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Game theory and history of economic thought: Walras's correspondence as a test of the effectiveness of cheap talk in achieving efficient outcomes.

Régis Deloche

Université de Franche-Comté
UFR SJEPG
LIBRE
25030 Besançon Cedex
France

Tel.: 00 33 3 81 66 65 78.
E-mail: regis.deloche@univ-fcomte.fr

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. First, through a survey of two famous game-theoretic analyses of historical facts, we show that letters matter. Second, building on these studies, we bring game theory, experimental economics and history of economic thought together by focusing on Walras's correspondence with British economists. This correspondence is considered as an economic setting in which renowned economists were repeatedly and randomly paired to play a battle of the sexes game. Results for all letters pooled over all periods reveal the existence of potential gains from coordination in a battle of the sexes game without communication. Third, we use Walras's correspondence with Cournot to shed a new light on the role of communication in overcoming these coordination problems. Through the study of these letters, we show that, in a battle of the sexes game preceded by one round of two-way communication, sequential announcements are more effective than simultaneous announcements

Key-words: Cournot, Walras, Cordination, Battle of the sexes, Cheap talk.

JEL Classification numbers: B13, B31, C72, C99

> "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, "La lettre", *Revue française*, 1859, p.201
>
> (translated from the French by Donald A Walker)

1. Introduction

According to Backhouse (1985), the 1870s do mark a twofold decisive turning point in the history of economic thought. On the one hand, economics became professionalized. Of the important economists writing in these decades, the vast majority were professors and also specialists in economics. The American Economic Association was founded in 1885, and the British Economic Association in 1891. It was at this time, too, that important contributions to economics came to be published in specialized journals: the *Quarterly Journal of Economics* was founded in 1886, the *Economic Journal* in 1891, and the *Journal of Political Economy* in 1893. On the other hand, a new orthodoxy – a system of economic equilibrium, in which maximizing behaviour on the part of individuals is brought into some sort of equilibrium through markets - replaced classical political economy. The use of mathematics enabled the economic theory to be stated more precisely, to be developed more fully, and to become more international.

In France, it was Léon Marie-Esprit Walras (1834-1910) who played the most distinguished role, both in the attack on the classical regime, and in laying the foundations of what was to become neoclassical economics. He is recognized as the founder of general equilibrium theory. He first saw the general independence of all prices and developed this idea into a comprehensive model of a competitive economy, contained primarily in his *Elements of Pure Economics*, published in installments between 1874 and 1877. His use of mathematics was the second major scientific accident that marked the progress of mathematical economics. Antoine-Augustin Cournot (1801-1877) was responsible for the first (Debreu, 1987).

In 1870, after he became established as professor in Lausanne, Walras engaged in a vast correspondence for a period of over 40 years (1870-1909) with the elite of the profession

throughout the world. He formulated, refined, and extended his theory of general equilibrium during a period of some 30 years. His desire to persuade others to accept his ideas and to recognize his priority of discovery in pure economics led him to sink three quarters of his modest private patrimony in his publications and their free distribution. He mailed his publications to economists in Europe and the United States. All these scholars were concerned with who first invented a complete system of economic equilibrium.

Correspondence of Léon Walras and Related Papers (Jaffé, 1965) reveals the tribulations of these pioneer scholars hewing out new paths. Walras and renowned economists hold a continuous seminar by correspondence. This correspondence left marks on the four successive editions of the *Elements* which appeared during Walras' lifetime. It contains unique and, at times, detailed information regarding behavior in strategic situations.

The purpose of this paper is to show that Walras's correspondence provides another laboratory in which to examine the relevance of the game-theoretic approach. Following Brams (1994), who uses works of fiction (novels, short stories, plays, opera librettos, narrative poems) to explicate the strategic choices of characters, as well as Metrick (1995) or Février and Linnemer (2002), who use television game shows as natural experiments to analyze behavior, we tentatively use Walras's letters as a natural experiment to test the effectiveness of costless, nonbinding, non verifiable communication (cheap talk) in achieving efficient outcomes in a battle of the sexes game.

