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# Paradigm Shift for Future Tennis

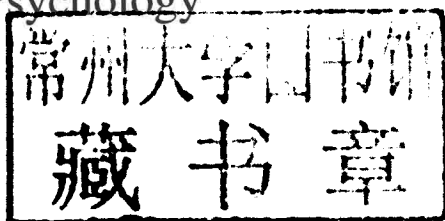
The Art of Tennis Physiology, Biomechanics  
and Psychology

Tijana T. Ivancevic, Bojan Jovanovic,  
Sasa Jovanovic, Milka Djukic,  
Natalia Djukic and Alexandar Lukman

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# Paradigm Shift for Future Tennis

The Art of Tennis Physiology,  
Biomechanics and Psychology



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## Preface

The book “Paradigm Shift for Future Tennis: The Art of Tennis Physiology, Biomechanics and Psychology” is a sequel to our previous book “Complex Sports Biodynamics with Practical Applications in Tennis”, Springer, Cognitive Systems Monographs, Vol. 2, 2009.

In a historic Wimbledon 2009 final, the celebrated Swiss player Roger Federer became the greatest men’s tennis player of all time, beating the popular American Andy Roddick in an epic five sets: 5-7, 7-6(8-6), 7-6(7-5), 3-6, 16-14. It was a battle of the two top serves in the game. Roddick won the first set. The second set went into a tiebreak; Roddick had 4 set points, yet he lost them all, and with them, the set. Federer proved successful in the next tiebreak, as well. However, Roddick came back very strong in the fourth set, broke Federer, and won it, six games to three. The American continued, starting the fifth set absolutely on fire, yet could not endure the four hour and sixteen minute marathon that followed. Federer won this battle of muscles and nerves to make tennis history.

This was Federer’s 15th Grand Slam title, the total list consisting of: Wimbledon 2003, Australian Open 2004, Wimbledon 2004, US Open 2004, Wimbledon 2005, US Open 2005, Australian Open 2006, Wimbledon 2006, US Open 2006, Australian Open 2007, Wimbledon 2007, US Open 2007, US Open 2008, French Open 2009, and Wimbledon 2009. It was also Federer’s sixth Wimbledon crown (2003, 2004, 2005, 2006, 2007, 2009).

Pete Sampras, holder of the previously unbeaten record of 14 Grand Slam titles and seven-time Wimbledon champion (1993, 1994, 1995, 1997, 1998, 1999, 2000), was watching the match from the Royal Box, along with fellow tennis legends; Sweden Bjorn Borg, a five-time Wimbledon champion (1976, 1977, 1978, 1979, 1980), and Australian Rod Laver, two-time Wimbledon champion of an Open Era (1968, 1969). In addition, the TV commentators were none other than American John McEnroe and German Boris Becker, both three-time Wimbledon champions (respectively, 1981, 1983, 1984 and 1985, 1986, 1989).

What's more, this was Federer's fourth Grand Slam finals victory over Andy Roddick. Previously, Roger beat Andy at the finals of Wimbledon 2004 (46, 75, 76(3), 64); Wimbledon 2005 (6-2, 7-6(2), 6-4); and US Open 2006 (62, 46, 75, 61). With his latest victory, the Swiss managed to extend his overall mastery over the American to 19-2, including 8-0 at Grand Slams. And all this against an ex-number-one player in the world. How can this astonishing resulting factor, 19-2, be possible? Is it due to Federer's forehand? His backhand? Or, perhaps his commonly underestimated serve? Could it simply be the entire *Federer package*? And if so, then what makes up this outstanding package? Notwithstanding the exceptional qualities of the ex-number-one, in this book we will reveal the secret weapon of Roger Federer. And much more: we will reveal *the blueprint of a future tennis champion*.

What is a *paradigm shift*? This beautiful term invented by Thomas Kuhn in 1962 in his book "The Structure of Scientific Revolution", implies on revolutionary changes in hard science theories. Today, popular and accepted in many areas *paradigm shift* depicts a dramatic change of view and perceptions. Is it time to radically change last hundred years of science development and come on track of unified field? Mechanics-oriented paradigm of today's science is coming to the "no through road" journey proving that we can't be treated as a computer. Human beings and human existence, as well as the whole creation have the matrix beyond the physical reality, closely connected with everything and everyone in the Universe.

