinarily difficult.

1. The Problem

Table 1 illustrates a simple coordination game with multiple Nash equilibria in pure strategies. In this setting there are three color choices and three individuals. Actors make simultaneous choices and payoffs are symmetric across actors. Payoffs are a function of an actor's choice and the number of others making the same choice. For instance, if only Actor 1 chooses Green, she earns 10 utiles. On the other hand, if everyone chooses Green, Actor 1 earns 100 utiles. Actors 2 and 3 face an identical choice problem. This setting is typical of coordination games in which there are multiple equilibrium. Which color actors choose is irrelevant. What matters is that everyone settles on the same color. Each color constitutes a Nash equilibrium in that once selected, no actor has a unilateral incentive to change.

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Table 1
Three actor coordination game. Symmetric coordination game with three actors and three equilibrium. All actors have the same payoffs and make their choices privately and simultaneously. If everyone chooses the same color (e.g., green) then no one will change their mind and unilaterally choose a different color

Actor 1 chooses	# Others matching the choice		
	0	1	2
Green	10	40	100
Yellow	10	40	100
Brown	10	40	100

The theoretical and empirical literature on coordination games is voluminous (see Ochs, 1995). Schelling (1960) initially suggested that coordination games could be solved with the presence of a "focal point." That is, actors could simply use obvious elements of the game to quickly settle on a single equilibrium where many exist. However, experiments by Van Huyck, Battalio, and Beil (1990) call into question the ease with which actors solve coordination games with the aid of focal points.

A different approach, suggested by Farrell (1987), allows actors to engage in "cheap talk." Farrell shows that if an actor signals her intended action prior to making a choice, she has no reason to lie about that choice in a coordination game. Because the problem is one of equilibrium selection, pre-play signals provide actors a means for committing to a particular play. Cooper et al. (1994) provide evidence that cheap talk can be remarkably effective. In their two-person coordination games, cheap talk allowed subjects to increase their rates of coordination from zero to 51 percent when only one subject signaled and to 91 percent when both subjects signaled.

As the number of actors increases, so too do the problems associated with coordination. While cheap talk remains a powerful solution its impact is attenuated by both problems of learning and path dependence.

2. Experimental Design

Two distinct experiments explore the role of signaling in n-person coordination problems. The first examines only single-stage games while the second examines repeated games. Because both experiments use a similar design (summarized in Table 2), we discuss first their common features.

The experiments involved groups of eight subjects who participated in highly structured decision settings and relied on computer-based instruction and interactions over a local area network. All computer terminals were separated by partitions so that subjects did not have a line of sight to one another's terminals. Subjects were cautioned that they could not speak with one another during the course of the experiment, as doing so would result in its termination. Each experimental session lasted about 60 minutes.

Table 2
Experimental design

– Computer-based instruction and interaction
– Subjects asked to select one color from three choices
– Four subjects per group
– Single stage games:
Randomize group composition, IDs, and colors before each decision period
– Repeated play games:
Randomize group composition and IDs once before game
Randomize colors each period
– Two conditions – no signaling and signaling
– No Signaling:
Simultaneous color choices without communication
– Signaling
One subject randomly selected to send cheap-talk signal to others

Prior to each round (either a single decision or a series of decisions, depending on the experiment) subjects were randomly assigned to a four-person group. At the same time each subject was randomly assigned a new identity (consisting of the letters A, B, etc.) in order to minimize reputation effects.

The subject's task was to select a color. Associated with each color was a row payoff indicating that the outcome was contingent on the color choice of one or more other subjects. Throughout the experiment six different colors were used: Brown, Gray, Orange, Green, Yellow, and White. At the outset of each decision three colors were randomly chosen and used. Those colors were randomly ordered at a subject's terminal for each decision period. Subjects were told that the group would see the same colors, but were cautioned that the order of those colors might be very different for other group members. For example, while {Yellow, Green, Brown} might be the order from top row to bottom row for one subject, another might see {Green, Yellow, Brown}. This was done to control for positional norms that could develop in the course of the experiment (e.g., always pick the middle row). Subjects were told that it was the color that mattered, not position.

