Introduction

Game theory, it may reasonably be claimed, has proved to be one of the more significant scientific contributions of the twentieth century. Albeit haltingly and unevenly, and in a manner quite unforeseeable in 1944 when the *Theory of Games and Economic Behavior* was published, it has affected not only economics and political science but also evolutionary biology, ethics, and philosophy proper. Within economics, particular areas such as microeconomic theory, industrial organisation, international trade, and experimental economics have all been reshaped under the theory's influence. Although game theory initially came from outside as a critical contribution, it has now been completely embraced by the economics discipline, as indicated by the awarding of the Nobel Memorial Prize in Economics to John Nash, John Harsányi, and Reinhard Selten in 1994, and to Robert Aumann and Thomas Schelling in 2005.

Various aspects of this development have received the attention of historians of economics and others. In 1992, under the editorship of Roy Weintraub, an exploratory set of essays titled *Towards a History of Game Theory* featured both historical accounts and reminiscences. Building upon their contribution to that volume, a 1996 book by Robert Dimand and MaryAnn Dimand provided a historical survey of the various game-theoretic contributions in the first half of the century. In his 2003 monograph on the evolution of economic rationality, Nicola Giocoli devotes considerable attention to game theory, particularly as it affected the neoclassical conception of the economic agent. A similar theme, treated differently, is central to Philip Mirowski's *Machine Dreams* of 2002, which casts the history of game theory as part of the rise of "cyborg" thinking, linked in an essential manner to von Neumann's work on computing and automata.

With the appearance in 1998 of Sylvia Nasar's biography of John Nash, *A Beautiful Mind*, and its subsequent adaptation as a Hollywood film, the

audience for the history of game theory has grown to include the general public. Tom Siegfried's (2006) *A Beautiful Math*, seeks to explain to a broad audience the success of Nash's game theory across the scientific spectrum, and a 2007 BBC documentary, *The Trap*, attempts to show how contemporary social and political life have been shaped by the adoption of game-theoretic conceptions of rationality in the policy sphere. The film traces a direct line from early game theory to World War II, RAND, McNamara's Pentagon and, ultimately, Margaret Thatcher's reform of the British welfare state.[1]

Although each of these accounts has its strengths, none of them, I think it fair to say, does justice to the rich historical process by which von Neumann and Morgenstern were led to the creation of *The Theory of Games and Economic Behavior*. Few of them treat the authors as flesh-and-blood figures, and none of them considers the cultural and political context of *fin-de-siècle* and interwar Europe, without which, in my opinion, the making of game theory cannot be understood. In some, von Neumann is given short shrift, and treated as a necessary stepping-stone towards John Nash; in others, Morgenstern is omitted entirely and von Neumann's game theory is forced to herald a future of machines and computation.

It is a commonplace that every historical account must strike a balance between the fact that the narrator is "omniscient" and the fact that, at any given historical moment, the future was neither fully determined nor known. The present account is an attempt to tell the story of von Neumann, Morgenstern, and the creation of game theory in a way that exploits authorial omniscience only minimally. Every attempt is made to restore the historical specificity of the subject, to hold the future in abeyance, and to allow our characters to develop over time in response to changing circumstances. The story carries the reader back to the world of Budapest and Vienna in the first half of the twentieth century, with its chess cafés, debates over the nature and purpose of economics, and intense concern with politics. It then moves to the very different world of Princeton in the 1930s and the postwar United States. When we treat von Neumann of the 1920s, it is not in the awareness that he would later come to the United States or work on the atomic bomb or the computer, but by deliberately suspending our knowledge of those developments. When we consider Morgenstern in interwar Vienna, we treat him not as future co-author of a book at wartime

[1] See Weintraub (ed.) (1992); Dimand and Dimand (1996); Giocoli (2003); Nasar (1998); Mirowski (2002); and Siegfried (2006).

Princeton, but as a dissenting Austrian economist in a particular cultural environment.

In a 1992 essay, published in the aforementioned volume edited by Weintraub, I portrayed von Neumann's 1928 paper on games as an isolated contribution, bearing little relation to the work or interests of his contemporaries. I have since changed that opinion considerably, having been led by a passing remark by mathematician Ernest Zermelo, to see the paper as connected to the rich discussion of the psychology and mathematics of chess in the first decades of the twentieth century. Our story, therefore, begins at the chessboard. Chapter 1 discusses the cultural importance of *Schach* in Central Europe and the emerging interest in the psychology of the game, and the idea, perhaps best illustrated in the writings of German chess champion and mathematician Emanuel Lasker, that chess might provide some insights into economic and social interaction. Chess emerges as a fruitful wellspring of mathematical, psychological, and sociological reflection, and the source of an emerging discourse of "equilibrium and struggle".

