Biofeedback

&

Neurofeedback

Applications

in

Sport

Psychology

Edited by: Benjamin Strack, PhD, BCB
Michael Linden, PhD, BCN
Vietta Sue Wilson, PhD, BCB, BCN

Association for
Applied Psychophysiology and Biofeedback

Founded in 1969, AAPB is the foremost international association for the study of biofeedback and applied psychophysiology. AAPB is an interdisciplinary organization representing the fields of psychology, psychiatry, medicine, dentistry, nursing, physical therapy, occupational therapy, social work, education, counseling, and others.
The mission of AAPB is to advance the development, dissemination, and utilization of knowledge about applied psychophysiology and biofeedback to improve health and the quality of life through research, education, and practice.

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- Training and developing athletes in mental skills for sustained peak performance.
- Creating Peak Performance Centers and providing peak performance skills training.
- Providing executive leadership performance coaching.
- Developing high-performance teams.

Currently, Dr. Csoka is the lead consultant for the U.S. Army's program for establishing Army Centers for Enhanced Performance (ACEP) throughout the Army. The program is under the supervision of West Point's Center for Enhanced Performance, and is modeled after the center and program established there in 1989. As SVP for Human Resources in a $6B global manufacturing company, Dr. Csoka led the successful transformation of the company's human resources function. Serving as director of research at The Conference Board, Dr. Csoka led the reorganization and transformation of the human resources and organizational effectiveness research cell, resulting in world-class reports on key human resources issues and best practices.

At West Point, Colonel Csoka (Ret.) created, developed, and directed the U.S. Military Academy's first-ever Performance Enhancement Center. The center provides education and training in *mental* skills essential for enhancing performance. More recently, Dr. Csoka has created the first ever Peak Performance Center in a Fortune 500 company. In addition, as Professor of Psychology & Leadership and part of the first leadership team of this newly formed department, he played a major role in the design of the organization and its curriculum, course development, and faculty selection and development. Colonel Csoka (Ret.) served with distinction as an Army officer in Germany, Holland, Korea, and combat leader in Vietnam.

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James Robertson's entry into professional sports came as the President of Sports Enhancement Associates, working closely with International Management Group (IMG) in the development of Peter Jacobsen, Raymond Floyd, Johnny Miller, and many others. As a PGA Tour Instructor, he works with players from the Nationwide, PGA, LPGA, and Champions Tours. As director of the St. Andrews Golf & Performance Academy—USA, he has authored the *Encyclopedia of Successful Golf Coaching*; the *Golf Team Swing and Performance Manual*; *Gateway to the Game of Golf; The Golfer's Profile System;* and *The Corporate Golfer.*

Stephen Sideroff, PhD

Dr. Stephen Sideroff is clinical director of Moonview Treatment and Optimal Performance Center, consultant, and assistant professor in the department of psychiatry at UCLA's School of Medicine. Dr. Sideroff is an internationally recognized expert in behavioral medicine, biofeedback, and optimal performance. He lectures and conducts training workshops around the world, and has performed groundbreaking research in addiction, neurofeedback, and stress management. Dr. Sideroff was the founder and former director of UCLA/Santa Monica Hospital's Stress Strategies. Dr. Sideroff has applied his expertise in the area of peak performance and has consulted with collegiate and professional athletes and sports teams.

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James Thompson, PhD, BCN
Dr. James Thompson holds a master's and doctorate degree in kinesiology (specializing in sports related brain injury and electrophysiology, Pennsylvania State University) and a BSc in human kinetics (athletic training & rehabilitation) and a minor in business and marketing (University of British Columbia). While practicing in Canada, he was a certified kinesiologist with the Canadian Kinesiology Association. He has been certified in electroencephalography (EEG) since 2002, is board certified in neurofeedback, and is an associate fellow of the Biofeedback Certification Institute of America.

Dr. Thompson specializes in the use of neurological and physiological testing and training techniques. His doctorate studies focused on novel assessment metrics of brain injury using electrophysiological measures. He has specialized in the field of neural functioning for over a decade, and is a leader in the field of technological developments and clinical applications of assessment metrics for brain injury. Dr. Thompson is the chief science officer of DJ Technologies, a company specializing the development and deployment of functional biometric assessment and rehabilitation equipment. He was formerly the director of brain injury research programs at the International Brain Research Foundation and the neurophysiology program director at the Comprehensive Neuroscience Center in New Jersey. Dr. Thompson has worked with many high level athletes including the Penn State football, rugby and hockey programs, Canadian Junior Alpine Ski Team, and consultation to the scientific coordinator of the UEFA (Union of European Football Associations) 2007 League Champions, AC Milan, and to the sport science team at Chelsea Football Club in London, England. He also holds level 4 technical coach certification in sailing and level 3 in alpine skiing.

Dr. Thompson has been an invited speaker at international conferences in the United States, Canada, Mexico, and Europe, has published multiple articles and book chapters in the areas of EEG, traumatic brain injury, sports related concussions, and peak performance & biofeedback, and is considered one of the top experts in the world in the specialized field of electrophysiological assessment and training.

Lynda Thompson, PhD, BCN
Lynda Thompson, PhD, CPsych, BCN is a registered psychologist who has worked in the field of combining neurofeedback and biofeedback since creating the ADD Centre in Toronto, Canada in 1993. She did her doctoral dissertation (1979) on hyperactive children treated with methylphenidate and is co-author with pediatrician Dr. William Sears of *The A.D.D. Book* (1998), the first book written for parents that had a chapter on neurofeedback. A noted educator in the field of EEG biofeedback, she has served on the education committee of the AAPB, the Board of BCIA, and was the international member on the ISNR Board of Directors. With her husband, Dr. Michael Thompson, she co-authored *The Neurofeedback Book* (2003) as well as numerous chapters and clinical research articles on topics ranging from ADHD and Asperger's syndrome to stress management. Teaching invited workshops in over 20 countries on five continents, Drs. Lynda and Michael Thompson have shared the techniques they employ regarding setting up for success with a wide range of clients, from those with ADHD to athletes who want to optimize performance.

Michael Thompson, MD
Michael Thompson, MD devotes his time to the administration of the Biofeedback Institute and teaching. When practicing medicine, he was medical director of London Psychiatric Hospital; associate professor and head of post-graduate education in Psychiatry, University of Western Ontario; examiner for the Royal College of Physicians (Canada); and chairman of their examinations committee in psychiatry. Numerous professional publications include *A Resident's Guide to Psychiatric Education*. While associate professor, University of Toronto, he was psychiatric consultant to The Hospital for Sick Children's neurology department and director of a center that specialized in treating pre-school children with autistic spectrum disorders.

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Foreword

Athletes are constantly seeking ways to enhance their performances. Physical exercise, sport-specific drills, and the analysis of mechanics have long been the focus of players and coaches. In recent years, however, much more attention has been placed on the mental side of competition. People now realize that an athlete's frame of mind is at least as important as his or her physical capabilities, and for this reason, most mainstream professional sports organizations employ "mental game" coaches in the same manner that they employ "on-the-field" coaches.

