ROUTLEDGE RESEARCH IN SPORT AND EXERCISE SCIENCE

Complexity and Control in Team Sports

Dialectics in contesting human systems

Felix Lebed and Michael Bar-Eli

ROUTLEDGE

Complexity and Control in Team Sports

Complexity and Control in Team Sports is the first book to apply complex systems theory to "football-like" team games (including basketball, handball, and hockey) and to present a framework for understanding and managing the elite sports team as a multilevel complex system. Adopting a whole system approach and exploring the concepts of control, regulation, and self-organization, this book argues that it is possible for coaches, managers, and psychologists to develop a better understanding of how a complex system works and, therefore, to more successfully manage and influence a team's performance.

The book draws on literature from the biological, behavioral, and social sciences, including psychology, sociology, and sports performance analysis, to develop a detailed, interdisciplinary, and multilevel picture of the elite sports team. It analyzes behavior across five interconnected levels: the team as a "managed institution;" coaching staff controlling players via cybernetic flows; the team as a playing unit; the individual player as a complex dynamic system expressed through behavior; and a player's complex physiological/biological system. Drawing these together, the book throws fascinating new light on the elite sports team and will be useful reading for all students, researchers, or professionals with an interest in sport psychology, sport management, sport coaching, sport performance analysis, or complex systems theory.

Felix Lebed is senior lecturer and head of the Physical Education Department at Kaye Academic College of Education, Israel. He is involved in the interdisciplinary studies of competitive game playing and has published more than 60 papers in English, Hebrew, and Russian, a number of chapters in edited collections as well as three books. Dr Lebed was previously senior lecturer at the Ukrainian State University of Physical Education and Sport and senior researcher supervising the Soviet national handball teams' Olympic preparation.

Michael Bar-Eli is professor and the head of Sport Management at Zinman College, Wingate Institute, Israel. He is also "Mercator Professor" at the University of Tuebingen, Germany, and currently holds the Nat Holman Chair in Sports Research at the Ben-Gurion University of the Negev, Israel. Having published extensively in English and Hebrew on Sport Psychology, Dr Bar-Eli has gone on to serve as associate and section editor for a number of leading sport psychology journals alongside consultant psychology roles for elite-level athletes and the Israeli defence forces.

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To my wonderful family: Yevgenia, Yanina, and Lior; to my wise friends, colleagues, and students, who have all provoked, challenged, and supported my insatiable curiosity.

Felix Lebed

To Asaph, my older son, my reason for living; and to A & A, with the hope that they will come back some day.

Michael Bar-Eli

Contents

Preface

The preface often determines the fate of a book (to read it or not to read it). Thus, a preface must be short, and it must explain the main point of the book as concisely as possible.

The focus of our study, from a purely academic point of view, is the phenomenon of "complexity" of human systems acting in extreme conditions of sport contest. The study is presented as an interdisciplinary review that (a) develops a complexity perspective on major levels of team sports functioning: from individual motor performance to elite sport club managing; (b) is methodologically based on the idea of dialectics (see Box 1) as a framework for complexity studies.

For example, according to the dialectical view, a person engaged in a physical contest constitutes a unique instance of two corelated and coordinated complex systems. The first is the dynamical system that perceives, moves, and flexibly adapts to changing internal and external conditions of motor action. The second is the specific person's mental system, endowed with free will (see Box 9), and therefore relatively independent of and unpredictable in terms of environment. We consider the transactional coordination of these two systems to be the "dialectical complexity" of physically contesting humans.

The constructive aspect of this book pertains to the development of terms defining possible professional interventions in team sports. The main point can be expressed as an "aspiration to unachievable order" reflecting a dialectic relationship between notions of order and disorder. Because the systems under study are human and thus complex and distinguished by wholeness and self-organization, only several of their elements and connections can be completely *controlled*. For the most part the book emphasizes a process of regulation in team practice and competitive playing. The challenge of understanding how control, regulation, and self-organization can be synergized in the case of team sports is a gripping interdisciplinary subject that sets this book apart from other works about complexity in sports.

