

**International Workshop on Behavioral Game Theory and
Experiments,
Capua, 12-13 May 2006**

Walras's Correspondence as a natural test of Aumann's conjecture

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Abstract

This paper is devoted to a study of Walras's correspondence as a test of the effectiveness of cheap talk in achieving efficient outcomes in coordination games. First, we use Walras's correspondence with Jevons as an *in vivo* "battle of the sexes" game experiment to show that, in such a game preceded by one round of two-way communication, sequential announcements may help a lot even when messages about actions are not messages to take literally. Second, we use Walras's correspondence with Cournot as an *in vivo* "stag hunt" game experiment to show that, in such a game preceded by one round of two-way communication, sequential announcements are less effective than simultaneous announcements when messages about actions are not simple.

Key-words

Aumann's conjecture, Cournot, Jevons, Walras,
Coordination, Battle of the sexes, Stag hunt, Cheap talk.

JEL Classification numbers:

B13, B31, C72, C99.

“In the real world – when the chips are down, the payoff is not five dollars but a successful career, and people have time to understand the situation – the predictions of game theory fare quite well.”

Robert J. Aumann (1990), “Foreword” in: A.E. Roth and M.A. Oliveira Sotomayor (eds), *Two-sided Matching: A Study in Game-Theoretic Modelling and Analysis*, Cambridge University Press: Cambridge, U.K.

“In short, I have serious doubts about behavioral economics as it is practiced. Now, *true* behavioral economics does in fact exist; it is called empirical economics. In empirical economics, you go and see how people behave in real life, in situations to which they are used.”

Sergiu Hart (2005), “An interview with Robert Aumann”, *Macroeconomic Dynamics*, 2005, p. 712

“Léon Walras’s letters, besides supplementing his published writings, reveal the role he played during his lifetime as an economist’s economist; and therein lies their chief value.”

William Jaffé (1965), “*Correspondence of Léon Walras and Related Papers*”, NHPC, Amsterdam, Volume 1, p.vii

“After an unavowed first love when he was eighteen, Chevreux went to Paris and took a mistress. He broke off with her in a decent manner, more alarmed for the future than dissatisfied with the present, when, one fine day, calculating the balance of happiness that she gave him on the one hand against the loss of time and financial expenses that she caused him on the other, he coldly recognized a deficit”

Léon Walras (1859), “La lettre”, *Revue française*, p.201¹

1. Introduction

“Cheap talk is just that: cheap – neither costly nor binding; and talk – not some roundabout form of communication, like mediation.... In a sense, cheap talk is communication in its purest and simplest form: purest in that there is no direct impact on the payoff, and simplest in that there is no intermediary” (Aumann and Hart, 2003, p.1619). Briefly put, cheap talk is “costless, non-binding, non-verifiable communication” (Farrell, 1988, p. 226).

The effectiveness of cheap talk in achieving efficient outcomes in coordination games, *i.e.*, games that exhibit multiple equilibria, is a subject of controversy that has attracted considerable attention among both theorists and empiricists (excellent overviews of work on

coordination are given by Ochs, 1995, Crawford, 1997, and Camerer, 2003; for discussion of cheap talk, see, *e.g.*, Farrell and Rabin, 1996).

From the game-theoretic point of view, Baliga and Morris (2002) briefly review the complete information debate about cheap talk and coordination. They highlight two key ideas. First, following Farrell (1988), a cheap talk statement about your planned behavior is credible if it is *self-committing*: if you expected your cheap talk statement to be believed, you would have an incentive to carry out your plan. Second, following Aumann (1990), a cheap talk statement about your planned behavior is only credible if it is *self-signaling*: you would only want it to be believed if in fact it was true. In other words, Aumann (*ibid.*) conjectures that, if a player has a strict preference over his or her opponent's choice, an announcement that he or she intends to make a particular choice can be met with skepticism.