This book does an exceptional job of acting as that "mental game" coach for athletes in any sport. It dives into the most cutting-edge psychological techniques behind peak performance, giving the reader creative tools to self-regulate—which is critical in fulfilling one's potential. Before an athlete can successfully self-regulate, however, he or she must first be able to recognize shifts in anxiety levels. During my years in Major League Baseball, I found that the sooner I was able to recognize my body's physiological signposts of a suboptimal mindset, the sooner I was able to recalibrate my focus. I did so using breathing techniques, grounded in meditation, which in essence is the less scientific forefather to biofeedback. I knew that my performance was directly correlated to my focus. With each passing year the "mental skills" side of my game became more refined, to the extreme of eventually eclipsing in importance the physical side of my game. Whenever I discuss the mechanics of hitting with young ballplayers, I try to engrain in them the importance of being able to physically differentiate between a good swing and a bad swing. In order to be successful, you need to know your swing better than anyone else does. You are the only one who can make the necessary adjustments in the middle of an at-bat, from one pitch to the next. Of course, coaches are necessary as an external set of eyes during practice, but they are of little help during the actual competition. The exact same premise holds true on the mental side of the game. Guiding an athlete into a state of deeper concentration through visualization and breathing techniques is the simpler task. The true challenge for sports psychologists resides in the ability to empower athletes with self-awareness. What would be the point of learning to find a deeper, more relaxed form of attention if the athlete is untrained in recognizing the body's warning signs *during* competition? Upon reading this book, athletes of any skill level will learn these warning signs. They will discover at which moment sweaty palms, muscle tension, changes in breathing and brain wave patterns become indications that it's time to "step out of the batter's box" and recalibrate.

Everything that an athlete needs to know regarding biofeedback/neurofeedback and self-regulation in sport is clearly laid out in the forthcoming pages. The lessons are easily understood by anyone—from the healthcare professional to a coach, trainer, parent, or elite athlete. This innovative book includes many specific exercises for athletes and detailed "how to" instructions for professionals interested in these cutting edge techniques. The pages in this book have the ability to empower its readers with a gift that can monumentally impact not only their successes in sports but also their successes in any endeavor. The reader will close this book with an understanding of the tools needed to gain control of the stress and anxiety associated with competition. How liberating would it be to once again play your sport from a place of passion and love, rather than from a place of fear? Not only will you reach unimaginable heights in performance, you will also find a greater level of fulfillment from your sport than you ever thought possible.

Shawn Green
Author of *The Way of Baseball**
15-year MLB veteran

*Published by Simon & Schuster, to be released June 2011

Biofeedback and Neurofeedback Applications in Sport Psychology: Introduction
Chapter 1

by

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Chapter Outline

I. Introduction

II. Who Can Benefit from Biofeedback and EEG Neurofeedback?

III. Chapter Overview

The thrill of victory and the agony of defeat—trials and tribulations are the true reasons why we participate in sport. The purpose of this book is to introduce the reader to the latest, most advanced computer-training technology for the mental side of sport. In today's highly competitive world of sports, athletes are looking for ways to get bigger, stronger, faster, and more equipped to excel at their game (including use of illegal performance-enhancement substances, such as steroids, for some). Technological advances in equipment (golf clubs, baseball bats) and physical strength training have made it possible to meet the rising performance demands of modern sport. However, a leaner, stronger body provides only a few of the ingredients necessary for successful athletic performance. Most serious athletes agree mastering the psychological side of sport—by maximizing motivation, concentration, and mental toughness—are also critical to success. Superstar athletes such as Tiger Woods, Jack Nicklaus, Alex Rodriguez, and many others regularly acknowledge the importance of the psychology of sport and the need to beef up their mental capacities to perform at their peak while simultaneously managing adversity on a daily basis.

The last few decades have seen a substantial increase in the employment of sport psychology and specialized sport enhancement consultants by individual athletes and Olympic and professional teams. This trend is filtering down to college, high school, and youth sports as well. This is because athletes and coaches know the mind shapes the outcome for almost all of our physical activity and sport behavior. Your mind tells your body what movements to make to properly execute a skill, and your body tells your mind what it is experiencing during the execution of that skill. Prior to the computer age, athletes and the sport psychology consultants who train them had to make guesses about what was going on in the body during a great performance. Now, we can see it—easily and quickly—firsthand.

New technology and computers allow us to obtain an inside view of our brain and body as we think, feel, and perform. These computer-based training methods are known as biofeedback and neurofeedback. The use of biofeedback and neurofeedback to assess and train specific sport skills is where key improvements in performance can occur.

With biofeedback (BFB), sensors are attached to various locations on the athlete's body. The sensors send signals from the body to the computer to provide instant visual and auditory feedback to the athlete as to how the body is functioning when it is relaxed and calm compared to when it is stressed and out of control. The mind and body react differently during poor performance and successful performance. Once identified, the athlete can use this feedback to learn how to duplicate a desired state or to control common stress signals, such as rapid heart rate, shallow breathing, or tense muscles, and increase the probability for success. For example, some athletes tend to breathe improperly or tighten their shoulder muscles, which can interfere with body responses and may cause panic-like feelings. With breathing and muscle BFB, this tendency can be changed to allow the athlete to move more smoothly and forcefully and to think more clearly.

With neurofeedback (NFB, also known as neurotherapy or EEG biofeedback), electrodes or sensors are attached to the top of the athlete's head to measure electrical activity coming from the brain. The electrical signals are amplified and sent to a computer that simplifies the signal so the athlete can see what is occurring in the brain. By oversimplifying the process, different mental states result in different types of brainwaves, which are associated with different thoughts, feelings, and actual physical performance. In specific sport situations, such as shooting, archery, or golf, using neurofeedback instruments to display electrical activity can help the athlete identify the brain state that leads to peak performance. For example, in order for an athlete to concentrate on a task (e.g., putting a golf ball), parts of the brain must produce more high-frequency beta waves (focusing waves) and fewer slow-frequency theta waves (distracted, wandering waves). To relax (e.g., just before an archer releases an arrow), the brain must produce more SMR brainwaves (calm and quiet waves), which enhance the likelihood the archer will release the arrow in a smooth, successful manner similar to his best shots from practice.

To train the mind, the athlete's brainwaves are conditioned using a visual display similar to a computer game. The athlete then learns to control the video display by achieving the mental state that produces changes in the desired brainwave. The athlete learns to make the brainwaves speed up or slow down, according to what state is required for the performance. Neurofeedback training is also referred to as aerobics for the brain or mental fitness training.

These performance strategies hold tremendous potential for the competitive athlete, coach, student, or anyone who wants to have more control over his or her performance in practice, competition, and high-stress situations. By obtaining immediate, ongoing reactions from the mind and body, athletes can discover how their thoughts and emotions affect their performance. Once the athlete knows what states create success, he can practice the state, or zone, needed for successful performance with the program giving him feedback as to how well he is maintaining control. With sufficient practice, the athlete will learn how to stop disruptive thoughts, negative self-talk, and body responses that limit physical skill. As a result, the desired performance state will become more automatic, leading to greater control of the mind-body and performance.

Who Can Benefit from Biofeedback and EEG Neurofeedback?

- A **professional athlete** who desires greater intensity and focus or to reach the effective performing state.
- A **sport psychology consultant, biofeedback** or **neurofeedback trainer**, or **therapist** in the field of psychology who desires to gain information and training in an exciting, cutting-edge application.
- A **coach** who wants to maximize creative decision-making and effectiveness on the field.
- An **athlete** who needs help recovering from a sports injury or serious health concern.
- A **student** who needs to boost attention and learning skills.
- **Anyone** who competes and wants more emotional control or balance in his or her life as well as a healthier mind and body.

Here's an example of how it works: C.J. was a talented baseball player who could hit a fastball a mile on any given day. However, give him a changeup or curveball, and it was lights out! He'd strike out every time. His inability to hit this pitch effectively was one of the few problems holding him back from reaching his full potential.

