COMPLEX SYSTEMS AND SPORTS:
Complex Systems insights to building effective teams

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Abstract

This lecture discusses the characterization of effective teams (their complexity / variety) and the role of competition and cooperation in the formation of effective teams. The context for the discussion, sports, provides examples that are also relevant to many other aspects of society and biology.

KEY WORDS: SPORTS, COMPLEX SYSTEMS, COMPLEXITY, COOPERATION, COMPETITION

Introduction

In this lecture I will be discussing some of the relevance of my research at the New England Complex Systems Institute to sports. I must state, however, that I find sports to provide important examples of complex systems that I often use to demonstrate the relevance of complex system research to many other areas of inquiry.[1] Sports provide a wide variety of semi-controlled (schematized) complex systems that can serve as a laboratory for testing and evaluating ideas from research on complex systems. I feel that there is a mutual benefit of the association of complex systems research and sports. This is an important reason for my enthusiastic embrace of this conference and my respect for the efforts of the organizers.

If you explore our website, at http://necsi.org you will find that I write there about the connection between complex systems and sports. I do so to illustrate that complex systems research and concepts are relevant and manifest in our daily lives. Please look at the Guide to Complex Systems that can be found linked from our home page.

Three approaches

To begin my discussion today, I have found that my research has revolved around three approaches to the study of complex systems. These approaches are not separate but form a kind of harmony. Still it is useful to identify them.

1) The first approach is the recognition of patterns of collective behavior and relating these patterns to the interactions between components. This approach, which is much of the study of complex systems in many research groups, also has a long history in sports. For example, consider the "play diagram" that is often used to illustrate the plan for what players are supposed to do. The idea of the diagram is to capture how the parts work together to make the action of the team as a whole.

2) The second approach is analyzing not a single play but rather the set of possible actions that a person or team can do. This topic is more difficult to talk about than the first approach because it is more abstract. If we think about the effectiveness of a person or a team (or for that matter any complex system) it turns out that effectiveness is generally not related to a single possible action, but rather the set of all possible actions that one can do. This set of possible actions is therefore of great importance in all of complex systems research as well as in sports.

3) The third approach discusses how complex systems form. This approach is different from the first two. The first two are analytic. They describe how we can understand the structure and behavior of systems. The third approach is synthetic,describing synthesis. The only way that we know that very complex systems are created is by evolutionary processes. Thus, the study of evolution is central to our ability to understand complex systems in any context, and also of course in sports.

My plan today is to discuss the second and third aproaches as keys to the problem of understanding effective teams. The second approach (my first topic) will be analytic discussing what constitutes effective team play. The second topic will discuss the process by which effective teams are formed..

The Space of Possibilities; Complexity of Team Play

I will now turn to the topic of the set of possibilities as a way of characterizing the effectiveness of complex systems Complexity itself is a measure of the number of possibilities [2-4]. In the context of sports, an effective defense has to meet the possible choices of the offense. Thus, the number of possible ways a player or team can create an offense is important. If a player or team has a more diverse set of offensive plays, the other side may not be able to defend against each play. The plays that it cannot defend against can be exploited. In basketball, this applies for two individuals playing one-on-one and for two teams playing against each other.

The 2000 NBA Finals between the Los Angeles Lakers and Indiana Pacers can serve to illustrate this principle both at the individual and at the team level [I note that I was a fan of the Pacers in this competition].

Shaquille (Shaq) O'Neil the 216 cm, 143 kg center of the Lakers is often called the most dominant player in basketball. When he has the ball near the basket, his opponents often send two or three rather than only one player to defend. He often scores anyway, averaging nearly 30 points per game during the 1999-2000 season, the best in the sport. Clearly his size had something to do with his success. However, when he talks about his abilities to defeat players in one-on-one play, he says that he can defeat his opponent because he has over thirty different moves.