Experimental economists have documented considerable evidence on behavior in complete information coordination games with communication (*cf.*, *e.g.*, Cooper *et al.*, 1989, 1990, and 1994, Crawford, 1997 and 1998, Charness, 2000, and Clark *et al.*, 2001). Experimental results suggest that the extent to which communication can enhance coordination may well vary across different forms of games and messages technologies. Crawford (1998, p.294) "highlights two important determinants of the effects of structured communication in these experiments: whether communication is simultaneous or one-sided; and whether players can achieve a desirable outcome without breaking the symmetry of their roles". On the one hand, when a desirable outcome requires symmetry-breaking (as an example, consider the "battle of the sexes" [hereafter, BOS] game), one-sided communication works well because it points to a single equilibrium; two-sided communication does not help because it creates as much conflict as no communication. On the other hand, when a signal pooling problem critically impairs the credibility of a message (as an example, consider the "stag hunt" [hereafter, SH] game), the effects of preplay communication are opposite: two-sided communication is much more effective than one-sided communication because it provides enough assurance and points to a consistent outcome.

Several profitable avenues for further research are suggested by experimental results in coordination games (*cf.*, *e.g.*, Clark *et al.*, 2001, and Crawford, 1998). Two of them are noteworthy. First, in a BOS game, is the performance of two-way communication improved if announcements are sequential? Second, in a SH game, is the performance of two-way communication worsened if announcements are sequential?

The present paper provides answers to both these questions by using Walras's correspondence (Jaffé, 1965) as *in vivo* experiments.

Walras's correspondence reveals Walras's lifelong struggle to teach others about his work. It contains unique and, at times, detailed information regarding behavior in strategic situations. It throws light on Walras's efforts to disseminate and promote his ideas. It may be regarded as a natural experiment to test the effectiveness of cheap talk in achieving efficient outcomes in coordination games.

The present paper continues experimental research on Aumann's conjecture by weaving together three strands of previous research.

One strand (Brams 1994) combines game theory and literature. Brams (*ibid.*) surveys studies that bring game theory and literature together. He presents applications of game theory to novels, short stories, plays, opera librettos, narrative poems, and the Hebrew Bible.

Another strand (Greif 2002) brings game theory and historical fact together. He shows that history is another laboratory in which to examine the relevance of game theory. "History is society's laboratory" (McCloskey, 1976, p.448): it supplies "factual grist for the game theorist's mill" (*ibid.*, 450); it provides an improved set of evidence to evaluate game theory; it illuminates this theory and tests it. In this connection, two examples of historical experiments are outstanding: Carlos and Hoffman (1986) and Moldovanu and Tietzel (1998).

The idea behind the third strand (Harrison and List, 2004) is to recognize that some events that naturally occur in the field happen to have some of the characteristics of a field experiment.

The remainder of the paper is structured as follows. In section 2, we use Walras's correspondence with Jevons as an *in vivo* "battle of the sexes" game experiment to show that, in such a game preceded by one round of two-way communication, sequential announcements may help a lot even when messages about actions are not messages to take literally. Second, we use Walras's correspondence with Cournot as an *in vivo* "stag hunt" game experiment to show that, in such a game preceded by one round of two-way communication, sequential announcements are less effective than simultaneous announcements when messages about actions are not simple. Section 4 concludes.

2. Walras's correspondence with Jevons as experimental evidence on behavior in the "battle of the sexes" game with two-way communication

Léon Marie-Esprit Walras (1834-1910) read his paper *Principes d'une théorie mathématique de l'échange* (hereafter, *PTME*), in Paris before the *Académie des sciences morales et politiques* at two sessions on August 16 and 23, 1873. *PTME* was "from beginning

to end a daring paper, a clarion call for a new approach to the theory of value and for the transformation of political economy into a mathematical science” (Jaffé, 1983, p.289). It was first published in January 1874, as one of the “Communications des savants étrangers” in the *Séances et travaux de l’Académie des Sciences morales et politiques*. It was then republished (without the “Observations” made by Levasseur, Valette, and Wolowski) in the *Journal des Economistes* (hereafter, *J.E.*), April 1874.

