The game is afoot: The French reaction to game theory in the fifties

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Abstract

In this paper, we are interested in exploring the history of game theory in France, and particularly the way it was received and was diffused in the fifties. It will be shown that France was the most fertile soil in the whole continental Europe for a multidisciplinary welcoming to game theory. Reviewing certain aspects of the intellectual trajectory of the mathematician Guilbaud, the ethnologist Lévi-Strauss and the psychanalyst Lacan, we show how each of them, in his own way, played a key role in advancing game theory: (1) Guilbaud for his constancy in disseminating game theory (and mathematics in general) (2) Lévi-Strauss for his original interpretation of game theory that had some impact on social sciences; and (3) Lacan for using the contributions of game theory. Lacan and Lévi-Strauss were particularly convincing since they were instructed on request about the principles of game theory by Guilbaud.

Keywords: Game Theory, Guilbaud, Lévi-Strauss, Lacan, interdisciplinarity, qualitative mathematics

1. Introduction

John von Neumann and Morgenstern's (1944) pioneering work on game theory, *Theory of Games and Economic Behavior*, was welcomed almost unanimously. The publication of numerous laudatory reviews about this fundamental book reflect this point (Dimand and Dimand, 1995). The originality of von Neumann and Morgenstern consisted in their pursuit of a mathematics for economics. For these authors, economic analysis could not achieve major developments without an adequate instrument. The analogy with heat theory in the introduction of the book is enlightening in this respect. For studying the propagation of heat, Fourier developed a mathematical tool, called Fourier's series, that was later used in different fields, for example in the cases of signal theory or digital image processing. The originality of Fourier consisted in his ability to conceive the required mathematics for his study.

It is true that if we look backward, we note that the long and sometimes tumultuous history of the relationships between economics and mathematics demonstrates that the authors like Cournot (1980/1838) and Stackelberg (2011/1934) had applied the mathematics of their time to their field of study without producing any new mathematical theory. They both used more or less elaborated forms

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of optimization under constraint. By contrast, von Neumann and Morgenstern caused a real turning point by developing a general mathematical theory for analyzing the situations of interactions.

The book is organized around three major themes: the theory of zero-sum games, the theory of cooperative games, and since the second edition, a presentation of the axiomatic foundations of the theory of expected utility under uncertainty. Despite its importance in founding a new approach, the book is limited on certain issues. For cooperative games, von Neumann and Morgenstern defined a solution concept which is known in the literature as stable-set or von Neumann – Morgenstern solution. But they do not provide a general existence theorem[1]. Similarly, the zero-sum games constitute a very specific type of games narrowing the potential field of application of game theory[2]. It should be added that the book's illustrative examples are rarely inspired by economic problems[3]. These shortcomings contributed to attenuate the initial enthusiasm for the book.

As noted by Luce and Raiffa (1957, p. 10): "We have the historical fact that many social scientists have become disillusioned with game theory. Initially there was a naive band-wagon feeling that game theory solved innumerable problems of sociology and economics, or that, at the least, it made their solution a practical matter of a few years' work. This has not turned out to be the case".

We have here an overview that conceals some specific points. France does not completely confirm the general tendency described by Luce and Raiffa. We do not claim that game theory was accepted unanimously; but in the fifties, the promoting efforts of some outstanding scholars allowed game theory to gradually make a name for itself. These scholars including the mathematician Georges-Théodule Guilbaud, the ethnologist Lévi-Strauss, and the psychanalyst Jacques Lacan were all motivated by the conviction that the future of social sciences requires the use of formalization. Although game theory was presented as the mathematics of economics, the deep-seated ambition of von Neumann and Morgenstern was not less than to make it as the favorite approach of social sciences (Leonard, 2010). Thus it is not surprising that an ethnologist and a psychanalyst acknowledged it as such. They even took up the cause of game theory more seriously since Guilbaud had trained them to some extent with this new type of mathematics.

In this paper, we are interested in elements of this history by underlining the part these three authors played in the reception and diffusion of game theory in France. We will particularly highlight the French institutional context during the fifties to determine the issues that each of these authors addressed and

[1] Their existence result only concerns games with three players.
[2] It may be recalled that zero-sum games represent two thirds of the book and non-zero-sum games are treated by using the "fictitious player" device (Schmidt, 1995).
[3] The book's examples that may be of interest to economists are bilateral monopoly as well as the game with a seller and two buyers.

endeavored to treat by advocating the use of game theory. This will allow us to cast light on the specific roles they played in renewing their respective fields of research[4].

2. From economics to social sciences

2.1. The economists' indifference

When von Neumann and Morgenstern's *Theory of Games and Economic Behavior* was published, French economists were not yet ready to grasp its subtleties. It is noteworthy to recall that in the aftermath of the Second World War, there was no economics department in French universities, and economics was not even considered as an independent field strictly speaking. The first bachelor degree in economics was created in 1961. At that time, economics was still a side discipline in law faculties, and specialization in economics was impossible earlier than the doctoral-degree level (Le Van-Mesle, 2004). This proximity with the faculty of law has led a significant number of academic economists to adhere to a literary tradition refusing for a long time the use of mathematical formalization. Hence, in French universities, a few exceptions aside, the two major movements, namely the liberal economists (represented among others by Charles Rist and René Courtin) and the economists with a sociological tendency (represented by Jean Marchal and Jean Lhomme for example) shared a deep-rooted mistrust for mathematical economics (Arena, 2000)[5]. Thus, they could not subscribe to game theory, and this lack of support was enforced by the fact that game theory seemed to be an adequate mathematical instrument for tackling microeconomics whereas they were all interested in macroeconomics.

We find the tangible presence of the influence of economists with a sociological tendency during the first years of the very new generalist peer journal *Revue Economique* in 1950. In its first editorial note, the editors declared that the new journal "would work to advance both the methodological problems and the objective knowledge regarding the facts" by framing "strongly the political economy within the whole social sciences and research such as history, geography, sociology, or other apparently more remote disciplines like anthropology and ethnology" (p. 3).

In fact, the advocates of mathematical modeling, namely the engineer economists were outside law faculties. They were the representatives of the neo-marginalist thought (Arena, 2000). Trained in the

[4] In this paper, we have drawn upon the English translations of all French references whenever they were available; otherwise we have ourselves translated the French texts in English.

[5] It is worth pointing out that despite the refusal to use mathematical models, statistics was an exception since it was the only mathematical teaching that found favor with academic economists. The use of statistics was partially inspired by the historical method in which observation had a prominent place. However, this did not concern econometrics (Le Van-Lemesle, 2004).

most prestigious engineering schools such as Ecole Polytechnique or Ecole Nationale des Ponts et Chaussées, they were high-ranking officials (Pierre Massé, Marcel Boiteux), research fellows at Centre National de la Recherche Scientifique - CNRS (Maurice Allais), or teachers in engineering schools (François Divisia), and schools like Ecole d'Application de l'INSEE[6] (Edmond Malinvaud) or Institut de Statistique de l'Université de Paris better known by the acronym ISUP[7] (René Roy). They adopted a representation of the economy in terms of models at a very early stage particularly under the influence of Divisia, one of the the founders of *Econometric Society*, who himself was inspired by Tinbergen's contributions (Armatte, 2005).

At the beginning of the 1950s, the neo-marginalist current was led by Allais and his pupils, namely Malinvaud and Boiteux, contributing to mathematical economics[8]. We could expect that they had some interest in game theory. However, none of them invested in this field.

Despite this unfavorable institutional context, von Neumann and Morgenstern's work received positive reviews. This started with two reviews published in 1949: one by the mathematician Guilbaud in the peer journal *Economie Appliquée* and the other by the liberal economist Justman in another peer journal, *Revue d'Economie Politique*. Lagache (1950), an economist with a sociological tendency, suggested, for his part, a reflection regarding game theory and what it can teach us about the advantages and the limits of using mathematics in economics. In 1951, another review was written by a liberal economist Fourastié (1951). A year later, Guilbaud (1952) published an article concerning different mathematics that were historically used to examine the distribution issue. He reviewed the works of Euclid, Plato, Chuquet, Pascal, Clausewitz and Borel, among others. This article concluded by discussing how the distribution issue could be tackled using game theory. The theoretical framework assumed a game with N players, but the suggested treatment considered a game with three players. This example enabled Guilbaud to illustrate the notions of the rule of the game, characteristic function and von Neumann - Morgenstern solution. Following this line of research, he highlighted the originality of the game theory approach.