Although the book deals with theory, it also offers practical guidelines for coaches and managers in the form of outlines that summarize its core parts. It concludes with a chapter of applications for the theory that proposes an organizational framework for providing multidisciplinary scientific support for the functioning of elite sport clubs and ways of analyzing the performance of teams in competition.

The common dialectic vision of "optimized disorder" in game playing and coaching served as the connecting link between the authors of this book. One of us is involved in interdisciplinary studies of human play and in teaching and consulting in team sports; the other specializes in sport psychology and management. This joint study was mutually enriching, and we are much more knowledgeable now about ways of successfully bringing disordered complex human systems into greater order.

In addition, we referenced academic sources in four languages (Hebrew, English, German, and Russian). As a result, a few "new" names and schools of thought have been brought to the academic discussion of the field of complexity. This is an advantage in any scientific review. Through the broad scope of complexity that is examined regarding humans engaged in physical play, we hope to encourage a dialogue with colleagues in various academic fields: complexity in human behavior and in cooperating human systems; sport and military pedagogics and coaching; psychology, sociology, and management. It would also please us if philosophers could find interest in our dialectical approach to the subject under discussion.

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Introduction

Complexity and sport sciences

One word in the name of this book needs to be defined with precision for the special context in which it is used. The term is "complexity" and its derivative, "complex system." In its specific sense in systems theory, "complexity" is the attribute of an object (or phenomenon) indicating a complicated structure in terms of its own dynamics and relative independence from the environment. Accordingly, a "complex system" is one that as a result of its autonomic quality and complicated structure has its own (often disordered) dynamics and emergent behavior (*output*), which does not necessarily depend directly on environmental influences (*input*). In this sense, complex systems are relatively free of outside control.

Because the "systems approach" has been in use for a long time in coaching team sports (Heinila, 1969; Zelentsov and Lobanovsky, 1985; Wilson, 2008), it is important to differentiate it from the complexity approach proposed here. The main difference between systems approaches and complex systems approaches can be understood in terms of the universal notion of the aspiration to order. The systems approach is based on the understanding that a system can achieve a basically ordered state (equilibrium) by means of self- or input-control and feedback (Bertalanffy, 1968). At the same time, the sport sciences do not always accept the idea that order is an obligatory state in playing systems (Bar-Eli et al., 1999). This ambiguity is well illustrated by a remark made by Larry Bird (a famous American basketball player and coach): "I don't like players who don't do what I say, and I don't like players who do exactly what I say" (quoted from Bar-Eli et al., 1999: 35). In other words, according to the systems approach *order is possible but not always necessary*.

In contrast, the complex systems approach negates the very possibility of reaching a completely ordered condition (Bar-Yam, 1997, Cilliers, 1998, 2005; Morrison, 2002). Consider the following two points: (1) When passive, a complex system is naturally drawn to chaos and destruction, thus it is always active; (2) When active, a complex system constantly aspires to greater order.

This concept is reflected in the main messages appearing throughout this book:

- Self-ordering in complex systems is *maximized* because order is impossible;
- Ordering external interventions (coaching, managing) has to be *optimized*, that is, they should support and not force a system's self-organization.

Human systems in sports are complex and this *fact* has become a *factor* that has influenced approaches to these systems during recent decades because of the problems of control and efficacy that are characteristic of such kinds of human activity. The actual need to promote the complexity view of human competitive activities is obvious.

It should be stressed that the complex systems approach is relatively new, and not only in the sport sciences, it is new in the natural sciences in general. Its roots lie in mathematics (Kolmogorov, 1965) and traditional elaborations within the applied mathematical sciences such as informatics, cybernetics, artificial life, and so on. The complexity of living systems (i.e., the impossibility of predicting their behavior with precision) became a leading "issue" in the last quarter of the 20th century (Maturana and Varela, 1973; Kauffman, 1993; Kelso, 1995).

In the sport sciences, many studies have addressed the questions of complexity mentioned above, for the most part in two often overlapping fields: (1) motor control and learning (Davids et al., 1999, 2003; Schmidt et al., 1999; Mayer-Kress, 2001) and (2) behavioral studies focusing on performance analysis in games (Lames, 1998, 2006; McGarry et al., 2002; Glazier et al., 2004; Lames and McGarry, 2007; Araujo et al., 2009). But mainstream research in sport biology, medicine, the humanities, and the social sciences in sport has paid little serious attention to the complexity approach.