On May 1, 1874, a few days before receiving a letter (267) from Aulnis de Bourouill, then a student at the University of Leiden, telling him how similar *PTME* was to a theory he had read in Jevons’s *Theory of Political Economy*, Walras sent William Stanley Jevons (1835-1882) a copy of *PTME* accompanied by a courteous letter (1783¹) in which Walras draw Jevons’s attention to it.

It is the first one of the thirty-two letters that passed between Walras and Jevons during the period from May 1, 1874 to June 24, 1882. Walras wrote seventeen letters to Jevons, and Jevons wrote fifteen letters to Walras (272*, 275*, 278*, 286*, 297, 301, 320, 328, 355, 358, 363, 376, 377#, 379#, 380, 381, 383, 409, 410, 411, 412, 417, 417(5), 419, 422, 431, 433, 465, 515, 518, 531, and 1783*).

Studying letters denoted by * together with two letters (276 and 282) sent by Walras to the *J.E.* reveals that, between May 1, 1874 (1783) and July 29, 1874 (286), Walras and Jevons played a BOS game (the normal form of which is shown in Figure 1, where $x > z > 0$) preceded by one communication round (letters 272 and 275) in which they made announcements about their pure intended decisions.

		Walras	
		W _y	W _c
Jevons	J _y	0,0	z,x
	J _c	x,z	0,0

Table 1

In this game, each player has two moves to choose between: to yield (*y*), *i.e.* to recognize the other as the inventor of marginal utility as an explanation of value, or to claim priority (*c*).

The values, also arbitrary, present the situation reasonably. There are two questions: the question of priority as regards the discovery of utility theory, and the question of the promotion of mathematical economics. Both Jevons and Walras wish to promote mathematical economics. In this connection, neither player derives any positive payoff from (J_y, W_y) or (J_c, W_c) . As regards the question of priority, Jevons prefers (J_c, W_y) , whereas Walras prefers (J_y, W_c) .

This game is symmetric: Jevons's payoff matrix is the transpose of Walras's payoff matrix; the two players value the outcomes along the main diagonal the same, whereas the utilities of the off-diagonal are mirror images of each other; each of the two players faces the same problems of strategic choice.

This game has two pure-strategy equilibria, (J_c, W_y) and (J_y, W_c) . Each player prefers a different equilibrium. In (J_c, W_y) , Jevons plays for his favorite equilibrium, and Walras plays for Jevons's favorite equilibrium. In (J_y, W_c) , Walras plays for his favorite equilibrium, and Jevons plays for Walras's favorite equilibrium. This game has a third equilibrium: a symmetric mixed-strategy equilibrium in which strategy $i = y, c$ is played with probability p_i where $p_y = z/(x+z)$ and $p_c = x/(x+z)$. In this third equilibrium, the players behave in a random and uncoordinated manner, which neither player can unilaterally improve on. Each player gets the same expected payoff $xz/(x+z)$ from going either way. This mixed-strategy equilibrium is worse for each player than his least preferred pure-strategy equilibrium.

The effect of adding a communication stage to the beginning of a game depends upon two key elements of the communication technology: the message space from which players are permitted to select their messages; who can communicate with whom and how often.

In the experimental research (see, *e.g.*, Cooper *et al.*, 1989) on the role of non-binding pre-play communication in a one-shot symmetric BOS game, communication represents simple message about actions, and two possibilities are considered. First, one player is allowed to send one cheap talk message: he can indicate which action he plans to play. Second, the two players are allowed to send these messages to each other simultaneously.

Experimental results are striking: "If a little (one-way) communication helps a lot, two-way communication must do even better, right? Wrong" (Camerer, 2003, p.356).