Like most Anglophone reviews, those of Justman, Guilbaud and Fourastié are highly laudatory and note the innovative nature of the book. The latter was presented as a "fundamental book for economic science" (Justman, 1949, p. 617), an "extraordinary success" (Guilbaud, 1949, p. 276) and "contributing most valuably" to our knowledge (Fourastié, 1951, p. 873). Lagache (1950, p. 410) expresses similar

[6] This institution became l'Ecole Nationale de la Statistique et de l'Administration Economique in 1960.
[7] In this paper, the acronym ISUP stands for l'Institut de Statistique de l'Université de Paris.
[8] Debreu was also a pupil of Allais, but we do not refer to him since during the period under our scrutiny, he was not in France but in the United States.

enthusiasm suggesting that "von Neumann's game theory and Norbert Wiener's *Cybernetics* are the first scientific attempt on the human social conduct and the first success".

While recognizing the abstract nature of this new mathematics, these authors thought that through game theory, economists could now have an instrument capable of capturing social and economic phenomena. For example, we can observe this point in Fourastié (1951, p. 875-876) according to whom: "von Neumann and Morgenstern have no difficulty in showing that far from applying only to a few invented games for men's refreshment, their calculation method applies to a very large number of observations related to the sensitive world. In fact, from the perspective of determinism and randomness, a man's situation in a good game of bridge is not different from a commander of a warship or an army at war, or the head of state seeking the maximum efficiency for a nation, or the head of an enterprise maximizing profit". Justman (1949, p. 633) also emphasizes the same idea when he writes: "This book provides the opportunity for economic science to capture reality more concretely than previous studies."

By contrast, Guilbaud's enthusiasm is accompanied by some reservations. For this author, von Neumann and Morgenstern's work is "monumental" but "incomplete". Game theory is "a marvelous mathematical-logical instrument" but "an instrument that has not necessarily proven itself" (1949, p. 276). Indeed, he formulates an original criticism of the book underlining that for von Neumann and Morgenstern, the game is "limited in time: it has a beginning and an end" (1949, p. 290), whereas economic reality is not governed by any time limit. Relaxing this time constraint is a necessary condition to apply the new theory in a more general context. In other words, the research program inaugurated by von Neumann and Morgenstern is in its early stages and the challenge will necessarily be a long-term process.

However, generally speaking, these comments had no influence on the discipline due to the widespread indifference among economists. By indifference, we mean the fact that the book was almost never cited in the work of this period. Even economists such as Justman, Lagache and Fourastié who were highly laudatory at the beginning, no longer mentioned this research. The only exception was Guilbaud aspired to familiarize economists with mathematics, a personal aspiration that dated back to his training in ISUP.

2.2. Guilbaud, an atypical mathematician

Guilbaud's trajectory is that of a mathematician who tried to cross the strongly separated disciplinary frontiers. Indeed, while he was a student at the Ecole Normale Supérieure (from 1932 until 1935), Guilbaud earned a certificate under the supervision of Georges Darmois in probability and statistics from ISUP. Darmois had undertaken the responsibility of this certificate at the request of the Mathematician Borel.

This first contact with Darmois and the fields of probability and statistics led Guilbaud to believe that mathematics could "be useful for everyone, including people doing economics, management, and even things that are clearly literary" (Colasse et Pavé, 2002, p. 68). This idea was strengthened in him particularly after Darmois first applied mathematics to economics in a paper in 1937, and notably when Darmois explored the role of mathematics and statistics in psychology in his book *Les Mathématiques de la Psychologie* (*Mathematics of Psychology*) in 1940.

Hence, it is not surprising that Guilbaud's first works were conducted in collaboration with non-mathematicians. This is the case of his first contribution in 1945, a book coauthored with the psychologist Daval in which he developed a reflection about the nature of mathematical reasoning. Furthermore, he published an article in 1946 regarding bilateral monopoly in collaboration with economist Guitton. Both of them settled in Dijon where Guitton taught in the Law faculty and Guilbaud in preparatory classes[9]. As a result, he was recruited in 1947 as a research fellow in the Institut des Sciences Economiques Appliquées, the center founded and directed by Perroux. He stayed in that center until 1955, and became its vice-president in 1951. Thus, Guilbaud became a mathematician who evolved in the economists' milieu.

He was thought of as eccentric as he differed from the standard profile of French mathematicians at the time. Indeed, the fifties were marked by Bourbaki's era during which mathematics was considered to be a whole profound unit (this unity justified the use of a singular term, and thus "mathematic" and not "mathematics"), and if that was not the case, unity had to be sought for, hence the importance of axiomatic and pure mathematics. It should be added that he took over Condorcet's "social mathematic" for his own account and expressed it in plural form as "social mathematics". In doing so, Guilbaud avered that his goal was, first, to be a go-between for ideas between mathematics and social sciences, and, second, to promote the idea that problems raised by social sciences could contribute to the development of mathematics. His goal of being a go-between agrees with Bourbakism to the extent that mathematical applications to other fields are encouraged (Aubin, 1997). Regarding the second point, Guilbaud found himself in stark contrast with Bourbaki group's principle, according to which mathematics should be preserved from the influence of the outside world and other scientific disciplines (Aubin, 1997). He took cognizance of the consequences of this point quite rapidly. As he noted: "At the beginning of the fifties, I had explained to Henri Cartan (one of the founding members of Bourbakism) that the École Normale Supérieure pupils had to be informed about these novelties [namely formalization in economics]. He kindly rejected my idea and I understood why he did so: he was afraid that I could pervert youth" (Colasse and Pavé, 2002, p. 68). He continued by underlining that for the

[9] Guitton was professor at the faculty of law in Dijon from 1939 until 1952 and Guilbaud taught at the Lycée in Dijon from 1941 to 1947.

mathematicians specialized in pure mathematics "there was some doubt about me: "why does he interfere?", "Why does he come to this trough?" Guilbaud was perfectly aware of having an unconventional profile but this precisely drew him to game theory as an instrument conceived for economists.

Guilbaud did not seek to contribute to internal developments of game theory. His priority was to disseminate the principles of game theory among academic economists given that this instrument was amenable to economic analysis despite the fact that a great majority of economists were averse to mathematics. The publication of his review of von Neumann and Morgenstern earned him a reputation as Mr. Game Theory among economists for at least two reasons. First, because the review was voluminous running to 45 pages and second, since it was accessible to the reader and well-balanced in its content (presenting the book as a roadmap and by insisting on the advantages and limits of game theory). This was his signature look, favoring pedagogy while maintaining equilibrium. This also explains why his review was translated in English, after being selected by a panel of editors for the first issue of a series of works titled *International Economic Papers* launched by the International Economic Association (with the support of UNESCO) in 1951.

It is against this background that the paths of Guilbaud and Darmois reconnected again, the latter inviting Guilbaud to accept the co-responsibility for a seminar on game theory with Massé, under the title of "Strategy and economic decision". This seminar was inaugurated in 1951 in Institut Henri-Poincaré where Darmois headquartered the secretariat of ISUP. Hence, the Institut Poincaré became the first place to diffuse game theory in France with the support of what was later known as Guilbaud's seminar[10].

2.3. Beyond economics

Guilbaud had set himself another major challenge, namely to apply game theory to other social sciences. In his advocacy of game theory, he quickly gained the strong personal support of Lévi-Strauss and Lacan, if not of their disciples. Indeed, Lévi-Strauss took the initiative to approach Guilbaud. Lévi-Strauss had lived in exile in New York during the Second World War where he took cognizance of the debates over von Neumann and Morgenstern's book. During his exile, he devoted himself to drafting his doctoral thesis (Thèse d'Etat), which he later defended in 1948. The thesis was published in 1949, titled *Les Structures Elémentaires de la Parenté* (*The Elementary Structures of Kinship*). In this book, he cited von Neumann and Morgenstern's book regarding the problem of incest using structural linguistic method, an issue over which he was inspired by the linguist Roman Jakobson. He had justified this orientation very early by underlining that "like phonemes, kinship terms are elements of meaning;

[10] Harold Kuhn as well as Boiteux and Malinvaud attended this seminar (Kuhn, 2007).

like phonemes, they acquire meaning only if they are integrated into systems. "Kinship systems," like "phonemic systems," are built by the mind on the level of unconscious thought. […]. The problem can therefore be formulated as follows: Although they belong to *another order of reality*, kinship phenomena are *of the same type* as linguistic phenomena" (Lévi-Strauss, 1963/1958/1945, p. 34) [11].