After months trying various mental skills strategies, we discovered something interesting about his internal images of hitting both pitch types. When we monitored his brainwave activity, he showed greater intensity or mental energy when visualizing hitting the curveball over the fastball. When he pictured himself hitting the fastball, he would describe the successful execution of the skill in perfect detail with great vividness and control. Surprisingly, as he described hitting the curveball, his brainwave activity suggested even greater vividness or clarity in his images—an experience you would only expect to obtain with positive outcomes. We discovered he was so stressed out about his failures with the curveball, and there were so many negative emotions attached to it, he inadvertently and obsessively rehearsed, in his mind, performing poorly on this pitch.

In essence, C.J. had unknowingly practiced failing and had constructed a self-fulfilling prophecy every time he faced a pitcher who could throw a respectable off-speed pitch. Over time, we were able to help him reframe and learn to control his mental and emotional states through EEG biofeedback training, which eventually led to improved results when hitting the curveball. What ordinarily could have been a very complicated long-term solution to arrive at was effectively and quickly achieved by monitoring his brain activity and cognitive processes. These discoveries are what talented athletes are now seeking to get an edge in their game and in competition.

This case example highlights just one of the many potential benefits of biofeedback and neurofeedback training. Athletes will benefit from the practical exercises that enhance mental skills such as staying focused, remaining calm, and solving bad habits such as overanalyzing and mental chatter. The exciting, cutting-edge material presented in this book delves into the work of several authors who have extensive but different sport experiences. The authors explain the techniques and strategies in an easy-to-read format so readers can employ the various approaches to improve performance. Worksheets and exercise assignments will be presented throughout the book to help the reader integrate the performance strategies into practice, workouts, and competition.

Sport psychology consultants, clinical psychologists and therapists, and psychological skills trainers will join a growing number of clinicians who are employing BFB and NFB in their practices, either as stand-alone techniques or in conjunction with other mental skills techniques. Although there are 100-plus books published in the last 15 years on mental skills for peak performance, only two books have addressed the specific use of biofeedback and neurofeedback. However, none have gone into as much rich detail and depth as the material presented here, including various frameworks and protocols for training, using the most up-to-date technological advancements.

Sport psychology consultants interested in becoming actively engaged in the practice of biofeedback and neurofeedback will discover how the latest advancements in technology and hardware, including wireless equipment, should significantly help bridge the gap in our understanding of the link between an individual's best performances and his or her corresponding psychophysiological state. A training tool with an inside glance such as this may help draw greater consumer attention to other performance-related services offered by the practitioner that may appeal to top-level executives or musical performers. This book does not use a cookie-cutter approach to biofeedback training and enhancing performance. Instead, the techniques and working models of the different authors will cover numerous areas of sport and specific sports skills and training regimens, so individual differences are better accounted for during training.

By helping athletes connect the dots between mind-body interactions, the most fundamental levels of cause and effect are revealed. When a thought related to performance occurs in the mind, there is a parallel physiological change in the body. When there is a physiological change in the body, change also occurs in the mind—this reciprocating process occurs almost instantaneously. Increasing the athlete's awareness about this process leads to opportunities for intervention.

Finally, the coach, team manager, and parents of an athlete can benefit from reading this book by learning what training resources are available in the sport environment. With knowledge, these individuals can help choose the appropriate personnel for training their athletes.

These discoveries of the mind-body connection are based upon scientific evidence and provide the underpinnings for the design of one of the most influential personal-growth and performance tools to come of age in the latter half of the 20th century. Biofeedback and neurofeedback are these modern, 21st-century tools. Biofeedback and neurofeedback involve sophisticated training devices that can be used to unlock true potential, regain control of performance, and maintain an edge on the competition.

Chapter Overview

Biofeedback and Neurofeedback Applications in Sport Psychology is divided into three major parts. "Part I: General Skills and Biofeedback for Achieving Optimal Performance" will include a chapter on the history of biofeedback in sport. Part I will also cover basic chapters on how to develop effective goals, pre-performance and performance routines, visualization skills, relaxation strategies, and cognitive thought techniques for confidence and self-esteem. Part I reveals biofeedback strategies for achieving optimal performance in general sport and sport-specific situations. In the first section, the reader will learn how biofeedback can be used to create a profile of the athlete's stress and recovery levels and how this can be used to guide the training process to maximize performance results. Subsequent chapters will cover the specific training modalities used to reduce muscle tension, optimize heart rate patterns, and minimize other common stress reactions such as galvanic skin response.

"Part II: Brainwave Training for Optimal Performance: Neurofeedback Strategies" will begin with a history chapter on EEG and sport. Part II will include chapters that discuss wireless technology and new opportunities for analyzing brain activity while the athlete is actually performing a task. Remaining chapters will highlight the use of neurofeedback for developing sustained concentration, alertness, or mental energy, and regulating arousal or intensity levels in the brain during sports such as golf.

"Part III: Other Optimal Performance Techniques & Related Concepts" will provide information for finding biofeedback or neurofeedback therapists and qualified sport psychologists and consultants. Limitations and methodological concerns in the use of biofeedback and neurofeedback by the consultant and various competency and ethical considerations the consultant should take into account before providing sport psychology services are then highlighted. Part III will also include a chapter on the transfer of skills from practice to competition and other seldom-reported but related techniques that work together with biofeedback and neurofeedback, such as the interactive metronome (IM) and sports visual performance training.

History of Biofeedback in Sport
Chapter 2

by

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Abstract

This chapter provides a discussion of the most common biofeedback measures used in sport, a decade-by-decade overview of the early uses of biofeedback, and the research that has evolved within sport beginning in the 1970s. Concluding sections cover the contemporary and future uses of biofeedback.

Chapter Outline

I. Introduction/History
   a) What is biofeedback?
   b) What happens in a biofeedback training session?
   c) Biofeedback modalities

II. sEMG

III. EDA or GSR

IV. HR and HRV

V. Thermal Biofeedback

VI. The Evolution of Biofeedback in Sport

VII. Contemporary Aspects of Biofeedback

VIII. Summary

Introduction

This chapter provides an overview of the most common biofeedback measures used in sport. A discussion of the early uses of biofeedback will be presented followed by a decade-by-decade summary to highlight the major research that has evolved within sport. Concluding sections will cover contemporary and future uses of biofeedback.

What Is Biofeedback?

Monitoring the mind's and the body's physiological reactions and then displaying this information for the athlete is referred to as biological feedback or biofeedback (see Schwartz, 2003, for a comprehensive review of definitions). Biofeedback can help an athlete detect and control shifts in his or her bodily functions by using sophisticated electronic monitoring devices. The athlete can view these physiological changes and see how and why they change while resting, practicing, or participating in a high-stress and competitive environment. The ultimate goal is for athletes to learn to control the biological functions that allow maximum performance to occur. Below are common descriptions of how biofeedback is used in sport:

Heart rate: Elevated heart rate may increase reaction time, while stabilization of heart rate may increase endurance, and cardiovascular efficiency.

Respiration: Improper respiration may lead to performance inefficiency or "choking" and hyperventilation.

Muscular tension: Excess muscle tension can inhibit movement speed, rhythm, timing, and flexibility.

Sweaty palms: An indirect measure of emotional reactivity and anxiety.

Brainwave activity: Athletes who learn to control brainwaves can enhance their ability to pay attention, control their emotions, and minimize a busy brain.