The present book lays out the main aspects of team sport games functioning—biological, behavioral, psychological, and managerial—through the prism of the complexity approach. The review focuses on various disciplinary aspects of how the entire system functions on its different levels, such as the body's movement system, the athlete as a person, the team as a domain, and the sport club as an organization. This facilitates an interdisciplinary multilevel approach to the question of effective coaching and managing, taking into account the regulation of performance equifinality and the self-organization of complex systems acting on different levels.

Methodology

An essential methodological basis of this study is the dialectical method of cognition (see Box 1), in which contradictory processes and phenomena can be grasped as complementary (Kelso and Engstrøm, 2006) transitive entities. Viewed in this way, one can discuss the rationality and irrationality of human activity in game playing (Bar-Eli et al., 1999) as a dialectical complementarity. Through this point of view, one is better able to understand how a playing athlete acts simultaneously as a reactive, skillful, and dexterous animal and as a proactive human planning his activity according to the coach's directives, taking into account, for instance, social tasks such as assuring his national team's success in the Olympic Games. The notion of transcending opposites through the dialectical method makes it possible to view successful playing and coaching as one harmonious unit comprising an intrinsically and extrinsically ordered activity in which disorder is present in certain elements as a normal component.

We see the dialectical method as philosophical support of the complexity vision in general. It is a framework that helps to explain three core identities of complex systems: (1) their being on the edge of chaos (both ordered and disordered), (2) the transition of quantity (a very large number of elements and their connections) in such systems to a new quality (new unpredictable characteristics of behavior caused by this quantity), and (3) the unity (dependence of existence) and disarray (relevant independence of behavior) of complex systems from the environment. Because these exceed the bounds of sport science views and integrations, we have appended a subtitle to the book: "Dialectics in Contesting Human Systems."

The interpretations suggested in this book (1) of a playing athlete as a "dialectical complex system" (Chapters 4–7); (2) of a team playing as an "ordered disorder" (Chapter 8), (3) the process of coaching as a regulation of disorder supporting the team's self-ordering (Chapter 9), were possible only in the framework of the dialectical method.

Box 1: Dialectics

The term "dialectic" (διαλεκτική - dialektikē) derives from ancient Greek philosophy. The Sophists teachers, would teach the young men of the polis the arts of rhetoric and dialectic, how to talk and how to prepare good arguments. Dialectics was the name of the art of discussion based on two contradictory affirmations. A philosopher should artistically be able to develop his own thesis by freely manipulating one contradictory argument by using an affirmation from the opposing argument, and by such way he comes to cognition of truth.

The philosophical concept of dialectics is connected to the 19th century, mostly to names like Hegel, Marx, and Engels. The German philosopher George W.F. Hegel (1770–1831) suggested the notion of a self-developing absolute Spirit (or thought), calling it the "thesis" in its primary state. Underlying the development of the thesis is a process of its negation by examining and reconstructing real and different expressions of the material world. The thesis that is negated through this exercise becomes an "antithesis," and this transition helps to continue development of the idea. The antithesis is enriched by the core principles of the primary thesis and becomes a "synthesis" of both. In changing its opposing quality through "thesis – antithesis – synthesis," the Spirit transcends itself to a new, higher level of development.

Hegel's dialectics of Spirit did not explain the development of and changes in material world itself. This was done by Karl Marx (1818–1883) and Friedrich Engels (1820–1895), German economical and political philosophers who created what is called Marxist philosophy. Marxism considers dialectics as the main pace of world development, which is realized through unity, struggle, and the negation of opposites. Both Hegel's and Marxist dialectics show the transaction of states as an ascension along a spiral where a new third-quality synthesis returns to its primary essence, but on a higher level of development (as a higher spire of the spiral).

Understanding the world dialectically, that is as a continuously developing and changing opposition of states, means not being able to relate to cognition of any object by a fixation on its current state but rather to envelop all stages of an object's growth. The dialectical method of cognition is a synthesis of both the ancient understanding of the term (taking two opposites while seeking the "golden mean") and an understanding of entities in the world as inconstant, developing, and being complementary to its opposite state. This methodological approach is utilized in the present volume for formulating the main theoretical points about complexity in human competitive playing.