Subjects made their choice privately and all choices were revealed simultaneously. Once each decision was made, subjects were informed of what the others had chosen and their own earnings for that decision. All earnings were in points and payoffs were based on a lottery conducted at the end of a set of choices (either five decisions in the single-stage experiment or at the end of the repeated game). The more points subjects earned, the more likely they were to win the large prize.

Two conditions were used in both experiments. In the *No Signaling* condition all four members of the group made a color choice and did so without cheap talk. Once everyone made a choice, the choices were revealed, the member's point earnings were displayed and the process resumed. Under the *Signaling* condition a single individual was randomly selected from the group. That member, referred to as a "monitor," was required to send a private signal to each of the other members of this group. The signal was nothing more than a color, was sent via the computer, and each member observed only their own signal. Following the suggestion by the signaler, members made their own choice and when all choices were completed, those choices were revealed, and the member's own point earnings were displayed. The signaler's payoff, like that of the others, was tied to the color choices of others, with the signaler's points increasing with the number of others choosing the same color.

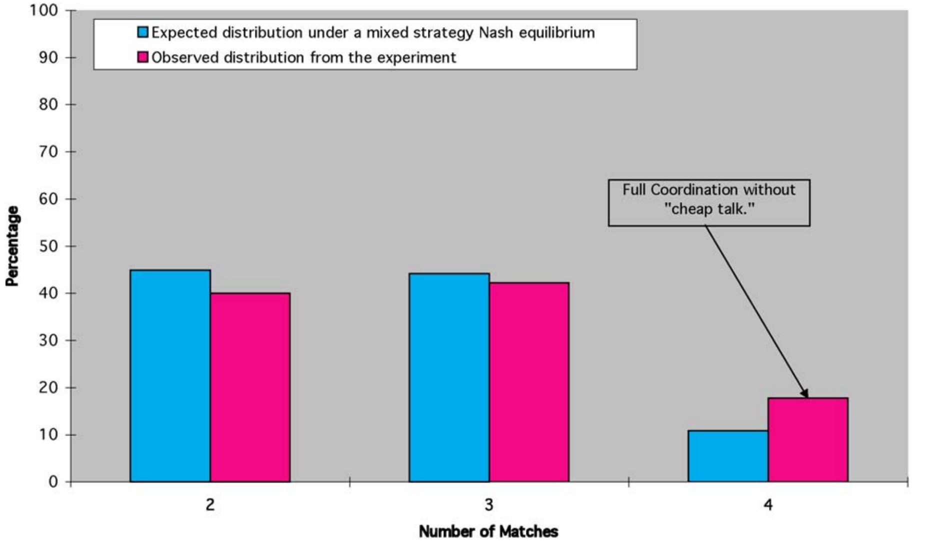
3. Single Stage Results

The first experiment required subjects to participate in 10 distinct decisions. The first 5 decisions were under the *No Signaling* condition and the last 5 decisions were under the *Signaling* condition. Between each decision subjects were randomly reshuffled and randomly reassigned new identities. Consequently subjects were unable to develop expectations about the behavior of any specific participant.