The originality of Lévi-Strauss was not in his use of structural linguistics but rather in his appeal to mathematical formalization as a complementary method to this type of structuralism. His goal was to use a hypothetic-deductive framework that could be verified. As stated by Lafrance (1978, p. 672): "[for Lévi-Strauss] a structuralism that does not include the idea of a constructed model does not deserve to be called structuralism unless a person applies an abusive and misleading homonymy in defining its true meaning. Hence, it is not sufficient to refer to the idea of a system or to think about totalities to be a structuralist." This point is particularly highlighted in an annex of his book written by one of the founders of Bourbakism, namely André Weil, who used group theory to characterize the rules of marriage in the Murngin tribe of Australia[12]. It is, among others, this successful collaboration with a mathematician that contributed to the rapid development of structuralism in France in which actors such as Lacan (in psychoanalysis) or Piaget (in developmental psychology) participated in their own way and received advice from different mathematicians in accordance with their specific field. It is hard not to see in this evolution the example given by the mathematician von Neumann and the economist Morgenstern.

Lévi-Strauss found in Lacan, whom he met in 1950, an influential fellow traveler. Lacan, r while identifying himself with structuralism, had already used mathematics in two articles published in 1945 and 1946. Furthermore, both of them were persuaded by Jakobson, who had come to Paris to meet them during the fifties, that Wiener's cybernetics and Shannon's mathematical theory of communications were instruments of interdisciplinarity (Geogeghan, 2011). This resulted in a paper by Lévi-Strauss (1963/1958/1951) in which he recommended the reading of Wiener's *Cybernetics*. However, he devoted most part of his paper to questioning Wiener's position that mathematics could not be used in social sciences. He particularly insisted on the use of mathematics in structural linguistics.

Aware of the lacunae in his knowledge of mathematics and wishing to develop his works in terms of models, it became urgent for Lévi-Strauss to be surrounded by mathematicians. Thus, he turned to Guilbaud by the end of 1950. Under the auspices of Guilbaud, working meetings were organized during the year 1951 in which Lévi-Strauss, Lacan and the linguist Benveniste took part. They wanted to establish links between mathematics and social sciences (Roudinesco, 2010). During these discussions,

[11] In the French version, see Lévi-Strauss (1958, p. 41).
[12] Regarding the characteristics of structural linguistics and Lévi-Strauss's approach, as well as the model developed by Weil, see Leonard (1997).

game theory occupied a considerable place[13]. Thanks to these meetings, Guilbaud became Lacan's advisor.

We do not have any information why Guilbaud approached Lacan (rather than Lévi-Strauss). But one possible explanation may be found by considering Lacan's article published in the review *Les Cahiers d'Art* in 1945. In this article, Lacan analyzed the solution to a logical puzzle – a solution that he criticized as a "sophism" – and, in so doing, developed a new way of reasoning that was directly related to game theory. However, after the publication of this article, Lacan did not refer to this type of reasoning until the fifties but then suddenly – and thoughout his subsequent career – he started to consider it as one of the cornerstones of his teaching and presented it as his contribution to game theory. Everything indicates that once he referred this article to Guillbaud, it was Guilbaud who let him know the link between his new logical reasoning and game theory.

To support our idea, it may be noted that Guilbaud (1953) was the first to highlight Lacan's article as an example of logical reasoning in conformity with game theory's philosophy. Hence, the proximity between Lacan and Guilbaud was strengthened by the fact that Lacan had already been imbued by the internal logic of game theory facilitating their dialogue.

What did this article contain? Without being aware of it, Lacan had developed a reflection in relation to common knowledge in this paper, i.e. an important notion in game theory (due to its consequences on agents' behavior).

An event is described as "common knowledge" among a group of players if all the players know the event, and if all the players know that all the players know the event and that all the players know that all the players know that all the players know the event, and so on and so on to the infinite. Under the assumption of common knowledge, information regarding the event is considered to be so perfect that the players' belief becomes transparent. The game-theory literature usually traces the origin of this notion to Littlewood (1953), who provided examples of reasoning based on common knowledge. But it was Lewis (1969) who coined the term and offered a first definition of the notion in a study in which he showed how a convention was the source of language. This notion was subsequently reintroduced by Aumann (1976) under its current definition. Aumann the also furnished a mathematical formulation for

[13] In fact, in her book, Roudinesco (2010, p. 1935) writes: "in 1951, Lacan, Benveniste, Guilbaud and Lévi-Strauss started to meet each other to work on the structure and establish bridges between human sciences and mathematics". This statement does not allow us to know whether their joint work was a long term project (expressing Lacan's and Lévi-Strauss's real desire to acquire mathematical instruments from Guilbaud) or just a temporary one. Having contacted Elisabeth Roudinesco in this respect, she brought the following clarifications in an email dated August 13, 2017 to our attention: "I checked my notes and I am able to respond with certainty. In my interview with Guilbaud on Octobre 10, 1985, he very clearly says that there were several meetings between Benveniste, Lacan, Lévi-Strauss and himself during 1951. Lévi-Strauss also confirmed this point. These meetings were about the structure, game theory, praxeology, possible relationships between human sciences and mathematics. But afterwards, it was only with Lacan that the work was continued, to the point that Guilbaud considered Lacan as a sort of pupil and that his passion for mathematics was highly sincere."

it. Eight years ahead of Littlewood and more than thirty years ahead of Aumann, Lacanclearly perceived the importance and the interest of reasoning based on common knowledge at a very early stage.

Lacan's starting point is a problem related to three prisoners. They are all held together in the same cell and the prison director should free one of them. In order to determine the one who should be released, the prison director considers the following situation. He announces that each of them will have a disk on his back, knowing that these disks are taken from a batch of 5, composed of 3 white disks and 2 black disks. None of the prisoners can see the color of his disk but each of them is able to observe the color of the other two disks belonging to the two other prisoners. However, they cannot communicate with each other. The prison director also emphasizes that only the first who discovers the color of his disk and who is able to demonstrate his conclusion by rational reasoning will be released. He has to get past the cell door to manifest his ability to solve the riddle.

These terms and conditions expressed, each prisoner was then given a white disk. The question is how each of them will behave to find this point. Lacan demonstrates that each prisoner will infer logically that he has a white disk so that all of them exit the cell simultaneously. In fact, Lacan (2006/1966/1945, p. 162) shows that the reasoning of each prisoner is as follows: "I am a white, and here is how I know it. Since my companions were whites, I thought that, had I been a black, each of them would have been able to infer the following: "If I too were a black, the other would have necessarily realized straight away that he was a white and would have left immediately; therefore I am not a black." And both would have left together, convinced they were whites. As they did nothing of the kind, I must be a white like them. At that, I made for the door to make my conclusion known."

The conclusion to which Lacan arrives is the result of common knowledge (1) none of the prisoners can see the color of the disk that belongs to him, (2) every prisoner can see the color of the disk that belongs to the other prisoners, and (3) at least one of the white disks is given to one of the prisoners. In fact, the rules of the game being perfectly known and identical for all, the prisoners know that they are in the same condition allowing them to deduce that everyone has a white disk. We now have a better understanding of Lacan's interest in game theory. Starting from his idea about logical reasoning, he sought in game theory the elements to confirm and deepen his approach, and this idea of logical reasoning certainly convinced Guilbaud to consider a rapprochement with him.