Without communication, the symmetry of the mixed-strategy equilibrium makes it a natural outcome of the game. The existence of potential gains from coordination is clear.

With communication, results are the following: allowing one-way communication is the most efficient way of achieving pure strategy equilibrium; when both players send one

round of messages simultaneously, there is chance of confusion that does not arise when only one player communicates, but multiple rounds of two-way communication are more helpful than single rounds.

The Walras-Jevons correspondence together with the letters (276 and 282) sent by Walras to the *J.E.* furnish new experimental evidence on the efficiency of pre-play communication in a one-shot symmetric BOS game.

Letters 272 and 275 constitute one round of two-way communication. However there are two differences between this two-way communication structure and the one used by Cooper *et al.* (1989). Non-binding announcements made by Jevons (in letter 272) and Walras (in letter 275) about their intended decisions in the following BOS game are neither simple nor simultaneous: they appear to be questions requiring a yes or no answer, but they are in fact veiled commands; they are sequential.

In letter 272 (p.394), dated May 12, 1874, Jevons tells Walras that he will claim priority: “**The publication of your paper** as it now stands is very satisfactory in so far as it tends to confirm my belief in the correctness of the theory, but it **might lead to misapprehensions as to the originality and the priority of its publication. I shall therefore take it as a favour if you will kindly inform me whether you are sufficiently acquainted with my writings** or whether you would desire me to forward a copy of my *Theory of Political Economy*”². The utterance “Inform me whether you are sufficiently acquainted with my writings” – which appears to be a question requiring a yes or no answer – is in fact a thinly veiled threat: “I shall claim priority.”

In letter 275 (p.399), dated May 23, 1874, Walras acknowledges Jevons’ priority, and he writes this: “**I offer you to ask Joseph Garnier, editor-in chief of the *J.E.*, to publish your letter along with my present reply in the *J.E.*’s next issue**”². The utterance “I offer you to ask Garnier to publish” our letters – which appears to be a question requiring a yes or no answer – is in fact a promise: “I shall make it known to all our peers that I recognize you as the inventor of marginal utility as an explanation of value.”

Letters 276, 278, 282, and 286 show that Walras played for Jevons’s favorite equilibrium, and Jevons for his favorite equilibrium.

In letter 276, dated May 23, 1874, Walras tells Felicité Guillaumin (daughter of Urbain Gilbert Guillaumin, and assistant to the editor of the *J.E.* of which the *Librairie Guillaumin* was the publisher) he will ask Joseph Garnier to publish his correspondence with Jevons.

On June 5, 1874, Walras carried out his program. He sent Joseph Garnier (co-founder with Guillaumin of the Société d'économie politique, and editor-in chief of the *J.E.*) a French translation of Jevons's letter of May 12, 1874 (272) along with his own reply of May 23, 1874 (275), accompanied by a letter (282), in which Walras asks Garnier to publish letters 272 and 275 in the next issue of the *J.E.* (282, p.409).

On June 15, 1874, the *J.E.* published both these letters exchanged by Jevons and Walras under the rubric, "Correspondance. Théorie mathématique de l'échange – Question de priorité. Correspondance entre M. Jevons, professeur à Manchester, et M. Walras, professeur à Lausanne."

This fact reveals that Walras played W_y .

In letter 278, dated May 30, 1874, Jevons writes: "I flatter myself with the hope that the unity of our results arises from the best cause, namely that we have both reached the truth, which must be one.... I cannot for a moment entertain the least doubt of the entire independence of your own researches as regards my own. As to the question of priority of publication, it is of course of less importance than that of the truth of the theory itself". He adds: "I feel it to be most honorable in you after seeing merely the brief sketch of my theory as printed in *the Statistical Journal for 1866*, to acknowledge at once my priority on some points ... For my own part I shall have much pleasure in doing what I can to make known in England your own excellent statement of the theory of exchange and to show my high estimation of your friendly conduct."