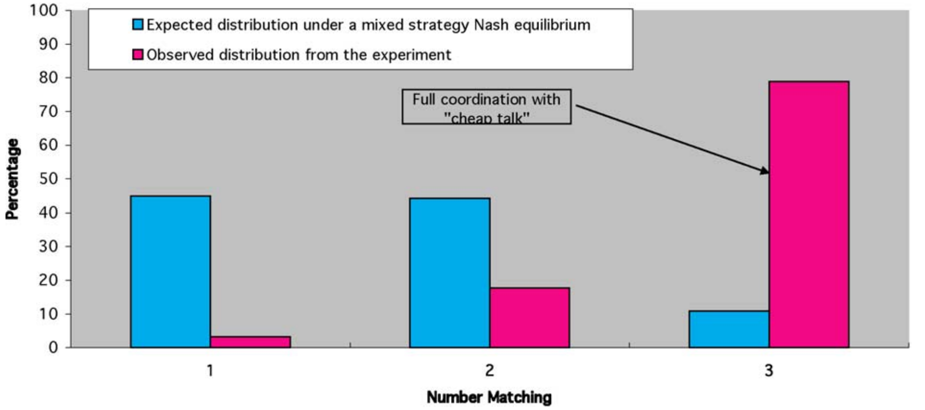
With symmetric equilibrium, randomization across sets of colors and reshuffling row positions for colors, subjects found it extraordinarily difficult to coordinate. Panel A of Figure 1 illustrates this quite well. It compares the percentage of actors choosing the same color across 90 trials with what is expected if all subjects played their mixed strategy Nash equilibrium (see Wilson and Rhodes, 1997). As is clear from the figure, subjects made choices that, in the aggregate, are remarkably similar to random play. They rarely stumbled into coordination, with all four subjects choosing the same color only 17.8 percent of the time.

Once choices were recommended, even though the recommendations were not common knowledge, rates of coordination increased dramatically. Panel B of Figure 1 illustrates what happens once a signaler is introduced. Instead of four subjects seeking to coordinate over the same color, three subjects now had to make a choice. As shown in the figure, all actors selected the same color 78.9 percent of the time. Moreover, their choices are considerably different than if all subjects played a mixed strategy Nash equilibrium. Signaling makes an enormous difference, although it is puzzling that even this simple mechanism does not result in 100 percent rates of coordination.

There are several behavioral deviations in these experiments which account for the imperfect levels of coordination. In order for there to be full coordination the signaler must send the same signal to the other participants and they must follow that signal. Most of the time (95.6 percent) the signaler sent the same signal to all three participants. Likewise, most of the time (93.3 percent) the participants did what the signaler suggested. Most of these deviations occurred early on in the experiment as subjects were learning the design. Only 9 of 18 groups completely coordinated their color choice in the first period. In the second period 14 of 18 groups did so and by the last period all 18 groups coordinated. Presented with a coordinating device, and given sufficient time to learn its value, subjects found full coordination to be an increasingly attainable goal.



(a)



(b)

Figure 1. Distribution of coordinated choices in single stage experiments: (a) no signaling condition, (b) signaling condition.

4. Repeated Play Results

The second experiment involves groups participating in five period, repeated play games. Subjects were randomly assigned to a four person group and randomly assigned new identities. For all five periods the same group members were retained (as were their identities) and subjects were reminded they were participating with the same individuals across each decision. The problem remained the same – to choose the same color. In each decision period the set of colors was randomly drawn, and as before, the row position for colors was randomly shuffled for each subject. Again groups were assigned to either the *No Signaling* or *Signaling* condition. If there was a signaler, that individual retained the position across all five decisions.

Figure 2 shows that subjects had a much more difficult time settling on the same color than under the single-shot experimental setting. Not once in 20 decisions, across four groups, did all four subjects settle on the same color. By comparison, as soon as someone was appointed to send private signals, the rate of complete coordination climbed to 46.7 percent (or 14 out of 30 decisions). While an impressive change from the *No Signaling* condition, it lags well behind what was observed in the single-stage experimental conditions.

The differences between the single-stage and repeated trials are due to the varying effects of learning and path dependence. Learning effects are especially clear in the single stage trials. In that experiment, as noted above, only half of the groups fully coordinated in the first period. By the second period, as the groups and signalers were randomly reshuffled, full coordination climbed to 78 percent of the groups. By the final period, subjects fully coordinated 100 percent of the time, learning that the cheap talk signals were useful.