A century ago, Nikola Tesla – the King of electricity – said: "When science begins the study of non-physical phenomena, it will make more progress in one decade than in all the previous centuries of its existence." Tesla is one example of scientist who had holistic and deep approach to our Universe and his achievements consequently dramatically improved the quality of our life.

This book starts with revelations that make obvious the limitations of today's tennis which does not use the Laws of Modern Biomechanics (see <http://adsabs.harvard.edu/doi/10.2478/s11534-009-0148-z>) and Neurophysiology. The second part of the book includes a new approach to the *quantum mind of a champion*. This paradigm shift started with the work of eminent physicists John A. Wheeler and David Bohm, and their ideas that we are active participants in the creation. Before them, Erwin Schrödinger, one of the fathers of quantum mechanics, mentioned the term "entanglement" as the very essential part of his wave mechanics. Today Guardian Science states: "Entanglements of two or more particles that have once interacted always remain bound in a very strange, hardly understandable way even when they are far apart and their connection being independent of distance." Very powerful quantum brain is the main characteristics of Roger Federer, as well as some other sport champions like Michael Schumacher.

## Acknowledgments

We wish to express our sincere gratitude to *Springer* book series *Cognitive Systems Monographs* and especially to the Editors, Dr. Thomas Ditzinger and Dr. Dieter Merkle.

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**The Laws of Core Future Tennis Science**



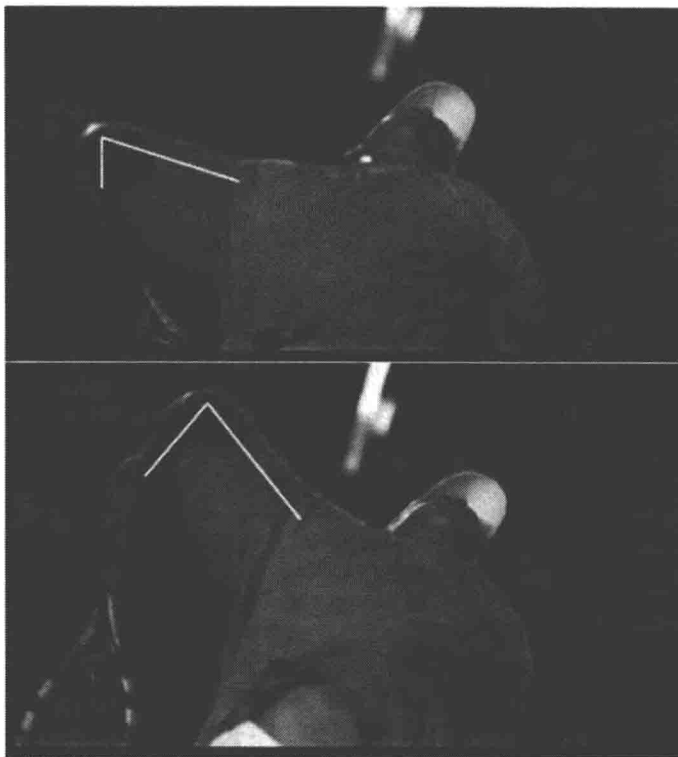
# The Federer Phenomenon and His Secret Weapon

The momentous five-setter in a historic Wimbledon 2009 final, eventually ended when Federer broke Roddick's serve for the first time all day (he himself was broken in the fourth set), with Roddick missing on a forehand. Federer had a total of 107 winners and 38 unforced errors (which is a W/E factor of  $107/38=2.8$ ). Roddick, on the other hand, had 74 winners and 33 unforced errors (a W/E factor of 2.2). Hence, the real difference in these statistics is the incredible number of Federer's winners. How does he make so many winners?

Firstly, the cheapest way to achieve a winner is by an ace. Federer served 50 aces, compared to Roddick's 27 aces (which is an A-factor of  $50/27=1.85$ ), to win this historic duel. On paper, his serve was more powerful than the most powerful serve in the game. But how can this be? Did Roddick serve poorly? No, Andy's serve was unbroken, repeatedly around 220 km/h and twice at 230 km/h (143 m/h), until the 77th – and last – game. Yet he only had 27 aces, while Federer, with a serve that was mostly under 200 km/h, hit an astounding 50 aces. So, does this mean that the speed of the ball is not important for aces? No, the ball-speed is actually the most important factor for an ace; but it is not the only important factor. Is it topspin then? Unlikely, as Federer and Roddick have about the same amount of topspin on both their first and second serves. What else is there? Well, this is the key question to ask, not just for this particular match, but to explain the whole Federer phenomenon. Before answering this question, let's biomechanically analyze the fastest serve in the game.