In this book, we discuss questions of complexity but not in mathematical language. This methodological choice is based on two notions. First, the authors proposed a number of theoretical concepts supported by philosophical ideas and originating in reviews of different fields of knowledge. These reviews mainly apply ideas and the results of theoretical and empirical research rather than to their mathematical and/or statistical tools. Second and more important is our wish (because we are not mathematicians) to be careful with mathematical language in general, in part because of the inadequateness of regular mathematic methods for explaining life. This view was proposed by the prominent mathematician Israel Gelfand (Box 2), who made great efforts to elaborate a special formal language of life studies and medicine:

> The weak development of a formal language for describing live systems and different aspects of human activity … seems to me to be an Achilles' heel of modern civilization. Truly, the absence of a uniform language creates

> Tower of Babel type turmoil in these fields. Some have suggested so-called mathematization, i.e., using methods borrowed from mathematics, as a possible panacea. However, they forget that mathematics was developed on the basis of and in close association with "simpler" scholarly fields for the study of inanimate objects: engineering, physics, astronomy etc. Thus, mechanically transferring mathematical methods to the fields mentioned above is not justified. Moreover, I see a danger in this transfer …
>
> (Gelfand et al., 2011: 3)

The special formal language for explaining life and human complexity has elaborated upon (Bar-Yam, 1997, Wolfram, 2002). Thus, elements of such language are recognizable from different fields of mathematics, for example: (1) probability theory—Boolean networks, for instance—is employed by Kauffman (1993, 2000) in his complexity approach to the evolution of life; (2) different mathematical cybernetic approaches correspond mainly with the Catastrophe theory (Arnold, 1992); for example, a swallowtail model of catastrophe is utilized in psychology of leadership research (Guastello, 2000, 2010); (3) chaos theory and bifurcations are important elements in the modeling of life complexity (Wolfram, 2002) in general and in sport behavior in particular (Mack et al., 2000); and (4) differential equations/dynamical systems theory, such as in the modeling of brain–muscle coordination (Haken et al., 1985, Kelso, 1995), has enhanced some aspects of sport biomechanics (Davids et al., 1999, 2003; Glazier et al., 2004).

Box 2: Israel Gelfand

Israel Gelfand (1913–2009) was a Soviet (since 1989 until his death—an American) mathematician, who made major contributions to many branches of mathematics, including group theory, representation theory, and functional analysis. Gelfand held several honorary degrees. In 1977 he was elected a Foreign Member of the Royal Society. He won the Wolf Prize in 1978, the Kyoto Prize in 1989, and a MacArthur Foundation Fellowship in 1994. In an October 2003 article in *The New York Times* marking his 90th birthday, Gelfand was described as a scholar who was considered "among the greatest mathematicians of the 20th century," having exerted a tremendous influence on the field through both his own works and those of his students.

The importance of Gelfand's views for this book lies in his long-standing elaborated position that life processes and, even more, human existence cannot be reflected by mathematical language, which developed from the measurement of inanimate nature.

Limitation

Using the complex systems approach as a framework, this book reviews theoretical studies and empirical research in several disciplines pertaining to team sports (Box 3). From among the wide spectrum of team sports, it focuses mainly on one exclusive group of ball games consisting of *football (all national versions), rugby, basketball, team handball, and ice/field hockey*, which are characterized by an individual's action with a ball versus the collectiveness of the activity, direct counteraction and physical contact between opponents, a "step by step" attack toward a goal as well as capturing territory as an obligatory condition for striking and scoring by shooting a ball or puck or by making a touchdown. In this volume, this group of games is referred to operatively as "football-like" games.

Box 3: Team sports

The term "team sports" is not unequivocal. In the direct sense, it means sports where competition occurs between athletes joined within groups. Thus, a bicycle team race on the roads and boat-racing in teams of 2, 4, and 8 athletes constitute team sports.

To consider a category of sports that encompasses, for example, football, basketball, team handball, and other similar sports, one must use a complicated definition entailing a triangle: ball—team—sport (game). This is how terms such as "ball-games" (Blanchard and Cheska, 1985) and "game sports" (Lames, 2006) were accepted in different times. But these options lose a special relationship of collective competition and encompass all games played with a ball by contesting teams, individuals, and pairs.