By comparison, the repeated play experiments suggest the presence of path dependence, although the effects of learning are clearly visible as well. Figures 3a–3f depict matching and signaling behavior for all six groups in the repeated games. Each panel constitutes the period by period activity for one of the experimental groups. The series colored in red displays the number of individuals matching the same color. The left (red) vertical axis represents the three ranked possibilities for this game: no one matching, two subjects matching or all three individuals matching their color choice. The series colored in blue represents the type of signal sent. The right (blue) vertical axis notes the signal combination sent: one color signaled to everyone, two colors signaled or three different color signals.

Groups A and B had no problem coordinating. In both cases the signaler always sent subjects the same color signal, the subjects relied on that signal and everyone collected the maximal payoff. Groups C and D began with the signaler sending the same signal to all subjects, but subjects responded differently to those signals. In the second period for Group D subjects began by choosing colors different than those suggested. By the 4th period, the signaler "punished" subjects by sending a different color to each, which they all implemented. In the following period the signaler resumed sending the same signal to everyone. For Group C the experience was slightly different. The signaler began by sending the same signal, but one subject ignored it. The signaler immediately punished everyone by sending two different color signals. Following that move the signaler switched back to sending everyone the same signal and by the 4th period it served as a coordinating mechanism, a pattern that looks like learning with a corrective.

Groups E and F are quite different and are the most "noisy." In both instances at the outset the signaler sent different color signals to everyone. Group F members ignored

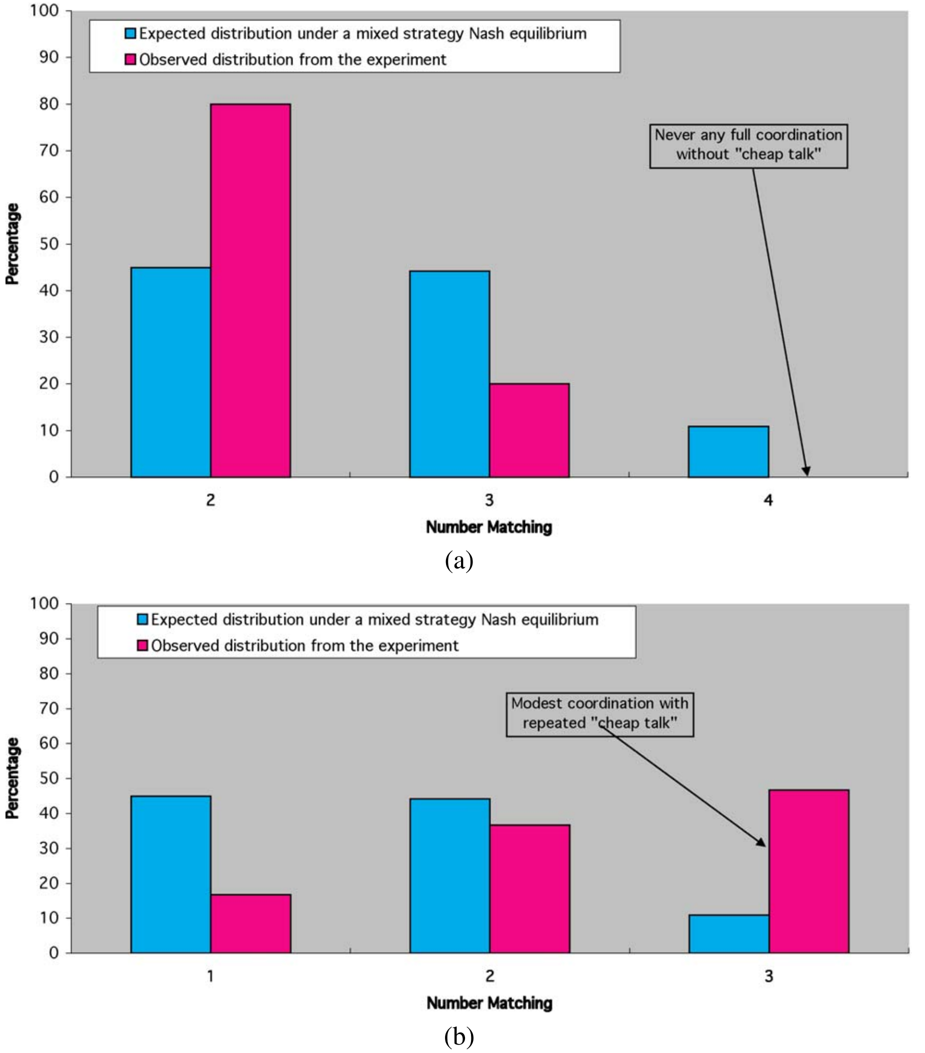


Figure 2. Distribution of coordinated choices in repeated play experiments: (a) no signaling condition, (b) signaling condition.