3. Ups and downs

3.1. Trial and error of Lévi-Strauss

The working meetings of 1951 with Guilbaud convinced Lévi-Strauss to focus on game theory as evidenced by his first attempt to apply it in *Race and History* in which he sought to show that cultural differences were the source of progress. This can particularly be observed in chapter 9 where the author adopts a narrative approach to demonstrate that the dichotomy between an "isolated player" and "coalition" leads to the following conclusion: "all cultural progress depends on a coalition of cultures. The essence of such a coalition is the pooling […] of the wins which each culture has scored in the course of its historical development. Lastly, we have recognized, that, the greater the diversity between the cultures concerned, the more fruitful such a coalition will be. If this is admitted, we seem to have two conditions that are mutually contradictory. For the inevitable consequence of the practice of playing as a syndicate, which is the source of all progress, is, sooner or later, to make the character of each player's resources uniform. If, therefore, one of the first requisites is diversity, it must be recognized that the chances of winning become progressively less as the game goes on" (1952, p. 46).

Furthermore, in a paper in 1953 reprinted in his work *Anthropologie Structurale* (*Structural Anthropology*), he furnished the bases of a model capable of capturing the rules of marriage in terms of game theory. He noted the differences between board games and the rules of marriage in the sense that "the former are constructed in such a way as to permit each player to extract maximal differential values from statistical regularities, while marriage rules, acting in the opposite direction, aim at establishing statistical regularities in spite of the differential values existing between individuals and generations" (1963/1958/1953, p. 298)[14]. From these differences, he inferred that matrimonial rules correspond to "upturned games", and hence they would be analyzable by the same method as the ones applied to board games. Thus in both cases, once the rules of the game are fixed, every individual or group tries to play the same way, that is to increase its own comparative benefits at the expense of others. In terms of marriage, this would mean gaining more women, or a more coveted wife, according to esthetic, social or economic criteria.

Even if Lévi-Strauss does not explicitly state it, the game he has in mind is a dynamic game. This is particularly clear in his study of kinship in which he wrote "kinship is not a static phenomenon; it exists only in self-perpetuation. Here we are not thinking of the desire to perpetuate the race, but rather of the fact that in most kinship systems the initial disequilibrium produced in one generation between the group that gives the woman and the group that receives her can be stabilized only by counterprestations in following generations" (Lévi-Strauss, 1963/1958/1945, p. 47)[15]. Marriage is thus described as the gift of a woman from one group to another. This implies a treatment in terms of an intergenerational game since this gift will have to be returned to the next generation.

[14]In the French version, see Lévi-Strauss (1958, p. 328).
[15] In the French version, see Lévi-Strauss (1958, p. 57).

He also specifies that the rules of game are independent from the nature of partners (individuals or groups), and that "what is important is to find out when a given player can make a choice and when he cannot" (1963/1958/1953, p. 298)[16]. These clarifications indicate that he had grasped the notion of game well since the status that he attached to the rules of game was perfectly consistent with the interpretation provided by game theory. Considering the framework thus defined, one can hope an "increasing consolidation of social anthropology, economics, and linguistics into one great field, that of communication, is to make clear that they consist exclusively of the study of rules" (1963/1958/1953, p. 298)[17]. This allows us to understand the reason for which Lévi-Strauss was so attracted to game theory resided in the fact that a social system could be grasped in terms of rules of the game. This notion could be used to describe a social system and analytically study such a system[18].

However, he does not suggest a complete analysis of his 'marriage game'. Failing in persuading Guilbaud to find an interest in his problems, he could not do more than he had done. After his meeting with the young mathematician Benoit Mandelbrot, he seemed to pay some attention to the links between linguistics and the theory of communication. As he mentioned in a letter to Jakobson: "I am in contact with a young television engineer (nephew of [Szolem] Mandelbrot) who classifies the world languages according to more or less degree of easiness with which they can be codified, and he believes that he has discovered in linguistic some rules of thermodynamics" (Jakobson and Lévi-Strauss, 2018, p. 146-147). He adds in another letter that: "he has not published anything but recently made a communication in which he says that he had proved that the distribution of information among words in several languages leads to a law […] more satisfying than the law of Zipf" (Jakobson and Lévi-Strauss, 2018, p. 150).

Mandelbrot's communication to which Lévi-Strauss refers is derived from his doctoral thesis defended in 1952, C*ontribution à la Théorie Mathématique des Jeux de Communication* (*Contribution to the Mathematical Theory of Communication Games*), in which he applies game theory to the theory of communication. The setup is a game with three players, a transmitter (of the information), a receiver (of

[16] In the French version, see Lévi-Strauss (1958, p. 329).
[17] In the French version, see Lévi-Strauss (1958, p. 329).
[18] He chose the same analogy for folk tales in an article in 1960 that was republished in *Anthropologie Structurale 2* (Structural Anthropology 2): "As we have seen, the tales containing several *parties* are characterized by the non-immediate recurrence of the same functions, as in successive card games one periodically shuffles, cuts, deals, calls, plays, and takes the tricks. In other words, *one repeats the same rules* in spite of *different deals.*" (Lévi-Strauss, 1983/1973/1960, p. 124). We find a similar logic in the Norwegian anthropologist Barth (1959, p. 15) who studied the political system of Yusufzai Pathans of Pakistan in terms of game theory. He underlined: "The crucial step in a transformation from real life to a Theory of Games model is the formulation of these rules".

the information) and Nature. The transmitter and the receiver communicate through a communication channel knowing that Nature alters the information by blurring it. The situation is analyzed from a zero-sum game perspective between two players: the transmitter and the receiver constitute a coalition to minimize the information loss (during the communication), while Nature maximizes it (by blurring the information). Although it may seem exaggerated to give an objective to Nature, this model constitutes the starting point of a work that allows Mandelbrot to determine, among other things, the statistical properties of language. Lévi-Strauss was precisely interested by these properties.

He thus invited Mandelbrot to his interdisciplinary seminars that he organized during the year 1953-1954 under the sponsorship of UNESCO. In addition to Mandelbrot, Guilbaud, Lacan and Benveniste, mathematicians and physicists (Pierre Auger, Roger Penrose, Jacques Riguet, Marcel-Paul Schützenberger), as well as researchers in social sciences (sociologist Paul-Henry Chombart de Lauwe, and psychologists Claude Faucheux and Jean Piaget and linguist Alan Ross) participated in these sessions (Leroux, 2018).

This seminar was the result of Jakobson having proposed to edit a collective volume in a new series from MIT Press dedicated to the problems of communication. However, all Lévi-Strauss's hesitations are easy to notice through this seminar. The book that Jakobson had requested had to be devoted to "the language, or the systems of sign in general from the perspective of anthropology and sociology" (Jakobson and Lévi-Strauss, 2018, p. 153). But the presentations were based on extremely varied topics: the theory of coalitions by Mandelbrot, the group theory of psychologist Piaget, the theory of information by Schützenberger, etc. (for the entire program, see Le Roux, 2018, p. 584-585). While Lévi-Strauss seemed to follow the research program of the theory of communication, he could not resist leaving the door open to all mathematical theories that interested him (game theory, theory of communication and group theory). This made it virtually impossible to determine a common thread for a collective volume. This created a distance with Jakobson who reproached Lévi-Strauss for putting him in a difficult spot with regard to the publishing house and the editorial board of the new collection. They stoped communicating for almost four years (Jakobson and Lévi-Strauss, 2018).

Despite his efforts, the seminar did not achieve the expected results for Lévi-Strauss: none of the mathematicians who had participated in this seminar accepted to work with him. In fact, the two major beneficiaries were Lacan and Piaget. As for Riguet, he recalled later that at the time of the seminar, "I was somewhat hesitant to choose between Lévi-Strauss and Jacques Lacan, and I finally chose Jacques Lacan's supervision. Lévi-Strauss had proposed I formalize the history of nexuses with string games, more exactly, among Indians. This proposal was far from stimulating me." (Riguet, 2011, p. 98). Riguet also became Lacan's mathematical advisor. For his part, Piaget, getting introduced to Mandelbrot,

invited him to his research center in Geneva for a two-year period (1955-1957). This led to the publication of two joint volumes.

3.2. Game theory as an argument for reforming teaching in economics

While Lévi-Strauss stumbled around, Guilbaud worked for the recognition of game theory in economics. In order to do so, he benefited from Guitton's support who was the only academic economist who had long stood for mathematics courses at law faculties (Bungener and Joël, 1989)[19]. For Guitton, game theory was another argument (in addition to statistics, probability calculation and econometrics) to justify the need for teaching mathematics at law faculties.