The rest of the paper is organized as follows. Section 2 surveys studies in economic histories that bring fruitfully game theory and bodies of correspondence together. Section 3 highlights the similarities between Walras's correspondence with the British economists and a battle of the sexes game experiment. Section 4 uses the eleven letters that passed between Cournot and Walras to provide a test of the effectiveness of sequential announcements in a battle of sexes game with two-sided communication.

2. History as a society's laboratory: letters matter

In the sixty years since the appearance of von Neumann and Morgenstern's classic *Theory of Games and Economic Behavior* (1944), game theory, which is the existing theoretical framework for analyzing strategic situations, has been widely applied to problems in economics and business, political science (on both the national and the international levels) and the law. During that period, following the seminal experiment conducted at the Rand Corporation by Dresher and Flood in 1950 (Flood, 1958), considerable attention has been paid

to experiments involving interactive behaviour. In recent years, economic history (Greif, 2002) has provided both a new support for the empirical usefulness of game theory and an unusual laboratory in which to examine the relevance of game theory.

Greif (2002) surveys studies that bring game theory and historical facts together. These studies contain unique data sets regarding strategic situations and the relationship between rules and outcomes. "History is society's laboratory" (McCloskey, 1976): it supplies factual grist for the game theorist's mill; it provides an improved set of evidence to evaluate game theory; it illuminates this theory and tests it. As is well known, to see how well game theory explains the behavior of individuals, economists have two options: to construct a laboratory experiment or to find real-life data. When historical data are detailed enough to be useful, their advantage over laboratory experiments is twofold. First, incentives can be much larger. Second, the preferences of an individual are better reflected by real life choices than in a laboratory setting. The drawback of using such natural experiments is that there are many factors left uncontrolled. Game theory had sharp predictions but it is difficult to test in the field. However, historical facts are often more rich, accurate, and variable for game theorist's purposes than recent facts. In addition, in the eighteenth and nineteenth centuries, men often sought profit in as clear-headed and competitive a way as a game theorist might wish.

In this connection, two examples of historical experiments are outstanding: Carlos and Hoffman (1986) and Moldovanu and Tietzel (1998). These two studies make it abundantly clear that bringing game theory and bodies of correspondence together may be useful: on the one hand, they shed a new light on historical facts; on the other hand, they test some behavioural assumptions of game theory.

Carlos and Hoffman (1986) analyze two rich bodies of correspondence: letters between the Hudson's Bay Company (HBC) and its London management committee; letters between the committee and the Northwest Company (NWC). HBC and NWC were in the business of trading European manufactures to the native peoples for animal furs. HBC was a joint–stock, Limited Liability Company, established by Royal Charter in 1670. It was rigidly hierarchical. NWC was a joint-stock partnership, whose organizational structure encouraged flexibility. Such a duopoly was unhindered by antitrust legislation. However, between 1804 and 1821, these two companies made various fruitless attempts to arrive at a profit–maximizing agreement. The previously undisturbed bodies of correspondence analyzed by Carlos and Hoffman (*id.*) reveal that, between 1804 and 1821, these two companies made various fruitless attempts to arrive at a profit–maximizing agreement. First, each firm tried to mislead the other about its initial position. Second, the two firms searched for a mutually

agreeable mechanism: initially merger, then territorial division, then drive the other firm out of business, and finally merger once again. The analysis made by Carlos and Hoffman (*id.*) provides insight into the historical development of the North American fur Trade and empirical evidence on the problems encountered in bargaining under incomplete information. It illuminates aspects of seminal models of bargaining under incomplete information: achievement of a profit maximizing agreement may be hindered by incomplete information, commitment to a strategy leading to bargaining breakdowns, delineation of each party's rights under law, and environmental changes. HBC and NWC did wanted to maximize profits, and they understood the gains from cooperating and the dangers inherent in delaying, but the nature of the bargaining process made it particularly difficult for these firms to reach agreement.

