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How an engineer was drawn to the study of evolutionary games

I would like to thank Joel Brown, Tania Vincent, and Mike Rosenzweig for organizing this special volume as well as all the authors and editors who have contributed to making it happen. I am honoured and humbled by this effort. I am looking forward to reading every contribution.

My interest in optimal processes dates back to my dissertation dealing with the application of optimization methods to problems in aerospace. Six years later, I was fortunate to receive an NSF faculty fellowship to support my first sabbatical at the University of California at Berkeley. The intent of the fellowship was to investigate interdisciplinary problems in biology using optimal control theory. While at Berkeley, I was a guest of Professor George Leitmann who introduced me to differential game theory. Because optimal control can be thought of as a one-player game, this point of view represented a nice generalization for me. It also opened my eyes to the concept that almost all problems we deal with are games. Indeed, all life is a game whenever there is more than one decision maker and the decisions made by one individual affect the payoff to all of the other individuals making decisions.

In keeping with the aim of my NSF fellowship at Berkeley, I worked for a number of years on various problems associated with controlling biological systems using optimal control theory. Examples include the harvesting of fish, controlling a predator–prey system, and chemotherapy. The population dynamic models used in these studies invariably involved a lot of unknown parameters. It bothered me that the parameters in these models should be unknown. If these parameters represented the end products of evolutions, then at least some of them should be predictable. Such thoughts helped lead me to the study of evolutionary games.

While optimal control theory may be used as a guide for making management decisions for non-evolving biological systems described in terms of differential equations (e.g. Lotka-Volterra equations), it was not clear how one should control biological systems that can and do evolve as a result of this control. Because classical solution concepts of game theory are not directly applicable to the evolutionary game, these games have fascinated me ever since I became aware of John Maynard-Smith's concept of an evolutionarily stable strategy (ESS). In these games, players inherit their strategies, and it has been most interesting to investigate connections between classical games, where the focus is on winning, and evolutionary games, where the focus is on surviving.

At the very beginning of my quest to understand evolutionary games, I was surprised one day when Joel Brown (then a graduate student in ecology and evolutionary biology at the University of Arizona) walked into my office and announced that he was interested in game theory. I handed him a copy of my recently completed book (1981), *Optimality in Parametric Systems*, co-authored with Walter Grantham (Washington State University), and suggested he read one chapter a week and we would get together for discussions. He did so with relish! The last problem in the last chapter of this book introduces the ESS concept and asks the reader to obtain necessary conditions to determine an ESS for a continuous system described by differential equations. Neither Walt nor I really knew how to solve this problem and Walt was a bit against including it in the book, as it seemed to be opening Pandora's box to a whole new class of problems that we had not covered. Anyway, I suggested to Joel that we solve this problem and that was the real beginning of a collaborative effort that continues to this day.

We spent many years developing a theory that would be applicable to both matrix games and continuous games. We generalized Maynard-Smith's definition of an ESS to include multiple mutants and the possibility that the ESS could be composed of a coalition of strategies. A key component of this generalization is the concept of a *G*-function and its adaptive landscape that allowed us to develop an ESS maximum principle relevant to a wide range of applications, including vector strategies, multi-stage systems, as well as non-equilibrium dynamics. The *G*-function also proved useful in the development of strategy dynamics for these systems. We refer to the simultaneous solution of the population dynamics and strategy dynamics as Darwinian dynamics. We now use Darwinian dynamics as the main tool for finding ESS candidate solutions, which can then be checked using the maximum principle. We gathered most of this material together with the publication of our 2005 book, *Evolutionary Game Theory, Natural Selection, and Darwinian Dynamics*.

This adventure into evolutionary games has not been a lonely one. The majority of my publications (http://evolutionary-ecology.com/data/TomVincentPublications.txt) are co-authored and I am indebted to these individuals for making my professional life fun and interesting. I truly enjoy collaborative research as is perhaps reflected by the co-authored papers contained in this volume.

Thank you all.

Tom Vincent