When Guilbaud published his article on the issue of sharing in 1952, he took a distribution model developed by a young Swedish author, Nyblen (1951), who was unique in applying game theory in macroeconomics, as his starting point. Guilbaud used it again at the end of his article to illustrate the concept of the von Neumann-Morgenstern solution, which was a way for him to introduce pedagogically the elements that could help grasp the mathematical aspects of Nyblen's PhD dissertation. However, the same year, Guitton (1952a) proposed a review of Nyblen's doctoral thesis in *Revue Economique* (a peer-reviewed journal that was dominated by economists of sociological tendency at the time) to demonstrate that game theory was not solely about microeconomic problems, and that it could also be used in dealing with macroeconomics.

After having highlighted Nyblen's thesis, Guitton and Guilbaud became complicit in a number of other projects. For example, Guitton sought to increase the visibility of Guillbaud's works by proposing review summaries of his work. This was the case for Guilbaud's 1949 article that had been published in English in the first collected volume of *International Economic Papers*. In his review of Guilbaud's paper, Guitton (1952b) mentioned: "No one has been more happy than me to see Guilbaud's article selected for representing a part of French thought, and for showing that at least one French mind is capable of mastering game theory" (p. 251). Similarly, when Guilbaud published his lecture notes in 1954 as a chapter of an edited volume, Guitton (1955a) wrote a review of the book in *Revue Economique* devoting a large section to the chapter drafted by Guilbaud.

In his review, Guitton addressed Guilbaud on amicable terms: "our friend G.-Th Guilbaud, known to all of us as one of the mathematicians who is the most open to economic questions of our time and one of the most qualified to express himself in their language" (p. 675). Finally,when Guilbaud was invited to present a report on game theory in the Congress of Francophone economists in May 1954, Guitton was

[19] Guitton traced back the origin of his conviction regarding the economics interest for mathematics to his attendance to a presentation by the Norwegian economist Ragnar Frisch in 1932: "I attended a conference delivered by Frisch at the Institut Henri-Poincaré in 1932. I was seduced by his communication. It took place at the time of the creation of the Society of Econometrics. He distinguished economic theory, statistics and mathematics and his fundamental idea was to reunite them together and make a sort of synthesis." (Bungener and Joël, 1989, p. 33).

included as a stakeholder. He extensively revised his paper to elaborate an article that was published the next year in *Revue Economique* entitled "Les Rencontres Economiques" (Economic Meetings) [20].

This shared commitment of Guilbaud and Guitton in favor of game theory led to some limited results. For example, the liberal economist Baudin (1953) introduced a section on game theory in his seventh edition of his *Manuel d'Economie Politique* (*Handbook on Political Economy*). This was also true for the economist with sociological tendency James (1955) in his *Histoire de la Pensée Economique au XXe Siècle* (*History of Economic Thought in the 20th Century*). But the great surprise came from André Marchal (1953) who was a tireless critic of using mathematics in economics (see for example Marchal, 1952). He made a positive appraisal of game theory (while continuing to be critical of the neo-marginalist school) in his study on French Economic Thought since 1945 entitled *La Pensée Economique en France depuis 1945*. He related it to Guilbaud by quoting some passages of his review in 1949. For Marchal, game theory described an economic subject guided by some psychological realism. He repeated the following year that game theory "moves us toward new perspectives" (1954, p. 556).

At the same time, the mathematician Fréchet (1953), while in retirement, opened a controversy in *Econometrica*. Taking cognizance of Borel's three notes regarding strategic games between 1921 and 1927 through Guilbaud, Fréchet asserted that Borel should be considered as the initiator of game theory. To support his position, the three notes were translated into English and published as alongside his comments. The journal also included a response by von Neumann. In his response, von Neumann (1953) argued that without his minimax theorem that he had pioneered to demonstrate in 1927, game theory could never have existed. He added that "by surmising, as he did, the incorrectness of that theorem, Borel actually surmised the impossibility of the theory as we now know it" (von Neumann, 1953, p. 124). It could be imagined that the controversy was closed, but this was not the case in France. In fact, *Revue d'Economie Politique* republished Borel's three notes, Fréchet's comments and von Neumann's response, to which the reaction of Fréchet to von Neumann was added. Fréchet was not convinced by von Neumann's remarks and tried again to present Borel as the initiator of game theory. Thus he wrote: "Nevertheless, [economists] will note with interest the information relayed to us by von Neumann: "I developed my ideas on the subject [i.e. the minimax theorem] before reading his notes." However, since he cites one of his [Borel's] notes in his first dissertation, we should conclude that if he has refined matured his ideas developed in his dissertation independently of Borel, he knew Borel's ideas before writing his dissertation." (Fréchet, 1959, p. 165). In the same vein, we can read that: "It is natural that von Neumann particularly focuses on this phase [the minimax theorem] since it is the only one over which Borel had not completely preceded him. However two observations are warranted. On the one

[20] The Congress of francophone economists was governed by a principle: the Congress acts were published as an edited volume by the publishing house Montchrestien, and the report of the invited author (Guilbaud in this case) was also published in *Revue d'Economie Politique*. But in addition to the publication of his intervention in the acts of the Congress, Guitton reworked on his report to publish a paper in *Revue Economique*. This gave a more pronounced echo to Guilbaud's report.

hand, although it is precisely true that Borel did not demonstrate the minimax theorem in general, he had shown it in the simplest cases. And on the other hand, it is an exaggeration to simply say that Borel did believe that it was not valid in its general form. On the contrary, I have shown in my comments how Borel modified his opinion in this respect" (Fréchet, 1959, p. 166). This controversy was not futile since it cast light on a branch of French game theory stemming from Borel, Ville, and Possel that had developed on a general theory of board games (Schmidt, 2001, p. 374), and as evidenced by the works devoted to them such as Leonard (1992, p. 31-37) and Dimand and Dimand (1992, p. 18-24; 1996, p. 159-164).[21]

This was also the time that Allais, who had never expressed himself on game theory, finally expressed his views during the Congress of Francophone economists in May 1954. His intervention was a true indictment. While acknowledging the qualities of the theory (for example, its capacity to determine the way the decisions of some people are influenced by others), his intervention was largely confined to enumerating its limits. Without going through all his criticisms, we may note that they pursued a well-defined goal, that of demonstrating that "there is more distance between Game Theory and concrete reality than the distance between pure competition and reality" (Allais, 1955, p. 154). The objective was to affirm the relevance and interest of a purely competitive model as a first approximation of reality. Generally speaking, Allais's intervention seeks to highlight the scope of his work by showing to which extent a purely competitive framework, despite its "crude pattern" has a great utility and still matches the economy better than game theory. Thus, for Allais, as compelling as game theory might be, it is at best complementary to the purely competitive framework. Through his intervention, one can understand why engineer economists were not interested in game theory. Their research program was largely focused on the general equilibrium theory; and, given the state of knowledge, game theory did not seem to provide an adequate instrument for dealing with their issue.

It is a matter of fact that game theory played an important role in reforming the teaching of economics in universities. Indeed, Guitton's diplomacy combined with Guilbaud's pedagogic efforts resulted in convincing a certain number of academic economists to teach mathematics in economics. Game theory provide Guitton with one of his best examples of the need for a mathematics course.[22]. Accordingly, in 1955 a bachelor degree course in law required four years instead of former requirement of three years.

[21] This French branch was prolonged by the mathematician Berge (1953a, 1953b, 1953c, 1954, 1955) in the fifties who turned his attention towards sequential games in which the players' choices are related to the "positions of the game", namely sequential games in which there is either a winner or a drawn position.

[22] Concerning the role played by Guitton, Ullmo (1977, p. 304) underlines that "before the war, the use of mathematics in economics was considered to be against the principles of a science on human beings and human behavior: there was a contradiction between the inherent freedom of human actions and the determinism involved in mathematical deduction. […] It took all the strength of conviction and persuasion based on Henri Guitton's diplomacy and goodwill to overcome these preliminary questions, and to demonstrate the movement of thought by walking towards the rationality and efficacy of a mathematical instrument. He will never be thanked enough."