Moldovanu and Tietzel (1998) analyze Goethe's letters. These letters reveal that Goethe employed a number of sophisticated strategies in his dealings with publishers. Goethe's letter, dated January 16, 1797, to the publisher Vieweg from Berlin, reveals that, 200 years ago, Goethe used a second-price auction (a sophisticated mechanism whose properties were first analyzed by Vickrey in 1961) with his publisher for his epic poem, *Hermann and Dorothea*. Goethe's letter, dated January 12, 1828, to Boissereée, reveals that Goethe's main motivation was to reduce the informational asymmetry pertinent to most author-publisher relations concerning the expected profit from a book. Goethe's aspiration was not fulfilled because Counsel Böttiger revealed Goethe's sealed demand (1,000 talers) to Vieweg. Goethe obtained exactly that sum, which was around 25% of the total profit from the first edition of his epic poem. In 1828, Goethe used the strategy of attracting many bidders for the publication of his *Collected Works*: he sold this collection (around 40 volumes) in an auction that included thirty-six different bidders. This auction with many bidders enabled Goethe to obtain 60,000 talers. That sum was around 90% of the total profit from this publication. The analysis made by Moldovanu and Tietzel (*id.*) illuminates aspects of modern auction theory. In addition, it sheds a new light on the main feature of the late eighteenth century German book market: the absence at that time of copyrights. As a consequence, a wealth of pirate copies plagued the book market, and, after buying a manuscript, even serious publishers did not inform the author about the number of editions.

Both these studies show that letters matter. Building on these studies, section 3 brings game theory and history of economic thought together. It concentrates on the correspondence of Léon Walras.

3. Priority matters: *Correspondence of Léon Walras* as a battle of sexes game experiment

The present state of opinion regarding the ways in which biography may be useful in the study of the history of economic thought is best represented by the differing views of George Stigler and William Jaffé: Stigler argues against biography, whereas Jaffé argues in favor of biography (Walker, 1983a).

Jaffé and Stigler believe that the history of economic thought has two aspects. First, there is the meaning of a theory. Jaffé maintains that biography is valuable for the purpose of establishing what an author intended to convey, whereas Stigler argues biography does not help us to understand the meaning of scientific theories because science consists of the arguments and evidence marshaled by a scholar that lead others to accept or reject his scientific views. Stigler contends that biography may even distort the interpretation of a writer's work. Second, there is the evolution of a discipline: the genesis of ideas and the sociology of the science. Jaffé asserts that biography is important for understanding the genesis of ideas, whereas Stigler does not indicate any interest in such genetic studies. Both Stigler and Jaffé think that biography is relevant for a study of the process of acceptance of a writer's ideas by his contemporaries.

In this connection, Jaffé's contribution to the literature of Walrasian scholarship is fundamental. Jaffé's annotated edition (1965) of the *Correspondence of Léon Walras and Related Papers* and Jaffé's *Essays on Walras* (Walker, 1983b) reveal the relation of other economists to Walras's intellectual biography. Jaffé's investigation of such a sociological matter has two dimensions. First, there is the story of scientific progress: the scrutiny by first-class minds of the important problems of neoclassical economics and the refinement of their ideas in their correspondence. Second there is the history that has reference to the characteristics and activities of the individuals who took part in the process of transmission, reception, and development of neoclassical economics' ideas and to the social, economic, and institutional conditions in which they lived and worked. Economics, like any science, is a social activity. Scientists are linked to the past by the knowledge they inherit. They are linked to their contemporaries by interaction.

Such a sociological history deals with the following questions. What is Walras's place in the history of general equilibrium theory? Was he the very first to have accomplished the working out of the general equilibrium theory? Who were the leading players? What were their number, personal motives and opportunities, clashes of will and temperament, striving

for recognition of priority, careers, means of communication, (use of) positions of power and prestige in the profession? Were the different contributions to the general equilibrium theory similar discoveries made by scientists working independently of one another? Were these different contributions an illustration of Merton's concept of a multiple discovery (Backhouse, 1985)?

Walras's correspondence directly answers the above questions, notably the latter. It reveals Walras's lifelong struggle to teach others about his work. It throws light on his efforts to disseminate and promote his ideas. Strictly speaking, it is in part constituted of those efforts.