Peripheral body temperature: Measures blood flow or blood-vessel constriction in the hands and feet. Stress can cause the constriction or shutting down of blood flow, which inhibits recovery from strenuous workouts or minor and major injuries

There is a growing recognition by sport psychology professionals that biofeedback can be helpful in aiding athletes to manage thoughts and emotions during competition, control levels of activation, and establish mental and physical readiness to perform optimally (Silva & Stevens, 2002; Golden, Tenenbaum, & Kamata, 2004; Strack, 2003). Therefore, it is critical to develop a complete understanding of the ideal individual levels of sympathetic and parasympathetic balance that fit for open (externally paced, e.g., basketball) versus closed (internally paced, e.g., golf) sport activities (Hanin, 2000). As a result, athletes, trainers, coaches, and perhaps sport organizations are in need of methods to objectively measure emotional constructs, such as stress, during sport performance.

How Can Athletes Benefit from Biofeedback Training?

- Control and reduce stress and anxiety.
- Reduce or induce energy and intensity.
- Improve focus and concentration.
- Facilitate injury rehabilitation.
- Improve performance consistency.

What Happens in a Biofeedback Session?

Biofeedback training is usually held in a private office or clinic but also occurs in university counseling centers. Although the length of the individual biofeedback training session depends on the physiological system being assessed and the specific needs of the athlete, generally, most sessions last from 30 to 60 minutes.

During a biofeedback session, a sport psychologist, mental training consultant, or biofeedback practitioner places electrical sensors at various locations on the athlete’s body. These sensors or electrodes monitor the athlete’s emotional and physiological reactivity to stress or pressure. For example, muscle tension in the forearms may be observed when an athlete makes a critical putt in golf. This information is then fed back to the golfer through auditory tones that vary in loudness, lines moving across a grid or graph, or a computer screen that incorporates video game–like graphics that are controlled through self-regulation. With feedback, the golfer can discover a link between how the body responds—in this case, putting the golf ball too hard—with certain physical functions, such as too much tension in the muscles while putting.

Once a golfer recognizes that poor putting performance is a result of excess muscle tension, the next step is to learn to create the necessary physical changes within his body to be more physically relaxed. With biofeedback training, the athlete can quickly learn to relax the forearm muscles (sometimes in one session) and then practice the maintenance of appropriate tension during practice and competition. Some biofeedback technology will allow the golfer to practice staying relaxed on the golf course in simulated competition. Eventually, the goal of biofeedback training is to help the athlete become aware of the correct responses on the golf course without the help of the computer device.

The number of sessions required to obtain changes in an athlete's performance varies, and no systematic research studies have determined the optimum length of training time. Experiencing an "aha" moment and understanding how the mind and body work together (Wilson, Peper, & Gibney, 2004) may occur in one session. Thus, the athlete can make changes in the body/mind immediately in the sport setting. Alternatively, if an athlete has not already achieved optimum mental and physical functioning, many sessions could be necessary to help the athlete become aware of and develop control over the mind and body.

Biofeedback Modalities

The terminology and descriptions of modalities introduced in these paragraphs will also be described in greater detail in the psychophysiological assessment chapter (see Chapter 3). Common types of biofeedback modalities include electromyography (sEMG), electroencephalogram (EEG, discussed in detail in other chapters), skin temperature, electrodermal skin response, and heart rate.

Surface Electromyography (sEMG)

The main purpose of surface electromyography (sEMG) is to determine the muscles' electrical energy or activity during various situations when an individual's muscles contract (Donaldson, Donaldson, & Snelling, 2003). Two electrodes (or sensors) are placed on the athlete's skin, over the muscle, to be monitored. The most common muscles monitored for relaxation training are the shoulder (trapezius) and forehead (frontalis) muscles (Zaichkowsky & Fuchs, 1988). Other muscles may be monitored, depending on the specific sport task the athlete is engaging in; however, careful consideration of electrode placement is important (e.g., shoulder muscles for free-throw shooting versus forearm muscles for gripping a baseball) (Blumenstein, 2003). During injury rehabilitation, injured muscles are targeted and monitored, as they tend to tighten even when other muscles are relaxed (Sime, 2003; Zaichkowsky & Fuchs, 1988).

SEMG biofeedback training is effective in reducing voluntary muscle tension and anxiety (Davis & Sime, 2005; Davis, Sime, & Robertson, 2007; Wilson & Bird, 1979; Cummings, Wilson, & Bird, 1984). Excessive muscle tension slows reaction time and can negatively impact the flow of timing and coordination during the execution of appropriate motor movements required in many sport skills or tasks (e.g., performing a penalty shot in soccer). Because excess muscle tension can have a major impact on reaction time, learning to control (or optimize) tension levels is one approach that can be used to enhance performance (Fontani, Maffei, Cameli, & Polidori, 1999; Sabourin & Rioux, 1979).

Sime (2003) suggests that to make EMG training particularly relevant to sport it is useful to incorporate a modified FpN placement, in which one sensor is placed over the masseter muscle and the other is placed on the posterior cervical region (Arena & Schwartz, 2003). With this placement, excess muscle tension in the face and neck muscles can be monitored prior to performance as tension in these areas may impede the smooth, coordinated movement required in fine-motor tasks such as putting a ball in golf.

Case Example: Professional Golf Applications of EMG Biofeedback

An FpN modified placement was used with a well-known professional golfer shortly before he won the U.S. Open championship (Sime, 2003). The golfer observed how biofeedback could be used as part of his practice routine while on the putting green. He was amazed to see that his posterior cervical and trapezius muscle tension levels were related to successful putting performance. These procedures were conducted as threshold measures, whereby he was encouraged to relax muscles prior to taking back the putter for each attempt. The procedures for this training were determined by simply exploring the various options with the athlete. We determined very quickly that the golfer was able to use the audible signal from the EMG to track the gradual decrease in muscle tension in the last few seconds of his pre-shot routine. We then set the threshold so the sound stopped near the lowest level that could be reached under these conditions. After each putting trial, the consultant made adjustments in threshold to make it more challenging to reach the no-sound point just prior to initiating the putt. The golfer was interested in this technology, which was associated with his preparation for playing more relaxedly under pressure. Shortly after this single session of training, the golfer's putting average improved, and he eventually won the U.S. Open a few weeks later.

Electrodermal Biofeedback (EDA) or Galvanic Skin Response (GSR)

Electrodermal biofeedback also referred to as galvanic skin response, measures activity in the athlete's sweat glands and the amount of perspiration on the skin. For example, as an athlete's anxiety increases, more sweat and perspiration occurs on the hands. Electrodermal biofeedback can be used to teach athletes how thoughts can affect physiological arousal, how arousal levels can be controlled to enhance the practice of emotional control during imagery practice, and to enhance the ability to concentrate (Wilson, Peper, & Schmid, 2006).

Heart Rate (HR) and Heart Rate Variability (HRV)

Electrocardiology or the electrocardiogram (ECG) records the electric impulses of the heart. ECG sensors are typically attached to the athlete's rib cage or the interior of both the right and left forearms.

Heart rate biofeedback has been used to help distance runners locate the most optimal zone for their heart rate (Robinson, Robinson, Stewart, Hume, & Hopkins, 1991). This type of biofeedback has been used to teach rifle shooters to shoot at the same place in between heartbeats to lessen variations of the shot due to tremor (Daniels & Landers, 1981). Performance improvements were also found with heart-rate deceleration in golf putting (Boutcher & Zinsser, 1990) and tennis (Carlstedt, 2001).