In letter 286, dated July 29, 1874, Walras writes: "I make no pretense of being above human frailty. I confess to you frankly that I was at first quite upset by the loss of my priority as the inventor of the equation which is so fundamental to the mathematical theory of exchange and of social wealth.... When there is nothing else left to do but yield, one might as well do so with good grace".

Toward the end (p. 414) of the same letter, Walras adds: "I have made some points, which I believe, will remain my own – for example, the theorem of general equilibrium and the laws of the emergence and variation of equilibrium prices. And there are many other things besides! Thus I find some consolation for my self-esteem".

In the light of these documents, it appears that, **in July 1874**², Jevons actually received a payoff x , and Walras actually received a payoff z , $x > z > 0$.

In the years following 1874, Jevons did not carry out his program (see, e.g., 328 and 355, 433 and 465), and Walras progressively became more than just a co-discoverer of marginal utility. "Jevons simply was not a one-subject man. Having worked out and published

his ideas on the basic ‘mechanics of utility and self-interest,’ he was anxious to move on” (Wood, 1988, p.305). Of the three protagonists (Walras, Jevons and Menger) of the marginalist revolution, “Walras was certainly the most outstanding figure and was destined to leave the deepest and most lasting imprint” (Ingrao and Israel, 1990, p.92). However, these facts, which are well known today, are irrelevant to the question of whether or not, in July 1874, Jevons’s payoff was greater than Walras’s payoff in the BOS game above-analyzed.

Jevons’s biography and Walras’s autobiography constitute excellent material to provide insight into this question

Jevons’s biography reveals that Jevons “first conceived his new views on the theory of Political Economy while still a student; and when he sent a paper on it to the British Association Meeting in 1862, a very brief abstract was inserted in the Annual Report” (H.W. Jevons, 1934, p. 228-9). Jevons’s “Brief Account of a general Mathematical Theory of Political Economy” was first published *in extenso* in the *Journal of the Statistical Society of London* for 1866. The *Theory of Political Economy* was published in 1871.

Walras’s autobiography describes his first step in the development of his pure theory as follows: “I had been working steadily with the idea of creating a mathematical economics ever since 1860” (Jaffé, 1965, p.5). Walras’s early unpublished “manuscripts both entitled ‘Application des mathématiques à l’économie politique’, one of eight pages, called *première tentative*, dated 1860 and the other of forty seven pages, called *deuxième tentative*, dated 1869-1870 ... were pathetic efforts, giving not the slightest inkling of what was presently to follow” (Jaffé, 1983, p. 22)

Thus, the Walras-Jevons correspondence as an *in vivo* game experiment sheds a new light on the effectiveness of cheap talk in achieving efficient outcomes in a BOS game: in such a game preceded by one round of two-way communication, sequential announcements may help a lot even if messages about actions are not messages to take literally.

3. Walras’s correspondence with Cournot as experimental evidence on behavior in the “stag hunt ” game with communication

On May 23, 1821, In 1901, Walras confided (1483) to Dick May (French Sociologist and minor novelist), that at the age of 19 he read in two sittings all of once famous Poincaré’s textbook in pure mechanics, *Eléments de statique*, and then kept this book by him as a companion book throughout his life. Both Chapter II and the third “mémoire” of Poincaré’s treatise, where the equilibrium among physical forces is described, bristle with systems of

simultaneous equations which are clear prototype of Walras's multi-equational systems of the general equilibrium of market forces (**1483** (7)). From these documents, it is possible to conjecture that the main inspiration for Walras's conception of general equilibrium was Poinso't's treatise.

However, Walras liked to give the impression that his father and Antoine Augustin Cournot (1801-1877) had furnished the principal elements of his economic theory. Walras acknowledged debts to his father for economic concepts and to Cournot for the application of mathematics to economics. For example, on January 2, 1906, in describing to Moore the genesis of his system (**1614**, vol. 2, p.292-293) Walras wrote: "To my father I owe the economic definitions which are the basis of my system, and to Cournot I owe the mathematical language which is most apt for formulating this system".