In the chapters dealing with von Neumann's Hungarian background, we devote our attention to two intertwined groups: the country's assimilated Jewish community and its mathematicians. The relevance of the latter is obvious: for a country of small size and limited state of development, Hungary produced a remarkable mathematical culture, and the prodigious von Neumann remained proud of his origins to the very end. As for the theme of Hungarian Jewry, the subject is broached here for both its cultural relevance at the time and its importance, especially later, in von Neumann's life. Chapter 4 considers his journey in the 1920s from Budapest to Göttingen, where he made his initial foray into the mathematics of games. As an attempt to provide a mathematical treatment of an unusal field, the paper bears the imprint of Göttingen's Hilbert, an influence that would remain important in von Neumann's work in the area.

Switching to Vienna in Chapters 5 and 6, we consider the early career of the very different Oskar Morgenstern. He began as a conventional student of the nonmathematical Austrian School of economics, and the influences to which he was exposed speak to the richness of debate in the period: the now-forgotten epistemological critique of Hans Mayer; the Romantic Universalist fantasies of Othmar Spann; and Ludwig von Mises' admixture of theoretical critique and political didacticism. In time, Morgenstern broke ranks with most of these economist mentors, stimulated, in part, by Viennese mathematician Karl Menger, who also happened to be – and the irony was not lost on him – the son of the founder of the Austrian School.

If gaining access to the papers of Morgenstern was easy, it was a different matter for those of Karl Menger. Indeed, it took months of diplomatic negotiation before I found myself one Friday evening in Chicago, in a dusty storage room at the Illinois Institute of Technology, with nothing before me but the weekend and twenty boxes of Menger papers, virtually undisturbed since his death in 1985. That exploration not only revealed ribbon-bound treasures relating to the life of his economist father, but allowed me to approach Menger from a different angle. It became clear that there were subtle connections between Menger's disparate spheres of activity, including the debates on the foundations of mathematics, his formal theory of ethics, and his political involvements in Vienna of the 1930s (see Leonard 1998). As we show in Chapter 7, politics was an important factor throughout, whether in shaping Menger's dissociation from L. E. J. Brouwer or in provoking his 1934 book, *Morality, Decision and Social Organization*. Morgenstern's view in the latter of the glimmer of a mathematical solution to what he regarded as weaknesses in the orthodox treatment of the rational economic agent showed, further, that only two short steps separated Viennese politics and the debate on economic theory.

This complex intertwining of economic, mathematical, and political themes is pursued in Chapter 8, where we explore the alliance that formed between Morgenstern and Menger. It owed much to a common search for "purity" and was not unconnected to local power struggles in Viennese economic research. Rejecting what they perceived as the infiltration of economics by politics, epitomized in the work of von Mises to the right and Neurath to the left, they felt that the use of mathematics, to the extent that it demanded clear thinking and logical demonstration, could make economic analysis more "value-free".

Menger's account of how his construction of this "geometry" of society was rooted in the political tumult of 1933–34 also sparked my interest in what we may call individual creativity: in this case, that of the creative mathematician in a particular context, moving in psychological time, one might say, from the "blank page" to the finished construction or proof. By what mysterious path, particularly when writing on such "reflexive" matters as the fields of rationality or social interaction, did the mathematician proceed from initial steps to a result deemed worthy of the name? The knowledge that the page was, of course, never quite blank did nothing to reduce the power of this image for me. Nor was I deterred by the realization that the inner creative process could never be completely recovered: to catch glimpses of it would be sufficient.

It was in the light of this experience with Menger that I renewed my probing of von Neumann. If, as a result of the examination of the world of chess, his initial interest in games now made sense, there still remained the puzzle of why he returned to game theory at the close of the 1930s, after a hiatus of more than a decade. The conventional wisdom among historians of economics seemed to rest upon two ideas: that he was always interested in the subject, as evidenced by the appearance of the minimax technique in his 1937 paper on equilibrium economic growth, and that it was Morgenstern who brought him back to the subject when they met in the late 1930s. A valuable paper by Danish historian of mathematics, Tinne Kjeldsen (2002), put paid to the first idea, by deconstructing the connections between the von Neumann papers of 1928 and 1937: the first did *not* involve a fixed-point theorem, and the second, which did, was observed by von Neumann to bear only an accidental relationship to the first. The technique-driven history was wrong, Kjeldsen showed. The idea that von Neumann was stimulated by Morgenstern's theoretical puzzles, presented at Fine Hall afternoon teas, while certainly true, somehow didn't seem adequate in explaining the mathematician's Herculean 600-page effort, in 1940–1941, in the middle of the Second World War.