Walras strove diligently for recognition of priority. Between 1870 and 1909, his desire to persuade others to accept his ideas and to recognize his priority of discovery in pure economics led him to engage in a vast correspondence with such scholars as Cournot, Jevons, Edgeworth, Marshall, Menger, Barone, and Pareto. Thousands of letters passed between him and these great figures in the development of the pure theory of economics in the 19th century. He had, for example, at least seventeen Italian correspondents, sixteen American correspondents and twenty British correspondents (*cf.* the *Select Index of Subjects* in his *Correspondence* [Jaffé, 1965]).

Walras and his Italian correspondents developed their ideas and reached agreement on a number of issues. For example, Walras had an important influence on the writing and teaching of Pareto and Barone. Similarly, in the United States, Irving Fisher and Moore greatly esteemed Walras's work. In 1896, Fisher was one of the rare defenders of the third appendix of the third edition of the *Elements of Pure Economics*, which contains an accusation of plagiarism against Wicksteed. In an exchange of letters that began in 1903, Moore declared himself to be a follower of Walras.

On the other hand, Walras was slighted by the British economists. Walras thought that he was the very first to have accomplished the working out of the general equilibrium theory, and he was rather touchy about matters pertaining to his self-esteem. He was quarrelsome. British economists refused to recognize him as the founder of general equilibrium economics, and they claim priority. They took a determined position not to make Walras's theory known in Engand.

As a consequence, the correspondence of Walras with the British economists may be considered as an economic setting in which a 2×2 battle of the sexes game arose. The normal-form of this game is shown in Table 1, where $x > z > 0$.

		C(olumn) Player	
		C_y	C_c
R(ow) Player	R_y	$0,0$	z,x
	R_c	x,z	$0,0$

Table 1

This game is symmetric. Each player has two moves to choose between: to yield, *i.e.* to recognize the other as the founder of general equilibrium economics, or to claim priority. The column player's payoff matrix is the transpose of the row player's: 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. Because of the symmetry of the game, each of the two players faces the same problems of strategic choice.

This game has two pure-strategy equilibria, (R_c, C_y) and (R_y, C_c). Each player prefers a different equilibrium. In (R_c, C_y), R plays for his favorite equilibrium, and C plays for R's favorite equilibrium. In (R_y, C_c), R plays for C's favorite equilibrium, and C plays for his 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.

Experimental results (see, *e.g.*, Cooper, *et al.*, 1989, hereafter CDFR) show that, without communication, the symmetry of the mixed-strategy equilibrium makes it a natural outcome of the game. The observed play of strategies *c* is less than the prediction from the symmetric mixed-strategy solution. The observed proportion of hits (the play of equilibrium strategies, *ex post*) is higher than the predicted level from the symmetric mixed-strategy Nash equilibrium. However the existence of potential gains from coordination is clear.

To some extent, it is possible to show that Walras's correspondence with the British economists furnishes experimental evidence that confirms these results,

A theory has three ingredients (Smith, 1989): environment (tastes and technology), institution (messages or actions) and behavior (agent choices of messages or actions given the

agent's characteristics and the practices relating such choices to allocations). A typical experimental design has one or more subject populations repeatedly, randomly, and anonymously paired to play a stage game in laboratory or other socially isolated settings (Crawford, 1998). To test the behavioral assumptions of a theory in its stage game, such an experimental design must control the environment and the institution. Control over the environment is achieved by using the techniques of induced valuation (Smith, 1976): preferences for actions are created by associating those actions with payoffs in a currency that subjects value. Payoffs that subjects are risk-neutral towards are created by the binary lottery procedure (Roth and Malouf, 1979): subjects are paid in lottery tickets, which are later used to determine their chance of winning a lottery for a fixed prize. Non pecuniary effects are suppressed by avoiding nonanonymous interactions such as face-to-face. Control over the institution is achieved by defining the manner (the language and the rules) in which subjects interact.

There are similarities between the above typical experimental design, which was used by CDFR, and Walras's correspondence with the British economists.

A great number of letters passed between Walras and his British correspondents, such as Jevons (about thirty letters), Edgeworth (about twenty letters), Marshall (about ten letters), and Wicksteed (about ten letters). Through this correspondence, each of these scholars strove diligently for recognition of priority. So they were repeatedly and randomly paired to play the game in Figure 1, in which each player has two moves to choose between: to claim priority or to yield.