Students studied both law and economics in the first two years and then specialize in one of the disciplines in the following two years[23]. Law faculties became faculties of law and economics in 1957. A bachelor degree in economics was created in 1960, including a course in statistics and a course in mathematics every year (Le Van-Lemesle, 2004). Guitton who was recruited at Paris Faculty of law and economics fostered the recruitment of Guilbaud in 1959. The latter defined and organized mathematics education at this faculty. Hence, the first doctoral thesis based on game theory was defended in 1961 by Simon-Pierre Jacot at the University of Lyon. This thesis that dealt with spatial competition in the presence of oligopoly was published in 1963 with a preface by Morgenstern.

3.3. Game theory as an instrument of interdisciplinarity

While Lévi-Strauss did not convince any mathematician to collaborate with him, he never stopped supporting the idea of a rapprochement between social sciences and mathematics particularly focusing his attention on game theory. We note this point on several occasions. For example, he drew a paper from the discussions of the interdisciplinary seminar that he had organized, and published it in an introduction to the special issue of the UNESCO's review, i.e. the *International Social Science Bulletin*. This issue was devoted to the relationships between mathematics and social sciences, and Lévi-Strauss's article was a genuine advocacy of the use of mathematics as the most appropriable language to "formulate a precise chain of propositions" (Lévi-Strauss, 1954, p. 583). He insists on the rapid development of a new "qualitative mathematics" (similar to set theory, group theory, topology, and others) "which are concerned with establishing exact relationships between classes of individuals distinguished from one another" (p. 586).

In the framework of this new mathematics, he mentions cybernetics and the theory of communication without giving much details[24]. Nonetheless, he more precisely dwells upon game theory that he presents as "a more complicated and delicate mathematical apparatus than that found in economics or even econometric treatises" (p. 587) but also more accessible and more comprehensible than what economists have developed until now. He went even further by underlining the two aspects of "pure or would-be

[23] In fact, the specialization was structured around three possible axes: private law, public law and political science, political economy.

[24] Reviewing different writings of authors advocating the idea that Lévi-Strauss relied on cybernetics in some of his works, Leroux (2009) afforded a critical assessment by showing that despite his explicit interest, Lévi-Strauss never invested in modeling inspired by cybernetics, to the point that it might be described as a missed opportunity. One of the reasons was that Lévi-Strauss never found any mathematician to help him to master the principles of cybernetics. Accordingly, his knowledge of cybernetics was still vague. Furthermore, Leroux included a letter (dated November 18, 2006) addressed to him by Lévi-Strauss in his article (on pages 185-186) in which the latter confirms Leroux's interpretation after reading a preliminary version of his paper. It should be added that Godelier (2012) also underlined the errors and shortcomings of Lévi-Strauss in using communications theory, and showing his lack of mastery in this field.

pure economics" based upon "a perfectly rational individual" and "sociological and historical economics as originated by Karl Marx "[…] that "are represented in von Neumann's theory", and because of that "for the first time, […] so-called bourgeois and capitalistic economics and Marxist economics have a common language at their disposal. This does not mean, of course, that they are likely to come to an agreement; but at least they have common ground for discussion, and it is the mathematical approach which has made this surprising development possible" (p. 587-588).

In 1956, he repeated his interest for game theory asserting that "no form of economic bourgeois thought is closer to Marxist conceptions than the highly mathematical treatment presented by von Neumann and Morgenstern in 1944 in the *Theory of Games and Economic Behavior* […] Contrary to what one might believe, the mathematisation of social sciences is not at all accompanied by dehumanization. It corresponds to the fact that inside each discipline, theory tends to become more and more general. In mathematical expression, economics, sociology and psychology discover a common language. And it may be very rapidly seen that this common language is possible, because the objects to which it is applied are, in reality, identical" (Lévi-Strauss, 2008/1956, p. 27).

Once again, he writes in *Anthropologie Structurale*: "the anthropologist's reluctance originated in the condition of economic studies themselves; these were riven with conflicts between bitterly opposed schools and at the same time bathed in an aura of mystery and conceit". However, "the complete upheaval of economic studies resulting from the publication of von Neumann and Morgenstern's book ushers in an era of closer cooperation between the economist and the anthropologist, and for two reasons. First — though economics achieves here a rigorous approach — this book does not deal with abstractions such as those just mentioned but with concrete individuals and groups that are represented in their actual and empirical relations of cooperation and competition. Surprising though the parallel may seem, this formalism converges with certain aspects of Marxian thought" (Lévi-Strauss, 1963/1958/1953, p. 297-298)[25].

As illustrated, he demonstrated consistency in his interpretation of game theory. According to Lévi-Strauss, this instrument is an economists' tool. It probably cannot allow them to reconcile themselves but they now have a common language in which every one of them can find the notions in which he or she can recognize himself or herself. It is also possible to study individuals in isolation or acting in coalitions (in groups or in social classes) through game theory. Thus we find terms related to individual interest as well as those of group interest in game theory. This is all the strength of game theory that invites economists to a dialogue by affording them the choice between these different behavioral

[25] In the French version, see Lévi-Strauss (1958, p. 328). It should be underlined that the last sentence referring to Marxist thought did not exist in the initial version of 1953.

rationales according to the context (a situation of competition versus cooperation) in line with economic reality[26]. By repeating his remarks, Lévi-Strauss does not seek to convince economists about the interest of formalization since the movement in favor of reforming the teaching of economics (by introducing mathematics courses) was already successful. In fact, his message was addressed to researchers in social sciences that lagged to follow the path of new "qualitative mathematics", since he was persuaded that the future of social sciences depended upon formalization. His message was clear within this perspective. Marked by the conflict on methodology, economists could not speak the same language rendering their discipline unfathomable. With the advent of game theory, the situation was likely to change. Consequently, if the mathematical instrument could improve the dialogue in economics, then it would allow the same thing for other social sciences.

4. The loop is completed

4.1 Lévi-Strauss's effect

By the end of the fifties, Lévi-Strauss's support for game theory began to bear fruit in social sciences. He did so much by exploiting his reputation to the point where it became necessary to take a position about this field of research in certain disciplines. Examples abound, starting with the sociologist Caillois. In an article published in 1957 (that is a prelude to his famous study of 1958 entitled *Les Jeux et les Hommes: le Masque et le Vertige*, in which he supports the idea that the spirit of the game is the source of conventions allowing the evolution of culture), he explains why he does not deal with the same subject as *Theory of Games and Economic Behavior* in an argumentation of almost 4 pages (pages 131-134)[27].

Another illustration is Aron (1962) in his major work, *Paix et Guerre entre les Nations* (*Peace and War: A Theory of International Relations*). After going into depth about his conception of international relations, he devoted, at the end of his book, several pages to introduce game theory with respect to potential applications that can be done (in studying international relations). For each suggested illustration, he revealed the limits of a reflection in terms of games. This allowed him to justify all the reasons why he did not favor this approach. However once we read his book, we note that his reflection is inspired by game theory. Indeed, Aron (2017/1962, p. 16)[28] maintains that "the theory of international relations starts from the plurality of autonomous centers of decision, hence from the risk of war, and from this risk it deduces the necessity of the calculations of means". The states being the autonomous

[26] Lévi-Strauss was the only person who permanently insisted upon the relationship between Marxism and game theory despite the fact that this had never stimulated any French economist to follow this path. Nevertheless, this relationship was developed much later through the works of the American economist Roemer (1982a, b) who updated the notion of exploitation on the basis of cooperative games.
[27] The pages of the article related to game theory have been fully reprinted in the 1958 book (see pages 328-334).
[28] In the French version, see Aron (1962, p. 28)

center of decision-making, it is aptly said that they act rationally, and since they are located in a plural situation (and hence in an interdependent situation), all the terms required for an approach in terms of game theory are justified. There lies a paradox in a book in which game theory is criticized while the illustrations prove the opposite.