Heart rate variability biofeedback is a relatively new concept in biofeedback (Lehrer, Vaschillo, & Vaschillo, 2000). HRV is a measure of the elapsed time in between heartbeats or the duration of the interbeat interval as measured by the distance from one R-wave to the next in the ECG recording. It is directly related to the electrical activity that stimulates the heart or, more specifically, the sinoatrial node (or the pacemaker) of the heart. In clinical populations, a lack of variation could indicate an imbalance in the autonomic nervous system and is a sign of poor cardiac health. Low HRV is correlated with mortality, myocardial infarction, coronary heart disease, and congestive heart failure (see Chapter 6 for an in-depth discussion of HRV). HRV is enhanced when heart rate fluctuates (increases and decreases) with the cycling of each phase of the breath (inhalation and exhalation). As the athlete inhales, increases in heart rate are seen, and as the athlete exhales, decreases in heart rate occur.

HRV is an indicator of greater autonomic nervous system balance. Research suggests HRV is related to increased physical and mental performance (Jeukendrop, 2002; Lagos et al., 2008; McCraty, Atkinson, Tiller, Rein, & Watkins, 1995; Raymond, Sajid, Parkinson, & Gruzelier, 2005; Strack, 2003). When heart rate oscillations are restricted and irregular in pattern, the composure needed for the performance of many complex motor skills is compromised (Katz-Leurer & Shochina, 2005; Kleiger, Miller, Bigger, & Moss, l987; Hymes & Nuernberger, l991).

Thermal Biofeedback

With thermal biofeedback, delicate sensors attached to the athlete's fingers or feet are used to measure skin temperature. When a stressful event occurs, blood vessels typically constrict (vasoconstriction), resulting in decreased blood flow to the body's extremities.

Thermal biofeedback has been shown to be effective in facilitating improved performance in cold-weather sports such as hockey and curling (Kappes & Chapman, 1984) and gymnastics (Peper & Schmid, 1983). Since many football, baseball, and soccer games are played outdoors under adverse weather conditions, the athlete's hands or feet may already be colder than normal. If vasoconstriction occurs as a result of the athlete being stressed, further decreases in temperature may be seen (Davis, Sime, & Robertson, 2007). Athletes participating in these sports may benefit significantly from temperature biofeedback.

The Evolution of Biofeedback in Sport

As early as the 1890s, psychologists and physical educators developed an interest in the study of the psychophysiological processes of athletes. However, it was not until the 1930s when Edmund Jacobsen began pioneering work with research on "The Course of Relaxation in Muscles of Athletes" (Jacobson, 1936). Jacobson built one of the first instruments that plotted the action potentials of muscles against time. He inserted an electrode through the skin (needle electrodes) then into the tissue of the bicep muscle. He believed he was able to measure a slight contraction of the muscle and release of muscle as the athlete learned to relax using a technique that he coined "Progressive Muscle Relaxation." His research led to a very early understanding of muscle tension and that some athletes will fail to relax quickly and, additionally, fail to maintain a relaxed state over time.

As the end of the 1960s approached, Jacobson's pioneering work, among others, led to regular implementation of programs for training relaxation using electrical monitoring devices, which enabled athletes to receive physiological feedback while learning to control different systems of the body.

Biofeedback—Sport Applications in the 1970s

Although biofeedback research studies with athletes were being conducted as early as the 1930s in Eastern Europe, research interests had not extended to North America until the 1970s (Cratty, 1989). In fact, computer-based searches of peer-reviewed biofeedback literature revealed few studies conducted before 1980 had assessed the effects of biofeedback training on enhanced athletic performance. The few peer-reviewed articles that were published were found in sport-related journals. One of the earliest research studies on biofeedback in North America was conducted by Wilson & Bird (1979). The researchers reported improvements in the flexibility of female gymnasts who were using EMG biofeedback as compared to a relaxation-only control group.

As biofeedback became more popular in American society, it was not long before the technique was more widely applied to athletics. Edwards (1970) reported how this new technology could be used in various aspects of daily life, specifically asking, “Now that researchers have learned how to monitor what is happening inside the human brain, how can this knowledge be applied to aid mankind?” (p. 57). Athletic performance was one of the areas he reported could be enhanced through biofeedback technology. Edwards wrote, “Even athletes can achieve the proper mental state away from the practice area by using feedback signals from brainwaves and muscle states to signal moments of optimal preparation” (1970, p. 2c).

By the mid-1970s, sport psychology textbooks were discussing how biofeedback could be used with athletes (Butt, 1976). In addition, the 1978 Biofeedback Society of America’s task force evaluated the use of biofeedback in athletics and found that researchers and clinicians were using biofeedback in three main ways: anxiety control, aiding athletes in rehabilitation from athletic injury, and as a way of providing feedback to athletes in relation to performing a skill with correct technique. Similarly, Ogilvie (1979) surveyed eight sport psychologists and asked, “Do you personally employ the use of any of the following: visual motor rehearsal, biofeedback, relaxation training, imagery rehearsal, autogenic training, or behavior modification?" (p. 181). He found that four of the eight sport psychologists used all of the techniques and just as many were using biofeedback with athletes.

Through several media reports in the 1970s, word began to spread about the potential benefits of using biofeedback to enhance performance. Eric Soderholm, a baseball player for the Chicago White Sox, gave credit to his use of a combination of biofeedback and hypnosis to help him recover from athletic injury. He also reported improvements in concentration and a greater ability to relax while performing. In fact, Soderholm believed the process of biofeedback helped him win the American League Comeback Player of the Year award ("Biogenics Helped Chisox Solderholm," 1977). Soderholm also described how he practiced meditation while he was hooked up to a biofeedback machine that recorded his brainwave activity. Soderholm said he liked the technique because he showed improvements in "coping with pressure situations" and said, "When I strike out with the bases loaded, I know it's not the end of the world. I've never been this relaxed in my life."

Another article in The New York Times in November of 1977 discussed the use of biofeedback by tennis players. It was reported that tennis pro Warren McGoldrick, created a training system for athletes, which included biofeedback (Ames, 1977). These media reports helped propel interest levels in biofeedback among the lay public.

Biofeedback—Sport Applications in the 1980s

Zaichkowsky (1982) considered biofeedback to be useful in helping individuals develop self-regulation skills and postulated that it was best used in combination with other types of relaxation techniques such as visualization, progressive relaxation, autogenic training, and meditation. Another study by Peper and Schmid (1983) analyzed the efficacy of a two-year biofeedback training program. The program included temperature biofeedback, GSR, and EMG biofeedback in combination with progressive relaxation, autogenic training, and mental imagery. The athletes reported that by integrating the various training methods, performance improvements occurred in workouts and competition.