To get beyond this impasse, I read and reread *The Theory of Games and Economic Behavior*, and at the same time dug more deeply into von Neumann's life in the 1930s. The exploration of new correspondence – some furnished by Marina von Neumann Whitman, more newly translated – brought a much-needed human dimension to his activities, and further reading on Hungarian social and political history shed light on his concerns as a Jewish expatriate at the time. It gradually became clear that the reawakening of von Neumann's interest in games owed something to his experience of the political tumult of the late 1930s, a truly dramatic period during which social questions drew much of his attention. Our examination of this interlude in Chapter 9 allows us to understand von Neumann's return to game theory, as well as certain emphases in his new mathematics of coalitions, such as the idea of multiple social orders and the stabilizing role played by conventions concerning social discrimination. This phase of von Neumann's creative life now made sense from both personal and historical points of view, and it was clear that game theory was shaped only partly by the discussion of economic theory. The collaboration with Morgenstern and the effect of this experience on the latter are discussed in Chapters 10 and 11.

The "emotional shock" that affected von Neumann during this time was the Nazi destruction of the world he had known, that socially heterogeneous

Mitteleuropean culture of mathematics and science. If his 1940 development of a new mathematics of society was in part a reaction to this – internal and symbolic in nature – so too was his simultaneous decision to "go to war", discussed in Chapter 12. Although von Neumann's wartime involvements gave expression to an "apocalyptic" attitude often evoked in connection with the Hungarian expatriates, they also had the more mundane effect of seeing a small part of game theory being used in operations research, on problems of strategic bombing and submarine search, worlds away from the abstract mathematics of stable sets and discriminatory social orders.

It was in this instrumental capacity that game theory received the postwar approval of a scientific community extending beyond its original authors. Following the war, it became a defining element in the worldview of the RAND Corporation. Adopted initially as an analytical tool to help in problems of strategic bombing or fighter pursuit, as RAND evolved, game theory became an integral element in a complex web of social–scientific activities at that institution, many of them reflective of the prevailing Cold War culture. This is discussed in our final chapter, 13.

This book is the result of a long and absorbing period of "detective work", an investigation that, to the understandable chagrin of my editor and many colleagues, has been every bit as enjoyable as the publication of results. A hint revealed in an article footnote or archived letter would open up a new vista, giving rise to months of new reading. The book was thus shaped by the results, often serendipitous, of research and reading, with new forays into the archives being conducted as late as a year before submission of the final manuscript. It took a while for me to realize that not all the vistas, or all the findings, could necessarily be featured in the same book.

In the story that follows, I have deliberately tried to bring the reader as close as possible to the "thinking" of von Neumann, Morgenstern, and others, all the while portraying the broader intellectual and social contexts in which they lived and worked. This attempt to relate biography, scientific creativity, and the evolution of external events has been one of the more rewarding aspects of writing this book. I hope that will be evident to the reader as he or she takes the time to read it.

PART ONE

STRUGGLE AND EQUILIBRIUM: FROM LASKER TO VON NEUMANN

ONE

"The Strangest States of Mind"

Chess, Psychology, and Emanuel Lasker's *Kampf*

Introduction

> I was in one of those moods where danger is attractive. Hence I plunged from the start into a combination the outcome of which was exceedingly doubtful. For the gain of a pawn I risked to retard the development and to accelerate that of the opponent. Mr. Speijer wisely sacrificed also the exchange, and opened a concentrated fire upon my King; but once he missed the best continuation, and therefore lost quickly. Games of this character, where every move counts for much, are best suited to entertain spectators, and they are of great value for the ripening of the "position judgment". He who relies solely upon tactics that he can wholly comprehend is liable, in the course of time, to weaken his imagination. And he is at a disadvantage against an opponent who tries to win through bold venture, yet does not step beyond the finely drawn boundary of what is sound.
>
> Emanuel Lasker (1908), quoted in Hilbert (2001), p. 5

Thus wrote world chess champion Emanuel Lasker in his *Evening Post* chess column in late December 1908, following his victorious third and final game in an Amsterdam match against the Dutch champion, Abraham Speijer. Having come to the city from Vienna, where he had been playing exhibition games the previous week, Lasker played Speijer in a pavillion in an Amsterdam park, watched by an audience of 150. The German beat the Dutchman in the first of three games but, to the delight of the Dutch audience, was held to a draw in the second. In the third game, shunning textbook play and avoiding safe continuations, Lasker won in twenty-seven moves.

