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How does communication affect beliefs in one-shot games with complete information? ☆

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ABSTRACT

This paper experimentally studies unilateral communication of intentions in eight different two-player one-shot normal form games with complete information. We find that communication is used both to coordinate and to deceive, and that messages have a significant impact on beliefs and behavior even in dominance solvable games. Nash equilibrium and cognitive hierarchy jointly account for many regularities, but not all of the evidence. Sophisticated sender behavior is especially difficult to reconcile with existing models.

1. Introduction

People speaking the same language may adapt quickly to new and unexpected situations, because communication allows them to make joint adjustments. On the other hand, a shared language also means that new situations create novel opportunities for deception and misunderstanding. Despite the obvious practical importance of honest as well as deceptive communication, game theory still struggles to capture them both within a single framework. Even in the simplest case, that of brief unilateral cheap talk about intentions ahead of a one-shot complete information game, theorists offer conflicting views.[1]

One line of analysis, associated with Farrell (1988), and dating back at least to Aumann (1974), emphasizes coordination. In some games, despite their selfishness, strategic players may improve their joint performance through honest messages. Indeed, if we see equilibrium points as self-enforcing agreements, and the game is only played once, communication appears essential for reaching equilibrium in many games; see also Kreps (1987). This literature not only assumes that behavior is rational, but also that the players' belief system is rational.[2] That is, rationality is common knowledge, and to the extent that

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[1] Once we move beyond this simple central case, the literature is vast, and we cannot provide a full survey here. For early studies of bilateral multi-round communication, see Farrell (1987) and Rabin (1994). For theoretical analysis of deception in games with *incomplete* information, see for example Sobel (1985), Kartik et al. (2007), Mullainathan et al. (2008), and Ettinger and Jehiel (2010).

[2] See Aumann and Dreze (2008) for a discussion of rational belief systems.

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players are of different types they share common priors concerning the type distribution. Because this approach assumes players believe other players also hold rational beliefs, we call it the *reflexive* approach. Major solution concepts include rationalizability (Bernheim, 1984; Pearce, 1984) and Nash equilibrium (Nash, 1950). Under common belief in rationality, pre-play messages may help to coordinate players' expectations on some Nash equilibrium, but as shown by Farrell (1988), communication does not guarantee equilibrium play in the underlying game. While communication is predicted to be unimportant in dominance solvable games, it is potentially helpful in games that are not dominance solvable, but have desirable equilibrium outcomes.

Another line of analysis, initiated by Crawford (2003), emphasizes deception. Strategic communication about intentions could be designed to mislead the opponent, and may well be driving behavior away from equilibrium. While players are assumed to behave rationally given their beliefs, the players' belief system is not assumed to be rational. For example, Crawford assumes that at least some players entertain the idea that their (opponent entertains the idea that their...) opponent is irrational. Among other things, he shows that players who believe that their opponents are irrational are susceptible to being deceived.[3] Because players in this approach typically believe others hold different beliefs than themselves, we call it the *irreflexive* approach.[4] The irreflexive solution concepts that have attracted most attention are versions of the level-k model (Stahl and Wilson, 1994, 1995; Nagel, 1995).

The level-k approach to communication, pioneered by Crawford (2003), extended by Ellingsen and Östling (2010), and surveyed in Crawford et al. (2013, Section 9), entails two predictions that contradict those of the reflexive approach. First, communication might well be used to systematically miscoordinate expectations, that is, to deceive opponents. Second, players' doubts about opponents' rationality might by themselves lead behavior away from equilibrium in the underlying game, thereby opening up a qualitatively new avenue for communication to improve coordination – getting behavior back towards equilibrium. In particular, under the additional assumption that players have a weak preference for honesty, Ellingsen and Östling (2010) show that pre-play communication among irreflexive players could be promoting coordination in a wide variety of games, including dominance solvable games (where the reflexive approach says that communication will be irrelevant). Moreover, Ellingsen and Östling (2010) also show that their model offers a reconciliation of the competing intuitions of Farrell (1988) and Aumann (1990) for the role of communication in games with multiple equilibria and a tension between payoff and risk-dominance, such as the Stag Hunt game.

Here, we experimentally test the predictions associated with the two approaches. We study eight different one-shot complete information normal form games. We let each subject play all eight games, but without any feedback between games. We also elicit subjects' beliefs about the opponent's action. All games have a unique Nash equilibrium and in all but two games, the Nash equilibrium is the unique rationalizable outcome. Since the reflexive approach implies that communication should not matter, and the irreflexive approach implies that communication should matter in a particular way, behavior in dominance-solvable games discriminates sharply between the two approaches.[5] As some of the games have not been studied empirically before, but were proposed and analyzed theoretically by Ellingsen and Östling (2010), the experiment also represents a first out-of-sample test of their version of the irreflexive model of communication. Whereas previous studies have identified player types across several communication games (Wang et al., 2010), to our knowledge we are the first to identify types across communication games with different strategic structures.

Overall, the evidence demonstrates that irreflexive models do help to explain systematic deviations from rationalizable behavior. The response to deceptive messages represents our cleanest evidence of irreflexive receiver beliefs. Many senders attempt to deceive the receiver in games with some conflict of interest, and if the receiver lacks a strictly dominant strategy, such deceptive tactics have a substantial success rate. For example, in one 2×2 game in which the sender has a dominant action, about forty percent of the receivers of a deceptive message are fooled into taking the wrong action.

The extensive information about each subject enables us study to what extent subjects' behavior and beliefs can be consistently described across all games. Since rationalizability entails quite weak predictions for some of our games, and because the simplest level-k model has some known problems, our structural econometric analysis considers two main solution concepts, namely Nash equilibrium and the cognitive hierarchy model with a Poisson type distribution (Camerer et al., 2004). In addition, we undertake a non-structural analysis that does not put any *a priori* restriction on subjects' behavior or beliefs. This allows us both to see if our exogenous categories emerge naturally and to investigate whether there are other consistent patterns in the data.

Overall, the evidence suggests that the reflexive and irreflexive approaches are complementary. Structural analysis of the action data alone classifies at least half the subjects as reflexive without communication, whereas about 70–75 percent are classified as reflexive with communication. Thus a conservative estimate is that the behavior of about 25–30 percent of the subjects is best explained by the irreflexive model. While the fraction of irreflexive subjects is considerably lower than in some previous studies, such as Costa-Gomes and Crawford (2006), so is the complexity of our games. Simpler games might induce more reflexive reasoning, but also make it more difficult to separate reflexive and irreflexive types. Our cluster analysis of actions is largely consistent with the structural analysis, suggesting that it picks up the major player types.

[3] As Ellingsen and Östling (2010) show, the irreflexive model sometimes predict better coordination, or at least coordination on better outcomes, than the reflexive model. Thus, the crucial difference between the two views does not concern coordination versus miscoordination.

[4] Strictly speaking, we are comparing particular reflexive models with particular irreflexive models. However, some of our results will be addressing (rejecting) the whole family of reflexive models.

[5] Recall that reflexive beliefs do allow a role for communication in some games that are not dominance solvable, as argued by Farrell (1988).