their signals and they happened to choose the same color. After that, however, the signaler was ignored. Much the same was true for Group E. Even though subjects fully coordinated in the fourth period, only one of the three members followed what the signaler proposed. In the final period every subject chose something different than what was suggested. In these groups, getting off on the wrong foot meant that recovering was very difficult – at least in the short run.

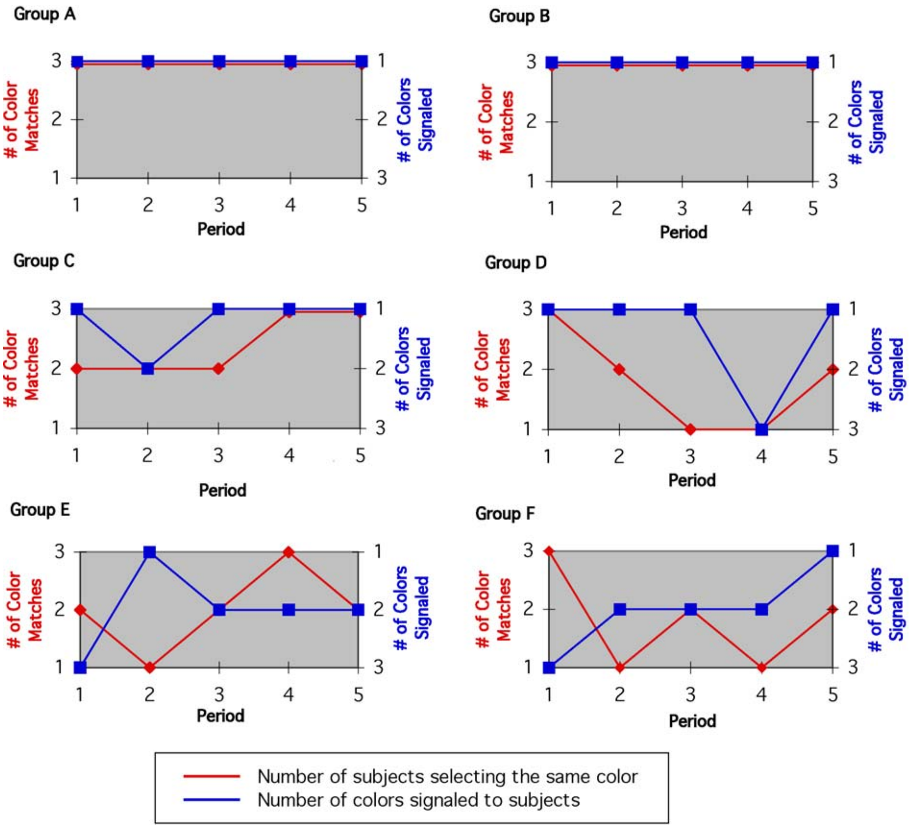


Figure 3. Consistency in signals and choices across periods by experimental trial.

These individual panels, while pointing out that subjects learned the value of cheap talk signals as a coordinating device, they also show that subjects are sensitive to the unfolding history of the trial. Once cheap talk is considered worthless, it is easily ignored.

5. Conclusion

Coordination problems are easily solved when there are clear and unambiguous signals. Institutional mechanisms that enhance the clarity of signals enables even cheap talk to work as a coordinating mechanism. On the other hand, learning about signals, especially if there is path-dependent noise in the environment, complicates the ability of subjects to settle on a common coordinating device.

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