Lasker's remark that "he who relies solely upon tactics that he can wholly comprehend is liable, in the course of time, to weaken his imagination" gets to the heart of what distinguished him as a chessplayer. This German mathematician was a dominant figure in the world of chess in the late nineteenth and early twentieth centuries, during which he had an extraordinarily long

reign as world champion. Regarded by some as the player who put psychology at the centre of the game, he was known for his unconventional play, being inattentive to game openings but given to heroic struggles in the mid-game. His chess writings, insofar as they tended to promote the conventional, textbook strategies set out by his compatriot Wilhelm Steinitz, from whom he had taken the world title in 1894, did not espouse the psychologically daring play for which he himself became known. However, those writings were very broad, revealing Lasker to be not only a player but also a humanist philosopher, keen to draw upon the lessons of chess in order to facilitate social understanding and progress. Lasker's life and writings provide a window onto the world of chess in the period during which he competed. They also are enlightening regarding why several of Lasker's fellow mathematicians, both German and Hungarian, began to take an interest in the structure of chess and parlour games.

The Perfect Strategist

In the first decades of the twentieth century, chess enjoyed great visibility in many parts of Continental Europe. The game was important in England, France, Germany, and Russia, and particularly so in the countries of the Austro-Hungarian Empire. Amongst the Jewish communities in those countries, it commanded special interest. From London to Moscow, the grand masters enjoyed great visibility and prestige, and the game was played in the chess cafés of the capitals, such as the Marienbrücke in Vienna and the famous Café de la Régence in Paris. Against a background of high tournament drama, chessmasters such as Lasker and Siegbert Tarrasch wrote manuals on strategy, and the influence of the game was felt in many dimensions of scientific and literary culture. Thus psychologists investigated the thought processes required in chess, and mathematicians wondered whether so human an activity could be made amenable to formal treatment. Others speculated philosophically about the relationship of chess to life in general, and the game was a source of inspiration for several writers, including Vladimir Nabokov, author of *The Defense* in 1929, and Viennese exile Stefan Zweig, whose *Schachnovelle* was the last thing he wrote before his suicide in Brazil in 1942.[1]

[1] See Stefan Zweig, *The Royal Game and Other Stories* (New York: Harmony Books, 1981), orig. *Schachnovelle*, written in late 1941-early 1942. Translated as *The Royal Game* (New York: Viking Press, 1944).

Looming large over the world of chess at this time was the figure of Emanuel Lasker (1868–1941), who held the title of world champion for an unprecedented twenty-four years, from 1897 to 1921. Son of a cantor and nephew of a rabbi, Lasker came from a German Jewish family of modest means. He trained as a mathematician – his mentors included David Hilbert and Max Noether – and he completed a doctorate in mathematics at Erlangen in 1902 with his dissertation on the theory of vector spaces. He shared these algebraic interests with several others, including Gyula König of Budapest and, at Göttingen, his teacher's daughter, Emmy Noether, who later developed Lasker's algebraic work further.[2]

Lasker's short path to chess supremacy began when he interrupted his mathematical studies to play the game for money. Although he long tried to obtain an academic post as mathematician, he was unable to do so as a Jew and was condemned, so to speak, to live by chess. Admired by Albert Einstein, who knew him in Berlin, Lasker was regarded as the player who introduced psychological considerations into the game. In this, he stood in particular contrast to previous world champion, Wilhelm Steinitz, and German champion, Siegbert Tarrasch, both of whom advocated a highly logical approach to chess and the idea that, for every position, there existed a theoretically optimal move, independent of the character of one's opponent.[3] Lasker took the game one stage further: like most players of the time, he had completely assimilated the analysis and prescriptions of Steinitz and he used that knowledge to seek to destabilize his adversary by playing moves that were unexpected and even, on the face of it, inferior. The effect was to provoke confusion and induce errors in his opponent's play, leading some to say that Lasker played, not the game at hand, but the man in front of him.

Of Lasker, British chess champion and commentator Gerald Abrahams writes: "If he had a style . . . it is revealed in a desire for an unbalanced game; a different type of imbalance from that sought by Alekhine, and possibly a greater strain on playing power . . . In the battles he fought he was conscious of the truth that there need not be 'a best move'. The consequence is that Lasker played a type of chess that is difficult to describe. His vision was very great . . . Consequently he was always dissatisfied . . . and frequently sought

[2] On Lasker's work in mathematics, see Neumann (2000) and the essay by Lang in Sieg and Dreyer (eds.) (2001), *Emanuel Lasker: Schach, Philosophie und Wissenschaft*, Berlin: Philo.
[3] On Lasker, see Hannak (1959). This book tends to be criticised for its hagiographic treatment of its subject. Recently, Lasker has been the focus of renewed attention, with the formation of a *Lasker Gesellschaft* in Germany. See Sieg and Dreyer (eds.) (2001).