All these scholars lived in a socially isolated setting: the ivory tower of pure science. Pure economics was their dominant passion. They praised highly those who found pure theory interesting in itself. However, they did not constitute a scientific community, because the situation in Britain and France was very different. Walras and Jevons, for example, were writing against two different backgrounds. It was only after 1874, *i.e.*, after Walras and Jevons discovered that they had independently developed similar theories (272, **275**)[1], that a widespread exchange of ideas and a scientific community began to develop on an international basis. As a consequence, in the course of his correspondence with the different British economists, it was difficult for Walras to know precisely the human beings he was playing with. To a certain extent, nonanonymous interactions were avoided.

[1] The numerals refer to letter numbers. Bold-face numbers indicate letters written by Walras; Arabic numbers letters to Walras. A numeral in parenthesis after a letter number indicates the note following the letter.

In addition, a procedure for creating payoffs that subjects are risk-neutral toward was used. All the scholars were eventually paid in lottery tickets, which were later used to determine their chance of winning a lottery for recognition.

Briefly put, results for all letters pooled over all periods show that the observed proportions of hits (the play of equilibrium strategies, *ex post*) was low, and the frequency of play of strategy *y* (to claim priority) high.

Walras's relationships with British economists began badly, with the shock of recognition that Jevons has preceded him. Early in May, 1874, Walras learned (267) that his theory of exchange was similar to a mathematical theory published in Jevons' *Theory of Political Economy*. Walras was discountenanced to learn that he was not the very first to have issued a marginal utility manifesto, but he honourably acknowledged Jevons' priority: "When there is nothing else left but to yield, one might as well do so with good grace" **(286)**. However, toward the end of the letter just quoted, he wrote that he believed that "the theorem of general equilibrium and the laws of the emergence and variation of equilibrium prices" would remain his own. In addition, he found some consolation for his self-esteem with the reflection that he had done better than Jevons in establishing a correct relation between utility and demand.

The relationship deteriorated further when Walras came to feel that Edgeworth did not try to give fair consideration to his work. Edgeworth was the first editor of the *Economic Journal* and continued in that post from 1891 to 1926. Walras denounced Edgeworth to Gide as "a past master of mathematical charlatanism" (**933**).

The relationship disintegrated when Walras was irritated by Marshall's device of printing his theorems for private circulation, thus preserving his rights to priority without publishing anything. Marshall was refusing to recognize Walras's priority of discovery in certain areas of economic theory. Marshall contented himself with approximations. Walras thought that there can be but a right and a wrong. He was contemptuous of Marshall: he denounced Marshall to Pareto as "that great white elephant of economic theory" (**1051**).

Finally, Walras went as far as to accuse Jevons and Wicksteed of plagiarizing his work. In this connection, Jaffé (Walker, 1983b) showed that it would be incorrect to credit Walras with any rights to priority in the mathematical formulation of the marginal productivity theory.

Thus, Walras's correspondence with the cohort of British players - Jevons, Edgeworth, Marshall and Wicksteed - reveals clearly the existence of potential gains from coordination in a battle of the sexes game without communication.

4. Walras's correspondence with Cournot as experimental evidence on behavior in a battle of the sexes game with communication: cheap talk matters.

Walras's correspondence with Cournot sheds a new light on the role of communication in overcoming these coordination problems.

Walras confided to a friend in 1901, that at the age of 19 he read in two sittings all of once famous Poinsot's textbook in pure mechanics, *Eléments de statique*, and then kept this book by him as a companion book throughout his life (**1483** [7]). Both Chapter II and the third "mémoire" of Poinsot'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. Thus the main inspiration for Walras's conception of general equilibrium was Poinsot's treatise.

However, Walras liked to give the impression that his father and Cournot 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. In describing to Moore the genesis of his system, 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 most apt for formulating this system" (**1614**).