More published research studies in peer-reviewed journals began to surface during the 1980s. Dewitt (1980) conducted two studies using EMG biofeedback. In the first study, six university football players went through a biofeedback training program. After 12 weeks of the training program, Dewitt found that all six athletes experienced enhanced performance based on coaches' ratings. In the second study, Dewitt implemented a biofeedback training program with university basketball players. He found that biofeedback enhanced the performance of the athletes over a group of athletes who did not participate in the biofeedback training program. Cummings, Wilson, and Bird (1984) examined the flexibility of track sprinters by assessing EMG biofeedback of the hamstring muscles versus a control group who only received a common stretching program (proprioceptive neuromuscular facilitation). They found that biofeedback enhanced flexibility compared to the stretching group and that flexibility remained improved four weeks after the intervention ended. Daniels and Landers (1981) studied eight elite shooters who were members of a university rifle team or a junior Olympic team. Participants received five sessions of training with audio feedback, which included heart rate and respiration biofeedback. The researchers found the biofeedback intervention improved performance more than the control group. Similar findings were later demonstrated in other shooting studies (Landers, 1985; Hatfield, Landers, & Ray, 1987) and handball (Costa, Bonaccorsi, & Scrimali, 1984). Although initial findings of research that analyzed biofeedback as a performance-enhancement intervention were encouraging, some of the research showed equivocal results (Cummings, Wilson, & Bird, 1984) and other research was conducted with basic methodological flaws, thus limiting the conclusions that could be drawn about the utility of biofeedback as an intervention in sport (Kavussanu, Crews, & Gill, 1998).

Despite the methodological concerns, practitioners' and researchers' attitudes remained optimistic about the future of biofeedback as a powerful sport psychology and performance intervention. In fact, biofeedback was introduced and taught to athletes in university settings (Petruzello, Landers, Linder, & Robinson, 1987). In addition, Suinn (1985) found that consultants who were providing sport psychology services to athletes training for the 1984 Olympics were also commonly using biofeedback as a training technique. Gould, Tammen, Murphy, and May (1989) reported biofeedback was used by some consultants when presenting and delivering sport psychology information to athletes; however, they also noted biofeedback was behind in popularity compared to more traditional topics on performance-enhancement interventions at the time.

Media attention and public awareness on the use of biofeedback training for athletes in the 1980s continued to grow. A 1984 U.S. News and World Reports article, “Training Our Olympians, Hi-tech Style” (Sanoff, 1984) reported various biofeedback applications were used by U.S. Olympians in the 1980s. One of the devices discussed was Americ 150, a monitoring device that allowed athletes to measure their heart rate via a radio signal sent from an apparatus attached to the chest and to a computerized wristwatch. Other media discussed Dan Landers’ work in the early 1980s with elite-level archers (Sanoff, 1984).

Biofeedback—Sport Applications in the 1990s

Although discussions continued in the literature about biofeedback in the 1990s, the number of biofeedback studies published in peer-reviewed journals remained small. In fact, a general shift in the type of biofeedback being discussed and studied with athletes occurred. This shift focused on a related type of biofeedback called brainwave biofeedback or EEG neurofeedback (Leonards, 2003). A detailed review of the use of and evolution of EEG biofeedback in sport is provided in Hatfield, Haufler, and Spalding (2006); thus, a comprehensive overview of this material will not be provided in this chapter. Aside from an expanding interest in neurofeedback, a few general (peripheral) biofeedback studies were published in the 1990s, which provided support from previous studies that found biofeedback could help athletes enhance performance.

Blumenstein, Bar-Eli, and Tenenbaum (1995) investigated the use of GSR, EMG, and HR in conjunction with autogenic training and imagery. Athletes in this study were taken through an experimental procedure in which relaxed and excitement states were induced. In each state, the athletes were monitored physiologically. Athletic performance was measured in the study by the athletes’ time in a 100-meter sprint. Results of the study revealed the biofeedback intervention was effective in improving 100-meter sprint performance when imagery and autogenic training were used by the athletes. Other studies showed enhanced performance when using biofeedback in such sports as golf (Crews, 1989; Crews & Landers, 1993), archery (Salazar et al., 1990; Ren, 1995), and distance running (Caird, McKenzie, & Sleivert, 1999).

In addition to studies conducted in rifle shooting, golf, archery, and running, Kavussanu, Crews, and Gill (1998) examined the effects of single (i.e., EMG) versus multimodal biofeedback (i.e., EEG, EMG, and HR) in relation to basketball free-throw shooting performance. These researchers were interested in understanding if perceived control and self-efficacy would influence the relationship between biofeedback and performance. The study also improved on the methodological flaws of previous studies, which had small sample sizes, a lack of a control group, and short training sessions. Results of this study did not indicate significant performance differences between the groups. In addition, self-efficacy was the only variable that predicted basketball free-throw shooting performance. Finally, neither perceived control nor self-efficacy influenced the relationship between biofeedback and performance.

Media reports also continued in the 1990s with some of the focus centered on the expanding sport applications of neurofeedback (also called EEG biofeedback). In one article, a World Cup speed ski champion credited biofeedback and mental training with helping him win the World Cup skiing event. “This kind of mental training has been used for the past 10 years by coaches who train Olympic and college athletes, and many credit biofeedback with improved performance” (Nelson, 1990, p. 39). Also, Super Bowl quarterback Boomer Esiason discussed his use of EEG biofeedback during the 1995 football season after suffering a concussion (Smith, 1997). Esiason called it “brain therapy—30 minutes in a room looking at a computer screen, making my brain work. There are two graphs on the screen, and I’m trying to maneuver them by concentrating” (Eskenazi, 1995, p. 11).

Contemporary Aspects of Biofeedback

Professionals in the field of sport psychology have examined the various ways in which athletes have reached the zone or a flow state

(Hanin, 2000; Jackson, 1995, 1996; Janelle, 2002; Ravizza, 1977). Meanwhile, other researchers have studied which variables may contribute to the effects of stress and tension that can cause performance decrements or choking (Gould & Udry, l994; Janelle, 2002; Martens, Vealey, & Burton, 1990; Weinberg & Gould, 2007).

Advances in the field of sport psychophysiology have continued since the 1980s (Davis, Sime, & Robertson, 2007) in part because of advances in neuroscience with sport psychology and with the recent interest devoted to understanding the broad range of emotional experience of individual athletes striving toward identifying optimal states of arousal during competition (Cerin, 2004; Hanin, 2000; Keil, Holmes, Bennet, Davids, & Smith, 2000). Regulation of emotional states (much like tuning a high-speed racing engine) and understanding the effects of stress on athletic performance is critical to the athlete (Lazarus, 2000; Hanin, 2000; Janelle, 2002). For example, sweaty and cold hands are signs of stress that can impact an athlete’s grip in many sports (golf grip on the club, the steering wheel in auto racing, the grip on the tennis racquet, and the grip on the baseball). Restless behavior and high eye-blink rate are also seen as possible predictors of decreased performance under a high level of anxiety (Kojima et al., 2002). The importance of recognizing the symptoms of emotional arousal as warning signals that the bodily system is getting too charged up is a critical first step to enhancing athletic performance.

The high level of interest in the construct of arousal and related terms such as stress and anxiety (and how to best manage them) from coaches, athletes, and sport psychology consultants is one of the many reasons biofeedback training is so appealing. Leonards notes recent applications of biofeedback have focused on the three main areas: reduction of arousal, helping athletes control automatic processes, and aiding in the assistance of injured athletes. The inherent problem lies in the fact that, although promising, more studies need to be conducted. In reviewing the literature between 1976 and 2001, Leonards (2003) found there were fewer than 100 studies that analyzed biofeedback in relation to sport compared to more than 7,000 studies completed in sport psychology. Overall, research has demonstrated that biofeedback training is effective in helping athletes manage the psychological and physiological stress that occurs during workouts and competition (Blumenstein, Bar-Eli, & Tenenbaum, 2002).