Another way to consider games with a ball can be seen in attempts to categorize games based on certain distinguishing criteria. The widely quoted classification today is by Ellis (1983) who divided games into four main categories: territory, target, court, and field games. Ellis' classification was further developed by Thorpe et al. (1986), and at present, the four following game categories (Hopper and Bell, 2001; Butler and Hopper, 2011) are used, for instance, by the national curriculum for physical education in the United Kingdom: (1) target games, (2) batting and fielding games, (3) net/wall games, and (4) territory games such as soccer, ice hockey, basketball, rugby, and football. The problem is that these categories cannot be included within a simple linear classification, because they are based on too many (four) criteria (aim, basic skill, core intent, and type of facilities).

Because of this logical problem, Lebed (2004) continued to develop what are called "non-linear" game classifications that use two criteria simultaneously. In Lebed's taxonomy, the first criterion is the *main intent* of the competition and the second is the *type of ball manipulation* (directly by a part of the body, indirectly using a tool, and mixed manipulation). According to these criteria, there are five categories of games (ibid.: 470): (1) those involving direct counteraction and bodily contact by the athletes; (2) those with direct counteraction without contact, (3) games of hitting a target, (4) games of juggling, and (5) race games with a play article. Each category is divided into three types of ball manipulation.

The problem of this book's purview is that taken separately, neither this approach nor "territory capturing" or Caillois' (1961) notion of organized–non-organized (Ludus–Paidia) games can reflect all the important features of the group of games analyzed here. Games such as football or basketball are characterized by team interaction, team contest, and a high level of organization.

These doubts have led us back to the broadest term, "team sports," as one that reflects the most important element—the collective nature of playing—in the games under analysis. This main category is followed by an additional one that makes the definition more precise—"football-like games" (see the main text). For example, taken together, these two frames are an optimal binominal tool for reviewing the main questions connecting this group of games to the notion of complexity.

The decision to restrict the object of the study to football-like games was taken for several reasons. First, this choice is related to thousands of years of history of football games. Their general character is representative of ancient Chinese "Shin-Chi" (Guttmann, 1978), Roman-Italian "Calcio" (Halpern, 2008), and medieval English folk football (MacLean and Jones, 2008). Football-like games provide what is perhaps the most universal physical-motor basis for modern team sports because traditionally they employ both hands and feet in manipulating the ball, aggressive contact between opposing sides is essential during the contest, and they share a similar sense of game development from beginning to end. These features make these games a relatively homogeneous object of study, which is important when seeking general professional solutions to outstanding teaching and coaching questions in the field.

Second, these are collective games that constitute a group sport activity in which individuals are mutually dependent on one another and require interaction and group cohesion at the team level (Carron and Hausenblas, 1998; Carron and Eys, 2012). From a scholarly viewpoint, this choice seems to offer the widest and most complicated object of study possible, because it is characterized by many open motor skills, individual cognitive ambiguity and emotional processes and states, divertive and latent group dynamics, and many perturbing forces originating in the social environment. Because it is so complicated, it is the most interesting case for us.

Structure

Dealing with team sport complexity from a multilevel view requires the proper book structure. This volume is divided into step-by-step themes (chapters) progressing from lower to higher levels of the multilevel complex system under examination: the body's movement system → the athlete → the team → the coach ~ team symbiosis → the elite sport club (Parts II and III, Chapters 4–10). At each of the levels, the book reviews sources and reveals the main characteristics of complex systems functioning with the intention of creating effective self-organization, regulation, or control. These main parts are prefaced by a methodological discussion (Part I, Chapters 1–3) about the complex systems approach to competitive game playing in general. The book concludes with a summary in the form of an applicative outline (Part IV, Chapter 11) that utilizes the complexity approach and delineates the main principles, professional consulting, scholarly performance analysis, and managing of elite teams in football-like games.