It should be added that the historian of *Annales School* Braudel (1958/1960), interested in the concept of modeling in social sciences, invoked the question of formalization in historical studies. He (1958/1960, p. 38) borrowed Guilbaud's "social mathematics" and Lévi-Strauss's "qualitative mathematics". As Braudel (1960/1958, p. 42) pointed out, with game theory "the move from observation to mathematical formulation does not have to be made along the painful path of measurements and long statistical calculations. One can pass directly from an observation of social reality to a mathematical formulation, to the calculating machine, so to speak."[29] In other words, game theory permits the elaboration of models in history. For Braudel, history needs modeling: by the latter, he (1960/1958, p. 40) meant: "Models are only hypotheses, systems of explanation tied solidly together in the form of an equation, or a function: this equals that, or determines the other. Such and such a reality never appears without that one, and constant and close links are revealed between one and the other. The carefully constructed model will thus allow us to inquire, throughout time and space, into other social environments similar to the observed social environment on the basis of which it was originally constructed. That is its constant value."[30]

Even Sartre, who was one of the main opponents of Lévi-Strauss, opened his journal, *Les Temps Modernes*, to submissions using mathematics in conjunction with social sciences, and by the same token to game theory. The salient illustration is the article of the Canadian psychologist and mathematician Rapoport (1963) whose books were later published twice by the publishing house Dunod, namely *Combat, Débat et Jeux* (*Fights, Games and Debates*) in 1967 and *Théorie des jeux à deux Personnes* (*Two-Person Game Theory: The Essential Ideas*) in 1969.

In the same period, Piaget (1957), who had participated in interdisciplinary seminars organized by Lévi-Strauss, suggested the first application of game theory in developmental psychology (most probably advised by Mandelbrot). Similarly, Faucheux, another participant of Lévi-Strauss's interdisciplinary seminars, became one of the craftsmen of experimental games in social psychology during the sixties in France, among others, experiences (in collaboration) regarding prisoner's dilemma and other games dealing with conformism, self-esteem, bargaining, and many other issues (among his works, see for example, Thibault and Faucheux, 1965; Abric *et al.*, 1967). The philosopher and logician Apostel

[29] In the French version, see Braudel (1958, p. 743).
[30] In the French version, see Braudel (1958, p. 740).

(1960), Piaget's associate and a strong advocate of interdisciplinarity, also invested in game theory by showing how this approach was capable of defining ethical norms.

Paradoxically, the French anthropolgists were the only ones who did not mention game theory, and did not even criticize it. None of them followed the movement instigated by Lévi-Strauss. In fact, the first works on anthropology based on game theory were born in the Anglo-Saxon world through publications by Moore (1957), Barth (1959), and Davenport (1960). Maranda (1964) was actually the first to insist on the importance of Lévi-Strauss's incomplete work regarding the marriage game for the study of kinship.

Game theory gained so much popularity that it became possible to present its fundamental principles to a large public. One piece of information to support this argument is the broadcast arranged by the mathematician Le Lionnais on the French channel RTL France III[31] on the topic "Des divertissements et des jeux : aux confins de la guerre et de la diplomatie" (Entertainments and games: on the boundary between war and diplomacy). This programme broadcasted on March 6, 1958 showed the mathematicians Berge and Schützenberger discussing the originality of game theory by drawing different examples to explain, among other things, the notions of optimal strategy and minimax strategy[32]. To some extent this was due to Lévi-Strauss since Le Lionnais as the chief of the teaching division and the science division of UNESCO during the fifties, had also attended the interdisciplinary seminar of Lévi-Strauss and was cognizant of these new mathematics coming from the United States.

Another element of favorable assessment of game theory in France was its influence in contemporary music. It became a great source of inspiration to the composer Xenakis. On the one hand, he theorized its use in *Musiques Formelles* (*Formalized Music*) published in 1963[33]; on the other hand, he constructed two of his musical works, Duel (in 1959) and Stratégie (in 1962) based on this approach[34].

Finally, to sum up, it should be also be mentioned that Guilbaud who had taught a course in Ecole Pratique des Hautes Etudes since 1955 (titled "Mathematical methods of social sciences") created his own group within this institution in 1958, namely Groupe de Mathématique Sociale et de Statistique[35] (the Group of Social Mathematics and Statistics). In doing so, he benefited from Lévi-Strauss's sponsorship acting as the research director in Ecole Pratique des Hautes Etudes (Rosenstielh, 2012).

[31] This radio channel corresponds to the national channel devoted to culture and art.
[32] An incomplete transcript of the program is accessible on the following site http://igm.univ-mlv.fr/~berstel/Schutzenberger/ under the heading "Autres publications".
[33] See chapter (3) of the book.
[34] A third one appeared in 1972, namely Linaia-Agon.
[35] In 1962, the group became *Center for Social mathematics and Statistics* (then *Center for Social Analysis and Mathematics* in 1981) and integrated in 1966 a group of musical mathematics directed by Xenakis.

4.2. The consecration of Lacan

By advocating and promoting game theory, Lévi-Strauss initiated a movement. This movement in favor of game theory was all the more important that his fellow traveler Lacan provided a concrete illustration of the benefits of interdisciplinarity during his seminar of April 26, 1955 known as the seminar on "La Lettre Volée". In this seminar, he came back to Edgar Allan Poe's short story ("The Purloined Letter" drawing upon game theory. Unlike "Temps Logique" (Logical Time), this was not about lessons from using logical reasoning based on common knowledge to cast light upon psychoanalysis, but using game theory to show his (structuralist) thesis according to which "It is the symbolic order which is constitutive for the subject" (Lacan, 2006/1966/1957, p.7)[36]. By 'symbolic order', he means unconscious laws and pacts that bind individuals together [37]. This thesis is consistent with game theory in the sense that the latter shows that interacting rational individuals constitute a system that follows universal laws and hence, somehow follows laws that are exterior to them (Dupuy, 1989).

Although Guilbaud was the pioneer in exploring Poe's novel from the game theory viewpoint, Lacan did not refer to him. However, his work appears to be a prolongation of Guilbaud's work. Indeed, Guilbaud had mentioned Poe's novel in his 1949 review. He was particularly interested in a scene in which the game of even or odd played a prominent role in Poe's novel. He also mentioned it in his lesson notes published in 1954. But as Le Roux (2007) noted, it was in an article that Guilbaud related in 1953, in a premonitory way, Lacan and game of even or odd in the same sentence. He refers to that game to criticize Belgian author Denis Marion's interpretation of the type of reasoning described by Poe to determine a solution. Indeed, Guilbaud (1988/1953, p. 343) states: "In his essay [*La Méthode Intellectuelle d'Edgar Poe*], D. Marion seems to disregard the fundamental problem (p. 23), it is not only to "get into the minds" of others. It is about "logic" and not "psychology". A more profound analysis is suggested by Dr. Lacan in his "logical time" (Cahiers d'Art, 1940-1944)". In this phrase, Guilbaud indicates, to some extent, that in order to capture the subtleties of the even or odd game, we need to borrow the type of reasoning introduced by Lacan's 1945 article. This is precisely what Lacan would do in his seminar on "The Purloined letter", applying his logical reasoning to different scenes of Poe's novel, and by the same token to the even or odd game.

[36] In the French version, see Lacan (1966, p. 12).

[37] It is interesting to note that in identifying different characteristics of structuralism, Deleuze (1973, p. 307) has introduced game theory: "[there is] a taste of structuralism for some games […], for some game spaces […]. It is not by chance that Lévi-Strauss often refers to game theory, and gives such an importance to playing cards. And Lacan to game metaphors which are more than metaphors: not only the ferret that runs in the structure but also the place of dead that circulates in the bridge. The noblest games such as chess are the ones that organize a combination of places in a pure spatium infinitely more profound than the real scope of chessboard and the imaginary extension of each figure".