A distinguished scholar (philosopher, mathematician and economist), a skilful writer, endowed with an original and lofty intellect, Cournot began and ended his career with writings in economics. In *Recherches sur les principes mathématiques de la théorie des richesses* (1838), Cournot first gave a rigorous analysis of market structure, and he gave it from a game-theoretic perspective. He then wrote *Principes de la théorie des richesses* (1863), putting into "literary" language what he had previously said in the language of mathematics. Despite the concessions Cournot made in the form of presentation, the *Principes* was no better received than the *Recherches*. His *Revue sommaire des doctrines économiques* (1877) is a long, non-mathematical statement of his earlier economic work.

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 August 16 and 23, 1873, Walras read his paper *Principes d'une théorie mathématique de l'échange*, in Paris before the *Académie des sciences morales et politiques*. Before making his debut as an economic theorist by reading this daring paper, which was a loud and clear call for a new approach to the theory of value, Walras wrote a letter to Cournot.

Dated August 12, 1873, this letter is the first one of the eleven letters that passed between Cournot and Walras between August 12, 1873 and February 14, 1875. Walras wrote six letters to Cournot, and Cournot wrote five letters to Walras. All these letters (Jaffé, 1965) had been published earlier by Jaffé with the assistance of Guilbaud in *Economie Appliquée*, January 1952. The letters of September 3, 1873 from Cournot to Walras and of March 20, 1874 from Walras to Cournot had been published earlier in *Econometrica*, January, 1935.

This 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 has 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 do any promotion of mathematical economics. Cournot declines the task (C). Fourth, Cournot and Walras part good friends (D).

(C) may be considered as an economic setting in which Walras and Cournot played a battle of the sexes game (*cf*. Figure 1) preceded by one communication round in which they made announcements about their pure intended decisions.

Cheap talk is costless, nonbinding, non verifiable communication (for a survey, *cf*. Farrell and Rabin, 1996). 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).

Theoretically, the effectiveness of cheap talk in achieving efficient outcomes is a subject of controversy. 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. Following Aumann [1990], communication cannot affect the outcome of the game if the speaker has a strict preference over the other player's strategy choice. A cheap talk statement about your planned behavior is only credible if it is *self-signalling*: you want to say it if and only if it is true. In the battle of the sexes game, players' interests are well aligned, and cheap talk can readily achieve coordination.

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 made by CDFR, 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. 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.

In (C) there is a simple sequential game of complete information, where an underlying battle of the sexes game, the normal form of which is shown in Figure 1, is preceded by one round of structured preplay communication in which Cournot and Walras make non binding announcements about their intended decision in the underlying game. Each player has two moves to choose between: to write an article to do any promotion of mathematical economics (*y*) or to do crucial research work (*c*).

Letters **293** and 294 constitute one round of two-way communication, but there are two differences between this communication structure and the two-way communication structure used by CDFR. First, the sentence within which the announcement is contained is "I want you to choose". Walras writes to Cournot: "I wish that you write a paper, the title of which would be *De l'application des mathématiques aux sciences en general et à l'économie politique en particulier*. Cournot's answer is: "You ought to write this paper". These two sentences are different from the sentence "I intend to choose", which is the sentence used by

CDFR. Second, announcements made by the players are not simultaneous: they are sequential.

Letter **327** shows the following: Cournot has played for his favorite equilibrium, and Walras has played for Cournot's favorite equilibrium. Walras wrote to Cournot: "I have written the first draft of *De l'application des mathématiques aux sciences en general et à l'économie politique en particulier.*" This result is striking. First, in a battle of the sexes game preceded by one round of two-way communication, sequential announcements are more effective than simultaneous announcements, though the sentence "I want you to choose", conveys no information regardless of whether trust is important or not, and so should not increase efficient play. Second, if the announcements of both players do not constitute a pure strategy equilibrium in the second stage game, the sender of the second message simply chooses his preferred equilibrium, and the sender of the first message best responds.

Written in 1875, Walras's essay *Une branche nouvelle de la mathématique. De l'application des mathématiques à l'économie politique* remained unpublished in French (345 and 347), but appeared in Italian, in 1876, in the *Giornale degli Economisti*. In this article, Walras denounces the established French economists for their hostility to the recent mathematical innovations in economic theory, and he makes short work of the objections frequently raised against the use of mathematics in political economy (**344** [2]).