Part I

Methodological aspects of complexity in team sports

Introduction to Part I

This part serves as an especially broad scholarly introduction to competitive activity in sports through the complexity perspective. The discussion draws on sources from systems and complex systems theories, cybernetics, general biology, kinesiology, psychology, and management science. The outline is constructed deductively (from the general to the particular). As the most general subject under discussion, the system is the first notion to be reviewed. After that the topics narrow funnel-like in a logical progression: complex systems in general → living complex systems → human complex systems in action → athletes, teams, and sport organizations as interconnected elements of multilevel hybrid complex systems.

1 Complexity in modern sciences

The notion of system and main terms: main characteristics and a definition of system; the complexity phenomenon and distinctive features of complex systems.

1.1 The notion of system and main terms

To substantiate the idea of complex system, it is necessary to reexamine a number of basic terms. The main term is "system." According to early definitions, system was considered "a set of elements standing in interaction" (Bertalanffy, 1968: 33). This approach was quite popular during the 1960s and 1970s (Zeigler, 1976). But with the development of systems theory, essential new elements became key indicators, the most important of which will be analyzed later in this chapter. A logical axis for the following discussion will be based on Bertalanffy's explanation of the theory of systems, which is one of the most fundamental generalizations in the field (Bertalanffy, 1968, see also Box 4). His opinions are presented here with additional notions and principles proposed by other theoreticians before, concurrently with and after him. One of them is Wiener's notion of cybernetics (Box 5).

Box 4: Ludwig von Bertalanffy

Ludwig von Bertalanffy (1901–1972) "was one of the most important theoretical biologists of the first half of this century. He developed a kinetic theory of stationary open systems and the General System Theory and was one of the founding fathers and vice president of the Society for General System Theory, and one of the first who applied the system methodology to psychology and the social sciences" (Brauckmann, 1999).

In the 1940s, he formulated his theory of open systems that shows a kind of self-regulation comparable to the behavior of an organic system. His notions of *wholeness*, *hierarchy*, *equifinality*, *feedback*, and *aspiration to equilibrium* were, in fact, a partial introduction to the theory of complex systems using different professional jargon.

During his professional career, Bertalanffy held positions at the University of Vienna (1934–1948), the University of Ottawa (1950–1954), Mount Sinai Hospital, Los Angeles (1955–1958), the University of Alberta (1961–1968), and the State University of New York (SUNY; 1969–1972). He was a member of the Deutsche Akademie für Naturforscher Leopoldina (Halle), the New York Academy of Sciences, the Canadian Physiological Society, and Study Groups of the World Health Organization.

Bertalanffy published over 200 articles on theoretical biology and General System Theory in journals and wrote more than 10 monographs. His works have been translated into English, French, Spanish, Swedish, Japanese, and Dutch (Brauckmann, 1999).

Box 5: Cybernetics and Norbert Wiener

The Greek [kibernetiks] or "steersman" was used rather widely as early as the days of Plato (Plato: Republic, 6.488A; *Laws*, 12.963B; *Cratylus*, 390d) and later it became a common metaphor for a wise leader of society.

Historically, after ancient Greece, the new use of "cybernetics" appears in the 19th century. The famous French physicist André-Marie Ampère (1775–1836) used the term "cybernetics" for his vision of governing society in the 1830s. Additionally, Zeleny (1979) cited three relatively old works from the late 19th to early 20th centuries dedicated to social governing analyzed through cybernetics, tectology, and holism, and joined by him into one vision of a system based on feedback flowing from those governed to the governor. According to Zeleny, the Polish philosopher Bronislaw Trentowski published a small volume entitled *The Relation of Philosophy to Cybernetics as an Art of Governing the People* in 1843.

Thus, when Norbert Wiener (1894–1964) suggested the term "cybernetics" for the "entire field of control and communication in the machine or in the animal" (Wiener, 1948/1965: 11) in 1945, he thought he was the first, but in truth he was not.

Nevertheless, the connotation of cybernetics pertaining to a science and to weapon technologies is connected to Wiener (Zeleny, 1979). He himself traced this term to Karl Maxwell's principles of "feedback mechanisms," published in 1868 (ibid.: 11).

Wiener used Maxwell's principle of feedback in his mathematical models for antiaircraft fire control in World War II (Wiener, 1956). Wiener conceived the idea of considering the operator as part of the