## 1.1 The Best Serve Ever: It's Biomechanics and Neuro-physiology

From Roddick's serve (see Figure 1.1), we can see that, as is properly advised by many coaches, at a certain point the racquet-head is parallel to Roddick's back. However, while most coaches assume (and hence teach their players) that the back should be upright at this instant, in Roddick's case, it is not. At this point, his torso is already leaning forward, as well as twisted around on the vertical



**Fig. 1.1.** The best serve ever of Andy Roddick: its biomechanical chain, whip-like movement and stretch-reflex in action.

body axis. This ‘little’ difference from the common (static) serve concept already shows the two most important physical (dynamical) factors of Roddick’s serve:

1. A whip-like movement, the main biomechanical factor (proximal-to-distal kinetic chain, in which there is always a time-lag between two consecutive joints: first legs, then torso, then shoulder, then elbow, then wrist); and
2. The stretch-reflex in action, the main neuro-physiological factor (stretching the leg-extensors, torso, shoulder, elbow and wrist muscles prior to their ballistic contractions).

From both biomechanical and neuro-physiological point of view, Roddick’s serve is by far the best ever in the tennis game. It is the only true whip-like serving action (the model of a proper serving movement) and the only true stretch-reflex-based serve in tennis.

In modern handball, volleyball, American football, rugby and water-polo, it is common knowledge that a high-performance throw (or smash) necessarily resembles the whip-like movement of an elite javelin throw. A biomechanical term for this whip-like movement is the kinetic chain: the sequential flow of



energy and momentum from bigger segments to smaller ones. Tennis requires sequenced activation of muscles and movement of bones and joints to achieve the motions, positions, and velocities seen in a player. Never rotate the “hips and shoulder together”, as you may often hear coaches advising while teaching the forehand. Instead, always first rotate the hips, then the shoulders, then the elbow, then the wrist. It is harder to hit the “sweet-spot” on a tennis racquet with this “loose” movement, but the result is unbelievable. All elite players do these shots – which are not in textbooks or coaching manuals – for their winners. Kinetic energy and momentum, as well as muscular power, are developed from the legs, hips and trunk muscles and transferred to the arm muscles. This allows the energy, momentum and power to be transferred efficiently to the hands, moving the racquet-head with maximum speed towards the ball. Furthermore, to achieve the highly-efficient whip-like technique of tennis serves, forehands and backhands, a proper sequencing of muscle stretch-reflex based actions must take place.

Andy Roddick holds the record for the world's fastest tennis serve: 246 km/h (153 m/h). His serve is a proper biomechanical chain, a full whip-like movement and the stretch-reflex in action. The stretch-reflex causes a stretched muscle to contract stronger and at the same time inhibits the antagonist muscle from contracting (that is, slowing the movement). Because this is an involuntary reflex response, the rate of contraction is significantly (several times) faster and more powerful than a completely voluntary muscular contraction. In fact, the faster the muscle is stretched eccentrically, the greater the force will be on the following concentric contraction.

When we train our skeletal muscles so that they efficiently utilize the stretch-reflex (and the related stretch-shortening cycle), then we effectively make powerful slingshots out of them. The prototype of such a muscular slingshot is a javelin throw; in particular, the world-record throw of Jan Zelezny (who was at that time only 80 kg!). We will talk more about Roddick's serve later.

## 1.2 The Secret behind Federer's Serve

So both biomechanically and neuro-physiologically, Andy Roddick has the best serve ever, clearly better than Federer's serve. However, it is better by only about 10% (or, even less), on average. And there is a hidden factor on Federer's side that is greater than 10%.

The explanation of the Ace-performance factor of 1.85 between Federer's and Roddick's serves is clearly non-physical: non-biomechanical and non-physiological. The explanation is cognitive. Roger Federer is simply the best blitz-chess player in the tennis game. This means three cognitive factors: He effectively plans his moves in advance; He effectively reads (anticipates) the opponent's moves and acts accordingly; and He effectively disguises his own moves. These three superior cognitive factors give Federer a huge mental advantage over his opponents, with the exception of his “nemesis”, Rafael Nadal – the current world number one, who