5. Conclusion

This paper was devoted to a study of Walras's correspondence as a test of the effectiveness of cheap talk in achieving efficient outcomes. First, we have surveyed two famous game-theoretic analyses of historical facts to prove that letters matter. Second, building on these studies, we have brought game theory and history of economic thought together by focusing on Walras's correspondence with British economists. We have shown that this correspondence may be considered as an economic setting in which renowned economists were repeatedly and randomly paired to play a battle of the sexes game. Results for all letters pooled over all periods reveal the existence of potential gains from coordination in a battle of the sexes game without communication. Third, we have used Walras's correspondence with Cournot to shed a new light on the role of communication in overcoming these coordination problems. We have shown that in a battle of the sexes game preceded by one round of two-way communication, sequential announcements are more effective than

simultaneous announcements Studying other bodies of correspondence is a natural topic for further research.

REFERENCES

Aumann, R. (1990). "Nash Equilibria are not Self-Enforcing," in *Economic Decision Making: Games, Econometrics and Optimisation* (J. Gabszewicz, J.-F. Richard, and L. Wolsey, Eds.), pp.201-206. Amsterdam: North-Holland.

Aumann, R., and Hart, S. (2003). "Long Cheap Talk," *Econometrica* **71**, 1619-1660.

Backhouse, R. (1985). *A History of Modern Economic Analysis*, Oxford: Basic Blackwell.

Brams, S. (1994). "Game Theory and Literature," *Games and Economic Behavior* **6**, 32-54.

Carlos, A., and Hoffman, E. (1986). "The North American Fur Trade: Bargaining to a Joint Profit Maximum under Incomplete Information, 1804-1821," *Journal of Economic History* **46**, 967-986.

Cooper, R., Dejong, V., Forsythe, R. and Ross T. (1989). "Communication in the battle of sexes game: some experimental results," *Rand Journal of Economics* **20**, 568-587.

Crawford, V. (1998). "A survey on experiments on Communication via Cheap Talk," *Journal of Economic Theory* **78**, 286-298.

Debreu, G (1987). "Mathematical Economics" in *The New Palgrave: a Dictionary of Economics* (J. Eatwell, M. Milgate, and P. Newman, Eds.), Vol 3, pp.399-404. London: Macmillan.

Farrell, J. (1988). "Communication, Coordination, and Nash Equilibrium," *Economic Letters* **27**, 209-214.

Farrell, J., and Rabin, M. (1996). "Cheap Talk," *Journal of Economic Perspectives* **10**, 103-118.

Février P., and Linnemer, L. (2002). "Strenghts of the 'Weakest Link'?" Crest Working n°2002-24.

Flood, M. (1958). "Some Experimental Games," *Management Science* **5**, 5-26

Greif, A. (2002). "Economic History and Game Theory," in *Handbook of Game Theory with Economic Applications Volume 3* (R. Aumann, and S. Hart Eds.), pp.1989-2024. Amsterdam: North-Holland.

Jaffé, W (1965). *Correspondence of Léon Walras and Related Papers*, 3 vols, Amsterdam: North-Holland for Royal Netherlands Academy of Sciences and Letters.

Metrick, A. (1995). "A Natural Experiment in 'Jeopardy,'" *American Economic Review*, 85, 240-253.

McCloskey, D. (1976). "Does the Past Have Useful Economics?" *Journal of Economic Literature* **14**, 434-461.

Moldonavu, B. and Tietzel M. (1998). "Goethe's Second-Price Auction," *Journal of Political Economy* **106**, 854-859.

Roth, A., and Malouf, M. (1979). "Game-Theoretic Modelsand the Role of Information in Bargaining," *Psychological Review*, 86, 574-594.

Smith, V (1976). Experimental Economics: Induced Value Theory," *American Economic Review*, 66, 274-279.

Smith, V (1989). "Theory, Experiment and Economics", *Journal of Economic Perspectives*, 3, 151-169.

Walker, D. (1983a). "Biography and the Study of the History of Economic Thought," in *Research in the History of Economic Thought and Methodology* (W. Samuels Ed.), pp.41-59. London: JAI Press.

Walker, D. (1983b). *William Jaffé's Essays on Walras*, Cambridge: Cambridge University Press.