In 1854, at the age of twenty, Walras read, and digested Cournot's *Recherches sur les principes mathématiques de la théorie des richesses* (1838) that Auguste Walras, one of Cournot's classmate at the *Ecole Normale Supérieure*, had in his library.

On July 16, 1863, the *Indépendant de Moselle* published Walras's review of Cournot's *Principes de la théorie des richesses* (1863). In the *Principes*, Cournot developed into literary language what he had previously said mathematically in the *Recherches*. In his criticism of the *Principes*, Walras "regretted that Cournot, instead of developing further the application of mathematics which was his forte, unfortunately dilated upon the weaker element of his earlier contribution, his economics" (86, (4), p. 130) Specifically, Walras attacked Cournot's "blind adherence to Ricardo's long discredited theory of rent" (*ibid.*).

On August 12, 1873, a few days before reading *PTME* before the *Académie des sciences morales et politiques*, Walras wrote a letter (**226**) to Cournot.

It is the first one of the eleven letters that passed between Cournot and Walras during the period from August 12, 1873 to February 14, 1875. Walras wrote six letters to Cournot, and Cournot wrote five letters to Walras (**226**, **228**, **230**, **231**, **253**, **257**, **258**, **293***, **294***, **325** and **327***)

Following Jaffé (1952), this Walras- Cournot correspondence may be divided into four parts - A, B, C and D - that include respectively letters **226**, **228**, **230** and **231** (A), letters **253**, **257** and **258** (B), letters **293** and **294** (C) and letters **325** and **327** (D).

First, Walras declares himself quite simply to be a follower of Cournot. He expresses his admiration to Cournot whose work possesses considerable interest. Cournot was the first to have applied mathematics to economics explicitly and competently. He shown the way to Walras. As as a dutiful son to Cournot's great friend, Walras expresses his profound gratitude

to Cournot: he pays him great deference. At the same time, Walras insists that in his own work, he has followed a line different from that of Cournot. On the one hand, Cournot took monopoly as his starting point and proceeded from there by steps to an analysis of unlimited competition. On the other hand, Walras took free competition as his starting point and studied monopoly as a special case (A).

Second, Walras comes to an agreement with his correspondent. Cournot’s work is on the road that leads to numerical applications. Walras’s work is confined to the abstract and rigorous plane of pure theory. Once Walras’s analysis will be finished, he will rejoin Cournot. Taking this agreement as a starting point, Walras asks Cournot to do him a favor concerning Cournot’s contacts at Hachette. Cournot answers him in generous and frank terms (B).

Third, Walras acknowledges debts to Cournot for the application of mathematics to economics, and he tries to persuade Cournot to write an article in the *Revue des Deux Mondes* to promote mathematical economics. Cournot declines the task (C).

Fourth, Cournot and Walras part good friends (D).

Studying (C) and (D) reveals that, between August, 18, 1874 (293) and February 14, 1875 (327), Walras and Cournot played a SH game (the normal form of which is shown in Figure 2, where $m > c > x > 0$) preceded by one communication round (letters 293 and 294) in which they made announcements about their pure intended decisions.

		Walras	
		W _p	W _r
Cournot	C _p	$x + m - c, x + m - c$	$x - c, x$
	C _r	$x, x - c$	0,0

Table 2

In this game, each player has two moves to choose between: to write an article to promote mathematical economics (p), or to continue pure research (r).

The values, although arbitrary, present the situation reasonably. There is a cost c , $c \geq 0$, of doing any promotion of mathematical economics. There is a public good: the promotion of mathematical economics. The public good is worth x , ($c > x > 0$), if one player plays (p) and $x + m$ if two play (p). There is enough synergy in producing the public good: $m > c > x > 0$.