The importance of having a variety of different team plays is generally recognized in the game of basketball. Teams practice passes to set up different shots, establishing first options and, if blocked by the defense, second or third options. However, the importance of having a variety of offenses extends to all aspects of the play in ways that are not always recognized. To illustrate this I will focus on the first game of the 2000 NBA Finals series which was won by the Lakers. Most of the commentators have emphasized how dominant Shaquille O'Neil was in this game where he scored 43 points. Once he had the ball, the Pacers almost never stopped him. While Shaquille's abilities are clearly important, I will argue that attributing the success to him is like saying that the head of the hammer is what pounds in a nail. To say that Shaquille could not have done what he did without the rest of the team is not the point. There is something specific about the way the Lakers played in the first game of the playoffs that was significant.

To understand the key to the Lakers' play, we need to understand how the Pacers played their game. The 1999-2000 Pacers were a remarkably good team, but for someone who studies complex systems, and even for some who do not, they had one clear weakness. As is often the case this weakness is related to one of their great strengths. They had a pattern of play which, at one point, was simple. This simplicity arose because they were so good at what they did that they didn’t feel they had to vary it. Because they didn’t vary it, they were vulnerable to an opponent who recognizes this simplicity and attacked at that point.

Mark Jackson, the point guard of the Pacers in that year, was the player who, for most of the game, was responsible for bringing the ball from one end of the court to the other. The reason he did this was to set up the offensive play after the Pacers regained the ball from the Lakers. However, Mark did it essentially the same way every time he took the ball up court. This consistency reflected the incredible reliance of the Pacers on his ability to set up the play for the offense. The problem was that an opponent who recognized this could attack at this point, and the Pacers had almost no alternative.

If you watched the game, you would have seen that Kobe Bryant, who is generally one of the most successful scorers for the Lakers, was consistently trying to bother Mark on his way down the court. Kobe didn't stop him, because Mark is too good a ball handler to be diverted for very long. What Kobe achieved was a delay in time. There were two

likely to succeed, because there was not enough time to try for several possibilities. Second, and very importantly, Shaquille O'Neill had enough time to move up the court and take a position for defense. The importance of this is not to be underestimated. As the most massive player, Shaquille also has an important weakness, he has to expend a much larger effort to move quickly. Stated differently, he cannot move as fast for as long as other players, and changing direction is a major effort. This is a law of physics, which is well understood in basketball, smaller players are generally quicker (quicker does not only mean faster, quicker also means able to change direction). The extra time given to him by Kobe's defense, makes a difference each time he has to run up the court. Over the course of the entire game this is significant, especially since each player is expending their maximum possible effort.

One interesting question is: Are the Lakers consciously doing this or is it just a coincidence that they know what to do? There is one clear evidence for the consciousness of their effort. In 1998, two years previously, the Pacers faced the Chicago Bulls in the Eastern Conference Finals. At that time, in what was a hard fought series, the first two games were also lost by the Pacers. What was going on at that time? It wasn't Kobe Bryant, but it was Scotty Pippen who was pestering Mark Jackson mercilessly. Pippen was very intensively doing this and was very good at it. It was also clear what he was doing. Both Pippen and Kobe are very good offensive players scoring highly in most games. In these games, Pippen and Kobe both scored uncharacteristically little. Their energy was expended in this defense. There is another common factor between these two games. The coach of the Lakers in 2000 was the same coach as that of the Bulls in 1998, Phil Jackson.

This discussion illustrates the importance of complexity as a measure of the behavior of a system. Counting the number of ways one can act or react to environmental conditions is an important part of the study of complex systems in general.

Cooperation and Competition in Sports

I would like now to turn to the next topic, the evolutionary formation of complex systems. This topic centers on the interplay of competition and cooperation. There is an interesting attitude that one finds toward competition and cooperation that exists among many people. Often I find people either like competition or cooperation and find the other to be reprehensible. Some like competition, others cooperation. I would like to discuss their interplay, and particularly in sports. First I will explain the connection to evolution.