Although biofeedback research has shown encouraging findings, it has also yielded inconsistent results because of several methodological limitations. The use of brief training sessions (Blais & Vallerand, 1986), small sample sizes, and subjective reports of performance (De Witt, 1980), and failure to train to a criterion (Zaichkowsky & Fuchs, 1988) has in part contributed to inconsistent outcomes and difficulty clearly defining the efficacy of biofeedback in applied sport psychology. A critical assessment of the specific methodological concerns can be found in other reviews (Tenenbaum, Corbett, & Kitsantas, 2002; Kavussanu, Crews, & Gill, 1998). More recent reviews suggest there is need for not only more research but also more rigorous designs that improve on the methodological issues that occurred in previous research (Collins & McPherson, 2006).

In addition to ongoing efforts to strengthen the scientific foundation for the applications of biofeedback in sport, it is continuing to be used with Olympic athletes at the United States Olympic Training Center (Lawson, 2000), the Wingate Sport Training Center for the Israeli Olympic Team (Fried, 2006), and the U. S. Military Academy at West Point. In addition, Sport Canada has partnered with the Sport Psychology Lab at McGill University to offer neurofeedback training services to athletes training for the Olympic Games (McGill University, 2007).

Other contemporary uses of biofeedback at the international level were presented by Wilson, Peper, and Moss (2006). Before the World Cup Soccer finals, in which Italy was playing France, players on the Italian national team were using biofeedback to assist them with their mental training. These athletes were being trained mentally using biofeedback to help them improve their ability to relax and concentrate during practice and games. The players used heart rate variability, EMG, and EEG biofeedback to prepare for penalty kicks, to assess muscle fatigue, and to recover from demanding workouts.

Another very recent example comes from the 2006 Olympics, during which biofeedback was used by the United States women's bobsled team (Boyle, 2006). Members of the bobsled team used the product Play Attention to aid them in their concentration skills. Play Attention is a video game in which the bobsledders wore helmets with sensors that relayed information about brainwave activity. (The brainwaves that are relayed to the computer move the simulated bobsled on the computer screen). Peter Freer (developer of Play Attention) describes the instrumentation, "What we provide is a 3-D simulation for the women, where they can drive a bobsled down the track by mind alone. The less they focus, the slower the screen goes." This example and many others provided within this chapter portray the exciting potential uses of biofeedback for a variety of sports.

Summary and Conclusions

The application of biofeedback and neurofeedback to sport or sport psychophysiology is a relatively new field that combines the psychophysiology of emotion with the psychology of sport performance. With the use of sophisticated technology, a clinician and athlete can monitor common physiological measures of performance in competitive settings. As a result, a wide range of stress- and emotion-management procedures are becoming more extensively understood and integrated within athletic realms. Consultants with applied sport psychology backgrounds who also have an understanding of psychophysiology and technology are discovering a growing number of opportunities to fuse their knowledge with traditional sport psychology interventions by developing comprehensive procedures within a variety of athletic venues (Carlstedt, 2004; Davis & Sime, 2005).

A consultant can now capture and record psychophysiological patterns such as HR, EMG, and EEG unobtrusively during actual practice and competitive events. In addition, a video recording of the athlete performing a skill can be taken while small sensors attached to his body provide information, which can be used as an instant replay analysis that includes the mental events that were coordinated with his movements. Consider a golfer who is hooked up to sensors that relay his emotional reactions to preparing for an important putt. Simultaneously, his performance of the task is being captured and video recorded, so each phase of the movement of putting the ball can be compared, precisely, with what is going on in his mind and body. In essence, consultants can instantaneously reflect physiological and emotional states back to the athlete and compare these states with desirable and undesirable performance outcomes. In this way, athletes will be more aware of the state of their minds and bodies and more equipped to make the changes needed to maintain the zone that optimizes sport performance.

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Psychophysiological Assessment and Training with Athletes©
Knowing and Managing Your Mind and Body
Chapter 3

by

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Abstract

This chapter provides details on the psychophysiological systems used in the initial assessment of an athlete's ability to control the mind and body. Included are temperature (hand surface), surface electrodermography (palmar sweat response for emotional involvement), electromyography (facial and shoulder muscle tension), heart rate (for reactors and heart rate variability), and respiration rate (speed, ratio, and location of breathing). These measures are taken at baseline, during tasks such as computer games, and during recovery from the tasks. Typical data from athletes are reported as well as what constitutes a high or low atypical response for performers. The training of psychophysiological parameters is illustrated through actual case studies of athletes. The results of the psychophysiological assessment are used to guide the goals for the training process.

Chapter Outline

I. Introduction

II. Personal Program Development for Optimal Performance
   a) Model
   b) Sample program outline

III. Self-Assessments in Sports
   a) Sport psychology mental skills assessment
   b) Cognitive and somatic anxiety questionnaire

IV. Psychophysiological Assessment of Body/Mind Systems
   a) Psychophysiological stress profile
   b) Heart rate/heart rate variability
   c) Respiration
   d) Electrodermal activity
   e) Hand Temperature
   f) Surface electromyography
   g) Electroencephalography

V. Summary

VI. References and Suggested Reading

Introduction

Performance is enhanced if the athlete's mind and body are responding in the ideal state, which, for most settings, is automatic. Too often, an athlete does not know or recall when his or her mind/body is off or not at the ideal performance state, especially during the excitement of high-level performance or critical moments of competition. Consequently, the athlete is unable to return to the ideal performance state. This can be resolved by collecting data on how each mind/body system is operating when performing well and training athletes to return the mind/body to this state when needed.

For more than 30 years, the authors have used psychophysiological recordings as objective measures for assisting athletes in identifying the different systems; how they respond under rest and competition; and if necessary, to train for changing system responses. For example, if an athlete is not performing as well in competition as he is in practice, a practitioner can assess if breathing is playing a part in nonperformance. Choking or a deer-in-the-headlights response are common for athletes who hold their breath or hyperventilate (Fried, 2000), and changing breathing patterns contributes to the cause of disruptive emotions such as fear (Phillippot, 2002). For other athletes, the failure to remain in a competitive state such as the zone may be a result of excessive self talk (Hatfield, 2006) or other interfering brain patterns. It is possible that these states can be assessed with electroencephalography. Psychophysiological monitoring in the office or in the sport arena while the athlete is at rest or, more commonly, during a competitive task can help identify these states. The objective is to then teach the athlete the skills to identify when an abnormal pattern is occurring, to prevent psychophysiological changes that lead to the non-optimal performance state, or to change the state to reach the desired level of optimal functioning.

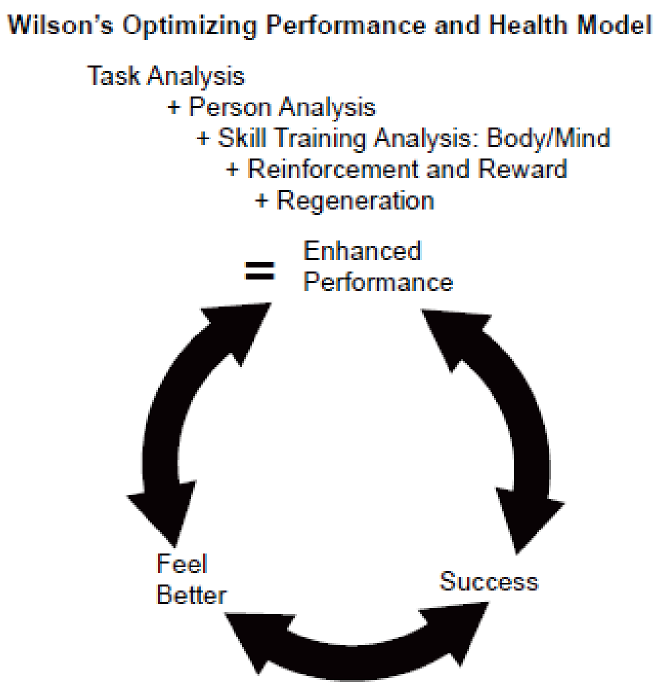
Later in the chapter, we provide a self-assessment that we have used with athletes, as young as 8 years old, to help them identify what their typical response during competition and practice is. This is normally followed by a psychophysiological profile and, if necessary, telemetry or the measuring of the athlete's mind/body responses while in the field of performance.