This game is symmetric: Walras's payoff matrix is the transpose of Cournot's payoff matrix; each of the two players faces the same problems of strategic choice.

This game has two pure-strategy equilibria, (C_p, W_p) and (C_r, W_r) . (C_p, W_p) is Pareto dominant, because it is better for everyone than (C_r, W_r) . This game has a third equilibrium: a symmetric mixed-strategy equilibrium in which strategy $i = p, r$ is played with probability p_i where $p_p = (c - x)/(m - x)$ and $p_r = (m - c)/(m - x)$. In this third equilibrium, the players behave in a random and uncoordinated manner, which neither player can unilaterally improve on. Each player gets the same expected payoff, $x(c - x)/(m - x)$, from going either way.

In such an Aumann game, it is not clear which outcome should be expected. Two types of coordination failures can arise. First, a fundamental kind of coordination failure can arise if a pure strategy equilibrium is not attained and *ex post* disequilibrium outcomes result. Second, players may unilaterally take actions that lead to a Pareto-inferior Nash equilibrium being played.

Such potential difficulties raise questions about whether communication facilitates coordination on the Pareto-dominant equilibrium. In this connection, two points are noteworthy. On the one hand, the promise "I will play (p)" by Walras (resp. Cournot) is *self-committing*: it is credible to Cournot (resp. Walras) because if Walras (resp. Cournot) expects his statement to be believed, he has an incentive to carry out his promise. On the other hand, such a promise is not *self-signaling* because Walras (resp. Cournot) would like Cournot (resp. Walras) to play (p) independent of the action Walras (resp. Cournot) plans to carry out: Walras (resp. Cournot) would want that statement to be believed even he were planning to play (r), because $x > 0$.

Experimental results on the role of non-binding pre-play communication in two-person SH games are striking.

In such games, communication appears to play an important *reassurance* role, allowing subjects to coordinate on more efficient equilibria by reducing their uncertainty about each other's decisions (Clark *et al.*, 2001). Reassurance is best accomplished *via* two-sided communication (Cooper *et al.*, 1990 and 1994). However, the effectiveness of communication is sensitive to the structure of payoffs: when there are positive spillovers ($x > 0$), agreements to play a Nash equilibrium are fragile.

The Walras-Cournot correspondence furnishes new experimental evidence on the effectiveness of pre-play communication in achieving efficient outcomes in a two-person SH game.

Letters **293** and 294 constitute one round of two-way communication. However, there are two differences between this two-way communication structure and the one used by Cooper *et al.* (1990 and 1994). Non-binding announcements made by Walras (in letter **293**) and Cournot (in letter 294) about their intended decisions in the following SH game are neither simple nor simultaneous: they are different from the usual announcement, “I intend to choose”; they are sequential.

In letter **293** (p.421-422), dated August 18, 1874, Walras suggests to Cournot that he should write a paper on the relationship between mathematics and economics: “**I greatly wish ... to see you writing a paper**² for the *Revue des Deux Mondes*, the title of which would be ‘*De l’application des mathématiques aux sciences en general et à l’économie politique en particulier.*’ Drawing on your own unique understanding of the rise of the scientific movement in the XVIIth, and XVIIIth, and XIXth centuries, you could provide an informational outline of how mechanics, astronomy, and physics became mathematical sciences. Combining the first chapter of Jevons’s *Theory of Political Economy*, the first section of Walras’s *Elements d’économie politique pure*, and some of passages of *PTME*, you could induce the scientific world to accept our view of the theory of social wealth as a mathematical science”. The utterance “I greatly wish to see you writing a paper” is in fact a question requiring a yes or no answer.

In letter 294 (p.423), dated August 23, 1874, Cournot answers Walras’s question as follows: “You understand very well what would have to be done to get things moving. Therefore **you ought to write yourself this paper**². I am 73 years old [...] I am writing a book on *Matérialisme, vitalisme, rationalisme*”. The utterance “You ought to write yourself this paper” is in fact a thinly veiled command.