Since the beginning, Darwin’s ideas and the study of evolution have focused on competition as the driving force of evolutionary change. As many of you know, evolution is a process by which populations of organisms change over time. The change occurs not because they change individually, but because of a change from one generation to the next. They change because some types reproduce more than others,

reproducing types to dominate the slower reproducing types over time. This description appears only to talk about competition Because of this, the idea that cooperation occurs among animals has seemed antithetical to evolutionary ideas. Indeed, many of you may be familiar with the book "The Selfish Gene" written by Dawkins. [5] This book popularizes the basic concepts of what is called NeoDarwinism. NeoDarwinism is the dominant theoretical framework in which evolution has been discussed since the early part of the last century, almost one hundred years ago. According to this theoretical framework, formulated by Fisher, Haldane and Wright, evolution can be understood as a competition between genes, and that's that. Any forms of cooperation arise merely through the hidden agendas of these Machiavellian genes.

For a number of years I have been unhappy with this formulation. In my textbook *Dynamics of Complex Systems* [3] I discuss the reasons that it is both formally (mathematically) invalid and conceptually incorrect. Since then, I have published a number of papers on this subject that you can find on our website as well. [6-11]

I have found, however, that a discussion of cooperation and competition in sports provides a remarkably good way to explain this matter and to clarify the real relationship between competition and cooperation in all contexts.

We can start by simply listing some of the ways competition and cooperation might occur in sports. We might not characterize all of them as positive, but that value judgment is not what we are talking about..

For example:

- Individuals compete among themselves to be players on a team.
- Teams compete to win games
- Teams cooperate to set times of events and to set the rules
- Different sports compete to gain media attention and audiences. In this they also compete with other forms of entertainment.
- Individual players cooperate as part of a team.
- Teams might cooperate (this is a no-no in most sports) to fix games so that box office receipts are larger, for example. by extending a series.
- Individual players might compete on a team to gain the best individual statistics, or individual salary.

When we think about these different kinds of competition and cooperation we recognize an important distinction. The type of relationship between competition and cooperation that we most often think about is the conflict between competition and cooperation of players on a team. We care deeply about their cooperation and we distinguish "team players" from non-team players. This relationship is the antagonism of cooperation and competition that disturbed Greek philosophers when they considered selfishness and altruism in social behavior and continues to be an issue till today: Why would anybody cooperate when they might benefit from selfish competition.

There is, however, a different relationship that is apparent, and is probably clear to

between teams as opposed to cooperation between players. When players cooperate they can compete better as a team. When teams compete, this motivates the cooperation between players. We see that there is a positive or constructive relationship between cooperation and competition when they operate at different levels of organization: team competition and individual cooperation.

This is a quite general observation that can be illustrated by a figure. In the first figure we see that competition between teams enhances the collaboration between players. How does it do this? By the evolutionary process of selection. The better team is the team with the players who cooperate. If we select teams that are better at competition over time, we will find that the players on the team cooperate better. Also it is the cooperation between players that enables the teams to compete with each other. So this is a synergistic relationship. We might actually state something stronger, which is that cooperation occurs only when there is competition, and competition occurs only when there is cooperation.

Figure 1.

The more usual relationship that people notice as a conflict between cooperation and competition occurs at the same level of organization. This is illustrated in the second figure, that shows the competition between players on a team at odds with cooperation between the players. The picture also shows that there can be ways in which players can compete and cooperate without conflict as long as these two behaviors are in some sense orthogonal, or independent of each other. For example, we can have players that are at different kinds of specialized positions. For example, “forward” and “point guard” in basketball. Players can compete for each of these positions separately without interfering with their cooperation as a team. The case of the LA Lakers is again interesting here, because over the past few years there have been periods of time when the two strongest players, Kobe Bryant and Shaquille O'Neil, competed with each other for attention, even though they are at different positions. This conflicted with their cooperation as teammates. When this occurred the team did not play well, and lost many games. When they cooperated the team was almost unbeatable.

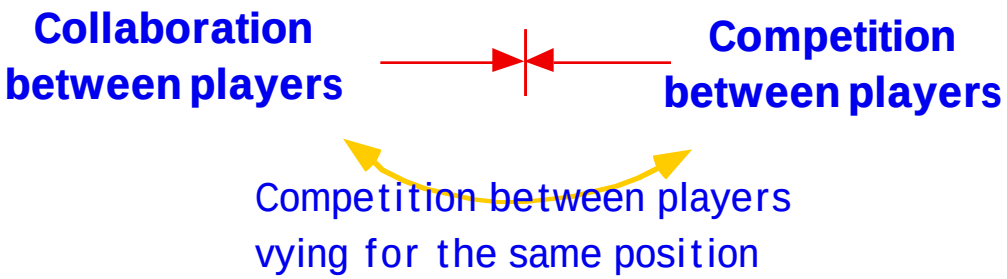

Figure 2.