Lacan's analysis of Poe's short story is rich and subtle and develops several properties in conjunction with psychoanalysis. We do not wish to repeat the whole analysis here, but we will focus only on the reflection about the even or odd game. Poe's novel is about an incriminating letter (for the Queen) that is stolen in the Royal Apartments by the Minister D. Despite the detailed searches conducted over several months in the heart of the Minister's house, the letter could not be found by the Prefect of Police of Paris. He thus called upon the detective Dupin who in return for a large reward, recovered the letter using logical deduction: the letter was placed on the fireplace of the Minister's house in the sight of all, so showcased that the police officers did not pay the least attention. In order to explain the way he reasoned to the Prefect of Police, Dupin tells the story of an eight-year-old child who served as an example. This child won the game of even or odd every time to the point that he earned all the school's marbles. This game with two players is a zero-sum game that should be played with marbles. It is based on the principle that one of the players keeps the marbles in one of his hands while the other player should guess whether the number of marbles is odd or even. If the guess is correct, the player wins a marble, if the player is wrong, he loses one marble. Dupin asked the child how he succeeded and got this response: "when I wish to find out how wise, or how stupid, or how good, or how wicked anyone is, or what are his thoughts at the moment, I fashion the expression of my face, as accurately as possible, in accordance with the expression of his, and then wait to see what thoughts or sentiments arise in my mind or heart, as if to match or correspond with the expression" (Poe, 1975/1844, p. 215-216). We thus find out that this corresponds to "the identification of the reasoner's intellect with that of the opponent", knowing that this identification "depends on the accuracy with which the opponent's intellect is admeasured" (Poe, 1975/1844, p. 216).

Like Guilbaud (1949) before him, Lacan is not satisfied with this response. Indeed, Poe thinks that he has offered a satisfactory solution by creating an asymmetry favorable to the child, who wins thanks to this asymmetry regardless of who he is facing. For Guilbaud, in this zero-sum game, the optimal strategy for each player is to play randomly (i.e. mixed strategies). Without explicitly expressing it, Guilbaud builds upon the minimax theorem. In fact, even if the child is more intelligent than his opponent, it suffices that the adversary plays randomly to outweigh the child's advantage.

Contrarily to Guilbaud, Lacan argues in terms of pure strategies on the basis of the following argument: "that it is through an internal imitation of his opponent's attitudes and mimicry that he claims to arrive at the proper assessment of his object. [38] But what then of the next level, when my opponent, having recognized that I am intelligent enough to follow him in this move, will manifest his own intelligence in realizing that it is by acting like an idiot that he has his best chance of deceiving me? There is no other

[38] Lacan does not speak of pure strategies but the validity of his argument depends on assuming pure strategies.

valid time of the reasoning in this moment, precisely because it can but repeat thereafter in an indefinite oscillation" (2006/1966/1957, p. 43-44)[39].

Hence, Lacan differs from Guilbaud by providing another way to tackle Poe's problem. By repeating the game indefinitely, the favorable asymmetry for the child will dissipate completely and the game will reiterate its true nature, namely a game in which following pure strategies leads to no solution. More accurately, Lacan argues that the first round result is not important and that everything starts with the second round when the child knows that the other player will not be silly enough to give the same response. But he knows that the other player knows that he knows and hence by replaying like the first time he will win. The problem is that he knows that the other also knows this, and hence he should modify the number of marbles, and so on and so forth. The two players are thus in a situation of indecision (in terms of pure strategies); this corresponds to a situation of no solution.

This illustration elucidates that Lacan adopted the inherent logic of game theory and, regardless of the way he applied it, he found it necessary to resort to this theory. Despite remaining outside the academic institution, his work had a considerable echo in acknowledging game theory as an instrument that received some attention beyond the single circle of psychoanalysts. He added importance to this theory through his seminar on "The Purloined Letter", and through that, increased the attractiveness of a reflection in terms of games by setting out the text at the beginning of *Ecrits*. This was also a way to grant a prominent place to game theory in his work[40].

Hence, our viewpoint is different from that of Sokal and Bricmont (1998, p. 34) according to which: "Lacan's mathematics are so bizarre that they cannot play a fruitful role in any serious psychological analysis". In fact, these authors do not refer to Lacan's use of game theory, since Lacan invested very early in game theory and mastered it when he was fully energized and surrounded by mathematicians. The criticism of Sokal and Bricmont related to Lacan's use of topology, i.e. a discipline that he did not master well since he invested on it later by the end of the sixties when he was more than sixty.

5. Conclusion

[39] In the French version, see Lacan (1966, p. 58).

[40] It should be added that the seminar on "The Purloined Letter" ends up with a long discussion of Lacan around the applications of automaton theory on the game of odd or even. This shows his interest for the Turing machine and also marks Riguet's aid, specialist of automaton theory, to Lacan so that he could grasp the foundations of this field (for more details on this point see Le Roux, 2007). According to Geogeghan (2011, p. 120-121), "The automaton, which Lacan refrained from citing by name, was entitled *SEER*, short for **SE**quence **E**xtracting **R**obot. David Hagelbarger of Bell Labs developed the machine in collaboration with Shannon".

According to Aubin (1997), the fifties were Lévi-Strauss's years in France, and we can add that this benefited game theory. The movement inspired by Lévi-Strauss to support game theory also owes much to Guilbaud who taught him the underlying principles of this discipline and worked, for his part, to convince economists. It also owes much to his fellow-traveler, Lacan, who confirmed the practical and original character of game theory by highlighting the advantages of his logical reasoning.

In the sixties, Lévi-Strauss continued using mathematical vocabulary in his works, notably that of communication theory and group theory. However, since he was not assisted by any mathematician, his use of mathematics was relatively poor. Thus he admitted that: "the occasional use of apparently logico-mathematical symbols should not be taken too seriously. There is a superficial resemblance between my formulas and the equations of the mathematician […]. The formulas that I have written with the help of symbols borrowed from mathematics (chiefly because these symbols are already available in typography) are not intended to prove anything. […] I am as conscious as anyone of the very loose senses in which I have employed terms as symmetry, inversion, equivalence, homology, isomorphism, etc. I have used them to refer to large bundles of relations that we vaguely perceive to have something in common" (Lévi-Strauss, 1964, p. 38-39). Having accomplished his goal of introducing mathematical teachings in economics in progressive construction, Guilbaud changed his position by addressing sociologists and convincing them about the qualities of quantitative methods. It was in this spirit that he participated in drafting of the monumental *Traité de Sociologie* (*Treatise of Sociology*) in 1960. Only Lacan continued to use game theory by transforming his seminar into one of the most prestigious French intellectual scenes.

More exactly, Lacan intermittently returned to game theory. He drew upon the bridge metaphor in 1961 for example, to determine the behavior of the analyst compared to the analyzed supporting the idea that an analytical relationship is not a relationship between two but four. Furthermore, in his seminar on January 29, 1969, treated Pascal's wager about God that was revealed to be a problem of decision-making (Lacan 2006, p. 137-152). He transformed this problem into a game by differentiating the player confronted with the bet into two individuals. By analogy, he also conducted his research, notably by drawing upon the definition of a game to represent psychoanalytic analysis as a triplet of subject, knowledge and sex. The triplet was depicted as three poles with regard to their relationship with knowledge: 1) subject that detaches itself from knowledge, 2) knowledge, i.e. "*qua* unconscious which knows everything, perhaps, except what motivates it" (Lacan, 1965, p. 217)) and 3) sex that "belongs to a sphere" in which the subject does not "want to know anything about it [where it comes from]" (Lacan, 1965, p. 217)). He introduced the game of analysis in his seminar on May 19, 1965[41]. His objective was to determine the conditions that had to be satisfied so that the analysis could be complete.

[41] The sessions of Lacan's seminar, held between December 2, 1964 and June 23, 1965, have never been published. Yet, we find different versions of it on internet.

It should be added that the fact that Lévi-Strauss and Guilbaud set objectives outside game theory for themselves is not important in itself, since this approach finally staked out its place in the French university of the sixties. A sign of this anchorage was the publication of handbooks (devoted partially or totally to game theory) by the French authors. It should be recalled that during the fifties and part of the sixties, except for the publication of Guilbaud's course in 1954, all available handbooks in France were translations of Anglophone books. Since the mid-sixties, the situation began to change with the publication of Faure *et al.'s* (1964) *Mathématiques Nouvelles* (*New Mathematics*), Daval's (1967) *Théorie des Jeux et Psychologie Sociale* (*Game Theory and Social Psychology*), Desplas's (1967) *Mathématiques de la Décision Economique* (*Mathematics of Economic Decision*) and others. It was also in this period that Guilbaud (1968) took advantage of the situation to remind the new generation (trained in mathematics) of his works by publishing a book which drew upon his past works on game theory. The game was now definitely afoot.

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