Letters 325 and **327** show that Walras played W_p , and Cournot C_r .

In letter 325, dated February 10, 1875, Cournot tells Walras that he wishes to offer him *Materialime, vitalisme, rationalisme. Etudes sur l’emploi des données de la science en philosophie* that appeared in 1875.

This document reveals that Cournot played C_r .

In letter **327**, dated February 15, 1875, Walras tells Cournot that, in fall 1874, he wrote the first draft of his essay “Une branche nouvelle de la mathématique. De l’application des mathématiques à l’économie politique”.

Written in an evident bid to whet the mathematicians’ interest, this essay was sent to the *Revue des Deux-Mondes* (letter **344**) where it fell into the hands of Joseph Bertrand, French mathematician (1822-1900), who was to become one of Walras’s bitterest opponents.

Bertrand took only two days to reject the paper and suggested that Walras should publish it in a specialized review (letter 345). Walras thus sent his essay to the *Giornale degli Economisti*, which published it in Italian, in April 1876. In this article, Walras denounces the established French economists for their hostility to the recent mathematical innovations in economic theory, and he shows the irrelevance of the objections frequently raised against the use of mathematics in political economy, such as: “free will which enters into the determination of price cannot be constrained within mathematical formulas” (344, (2), p.494).

These documents reveal that Walras played W_p .

Thus Walras’s correspondence with Cournot as an *in vivo* experiment sheds a new light on the effectiveness of cheap talk in achieving efficient outcomes in a SH game: in such a game preceded by one round of two-way communication, when announcements are not simple (“I wish you to choose” instead “I will choose”), sequential announcements are less effective than simultaneous announcements. Cournot and Walras were living in a common environment, in which seniority was the principal criterion for the establishment of a social order. Thus they had a common incentive to follow the following convention: the system of ranking by seniority. Such a system brings with it a high degree of rigidity: there is only one ranking order for a given set of persons, regardless of variety of situation.

4. Conclusion

Coordination games feature multiple equilibria. The effectiveness of cheap talk in achieving efficient outcomes in such games is a subject of controversy. From a game-theoretic viewpoint, two types of coordination failures can arise. First, a fundamental kind of coordination failure can arise if a pure strategy equilibrium is not attained and *ex post* disequilibrium outcomes result. Second, players may unilaterally take actions that lead to a Pareto-inferior Nash equilibrium being played.

In this connection, Aumann (1990, 203) conjectures the following: on the one hand, in a two-person SH game, communication cannot affect the outcome of the game if the signaler(s) has (resp. have) a strict preference over the other player’s strategy choice; on the other hand, in a two-person BOS game, “an agreement to play an equilibrium often is self-enforcing”. Put briefly: “A non-binding agreement can affect the outcome of a game only if it conveys information about what the players will do” (*ibid.*).

In this paper, we have provided new tests of Aumann’s conjecture by using Walras’s correspondence as natural game experiments.

Through the study of the Walras-Jevons correspondence, we have shown that, in a BOS game preceded by one round of two-way communication, sequential announcements may help a lot even when messages about actions are not messages to take literally

Through the study of the Cournot-Walras correspondence, we have shown that, in a two-person SH game preceded by one round of two-way communication, sequential announcements are less effective than simultaneous announcements when messages about actions are not simple.

These results shed a new light on Aumann's conjecture: in a BOS game, it is possible that two-way communication does not hurt; in a two-person SG game, it is possible that two-way communication hurts.

Studying other letters is a natural topic for further research.

Notes

- 1) The numerals refer to letter numbers in Jaffé (1965). Bold-face numbers indicate letters written by Walras; arabic numbers letters to Walras. A numeral in parenthesis following a letter number indicates the note where the listed letter is found. * denotes letters studied in this paper. # denotes letters have been published earlier by Antonelli in *Econometrica*, January 1935.
- 2) The emphasis is ours.

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