We can generalize these figures to recognize that there is a multilevel picture that illustrates the interplay of competition and cooperation. As shown in the third figure the competition between sports is what gives rise to the collaboration between teams, the competition between teams gives rise to collaboration between players. Conversely cooperation at each level enables competition at the higher level of organization. At the same time competition and collaboration are antagonistic when they take place at the same of organization unless they are made `orthogonal' referring to different times or types of behavior.

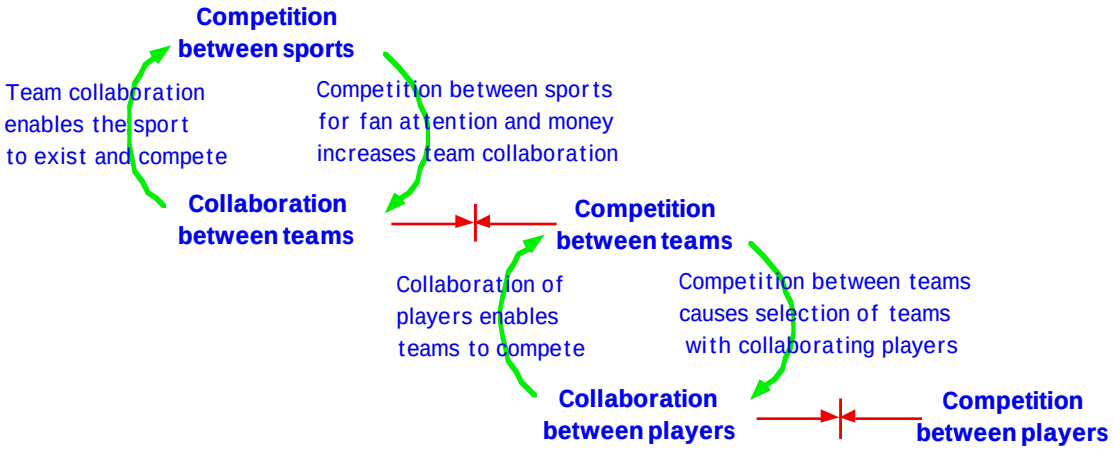

Figure 3.

The key point is that competition and cooperation always occur together at different levels of organization This topic might be so intuitive to some of you that you are wondering why I am talking about this at all. Surprisingly, it has not been clear to many in the context of scientific dialog about evolution. Even if understood intuitively in sports, and even if some scientists understand this intuitively as well, it is important to state clearly these basic relationships.

How does this help us make effective teams? The answer is, self-evident. Effective teams form naturally when there is a process of evolutionary selection of teams that perform well in competition. This may be a useful lesson for those who try hard to compel player behavior in one way or another. While I do not want to say that teaching is not important. Still, it is the role of competition itself to teach about cooperation. I would also say, that evolution teaches us something about the proper place of rewards for effective competition. The main reward is simply the right to stay together. This, after all, is what survival, survival of a collective, is all about.

Conclusions

I would like to summarize by emphasizing that to me sports provides a rich context for discussing complex systems ideas and application of complex systems theories. I also believe that complex systems research has a lot to contribute to the analysis of the effectiveness of teams, and the understanding of how they form. I have not discussed the more technical details of our research that can help in quantitative analysis of both the problems of analysis and the problem of creating an environment where effective teams will form. This will have to wait for more technical papers. My emphasis here has been on the power of concepts from complex systems to discuss teams in sports.

The specific conclusions have been as follows. First, that the complexity as a measure of the set of possibilities is a powerful tool for evaluating the effectiveness of a team and of its vulnerabilities. Second, that the main way that we create cooperative teams is through the competition and selection that is modeled by evolutionary process. This reflects the profound interplay of competition and cooperation wherever they occur.

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