Personal Program Development for Optimal Performance

There are many areas where psychophysiological measurements can be applied to benefit the athlete. In figure 3.1, the optimizing performance model provides an overview of what is necessary to maintain optimal performance. Each of the components of the model is dependent upon the needs of the task, the abilities of the athlete, and the training of the athlete in the skills to perform those tasks. Psychophysiology can be used to objectively assess the athlete, train the athlete, and monitor the athlete during performance. The athlete needs reinforcement and reward and time periods of regeneration, which again can be assisted by psychophysiological monitoring.

Model

Figure 3.1 Optimizing Performance and Health Model



In Figure 3.1, the performance enhancement model illustrates that performance is a complex but progressive interrelationship. A change in one variable will affect all others to varying degrees. Central to the concept is that a plan for enhancing performance is necessary, and the plan needs to be practiced.

Sample Program Outline

1. Task Analysis

To optimize performance, the athlete first needs to know what the task requirements are and then whether he or she possesses the skills/abilities required to complete the task (or what is needed to continue to learn or improve). Before training begins, it is also helpful to know the situation (other competitors, coaches, etc.) and whether there are other factors that have a direct impact on the athlete or the training process (lack of sleep, nutritional status, etc.). Athletes can then begin training in both physical skills and mental skills to be able to complete the task. Physical and mental tasks must consistently be performed with high quality if elite performance is to be attained and maintained.

Task analysis involves the evaluation of what is required to perform in the sport. For example, to be competitive in tennis, what percentage of successful first serves and what serve speeds are necessary? What free-throw percentage in basketball is needed to be a high performer? What is the time needed to win a race? Some tasks require physical flexibility, and others require primarily strength or endurance across a long period. Others require precise movements at the correct time.

Not only are physical skills necessary; mental skills are deemed critical to elite performance. The mental skills most often reported by athletes and cited by researchers as being beneficial for enhancing performance include the following (Williams, 2006):

- Goal setting
- Imagery
- Thought Control
- Arousal Management
- Pre-competition readying plans
- Competition plans
- Coping strategies

It is critical that the athlete understands the **task requirements** of his sport in order to select the best learned-self-regulation (LSR) technique to enhance performance. For example, for a long-distance swimmer, skier, or runner, an initial increase in heart rate and anxiety at the starting line is probably not too important as long as he gets off the starting line in a good position. However, the athlete's awareness and ability to control heart rate and muscle tension through the different stages of the race are crucial. The types of LSR an athlete needs to learn and use differ by sport task requirements and lead to bigger payoffs. Thus, if an athlete is about to compete in a race that lasts for several hours, it is reasonable to spend more time practicing skills such as maintaining the rhythm of breathing that keeps heart rate under control, frequent checking of the tension in muscles, and technical cues that maintain proper skill mechanics rather than practicing pre-race relaxation skills.

On the other hand, if the athlete is a rifle shooter, archer, or gymnast, it is crucial that the first response is correct. Much attention and skill learning has to be devoted to attaining the proper first response as there is little room for error correction, and one minor mistake can mean the difference between winning and losing. Whether the athlete needs to learn to shoot at a certain time in the cardiac cycle to get off good shots, to maintain an automatic mind, or to use cue words to maintain fine motor control for a difficult mount in gymnastics, it requires specialized training relevant to that skill—not just deep relaxation. **In addition to the task requirements, the athlete's skill requirements will dictate how he will need to train his mind and body to perform**.

2. Person Analysis

In the **person analysis**, the goal is to determine how the athlete's abilities and skills meet the task requirements. Whether it is on the farm or the racetrack, the saying goes "you can't make a racehorse out of a plow horse." However, at a young age many individuals possess the ability to become stronger in almost any sport. The coach or athlete's observations are all that is sometimes needed to determine these capabilities at an elite level. While most athletes can obtain an elite level of performance with specific, quality practice across time (Dobbs, 2006), individual differences must be respected in how quickly the athlete learns, and to what level he can achieve a desired result.

While an athlete's self-analysis, competition videos, performance results, and coach or parent input is valuable, we often use psychophysiological monitoring to aid in the discovery of the athlete's typical responses. For example, in the case of a tennis player, does he begin with unnecessarily high muscle-tension levels in the shoulders such that further increases in muscle tension may inhibit the stroke and thus, power?

It is not the strengths or weaknesses of athletes that limit their ability to compete at the highest level. It typically is that they are unaware of, and thus have no control over, the responses that are necessary to perform in their sport situations. Or they know when something is wrong, but they cannot figure out exactly what and how to return back to winning form.

3. Skill Training Analysis

The purpose of repetition of practice is to make the skill automatic with over-learning. It is the over-learning that increases the probability of the skill being retained during times of fatigue, loss of concentration, or high stress. Effective **skill training analysis** assures repetition is executed with quality as well as quantity. Motor learning research (Magill, 2002) has firmly established feedback is essential for learning. Nowhere does psychophysiological monitoring improve performance more than in the provision of immediate, accurate feedback for training the athlete to control mind/body systems (biofeedback or neurofeedback). Decisions regarding what feedback and when to provide feedback need to occur in an organized, planned fashion based upon the needs of the setting. Athletes need a mental plan for what to learn and then to practice what will be needed during the stress of competition (Lidor & Singer, 2002). Our Performance Preparation Plan (P3) is first practiced under ideal conditions in the office and then under stressful conditions. The coaches then have the athlete practice P3 with its mind/body skills in practice, under competitive practice situations, and then in actual competition (see chapter 5 on LSR for the P3 plan).

An example of using psychophysiology within the P3 would be in identifying and changing muscle-tension levels and breathing responses that interfere with performance prior to a serve in tennis. Athletes can quickly learn muscle release and breathing in the office (typically in one or two sessions), but it takes consistent monitoring and reinforcement (coach or sEMG telemetry) to see the changes in their serve on the court. Once athletes have acquired control in practice, they have heightened confidence as they now have additional weapons to control their mind and body under the stress of competition.

Psychophysiological monitoring can also be valuable when the athlete is using imagery as the changes in sEMG or EEG indicate when the athlete is no longer attending to the image, or as his or her skill increases, so does the imagery patterning (Bird & Wilson, 1988). Video recordings of athletes' performances can also be integrated with psychophysiology monitoring to enhance imagery or, when it is a past negative event that is limiting current skills, to desensitize the athlete to the past failure.

4. Reinforcement and Reward

Reinforcement of progress or success creates the probability of more progress or success, so the athlete is encouraged to take time to celebrate each small success. Some coaches recommend celebrating before an upcoming major event, as they believe true success is the journey. Reinforcement is the basis of improvement and overall satisfaction of achievement. It is important to plan and implement a regular reinforcement schedule. Motivation can be increased by having visual progress reports of improvement.

5. Regeneration

Regeneration is the time and techniques necessary to allow the body/mind to fully recover after either a series of extensive physical or psychological stresses or a long period where the mind/body have not had adequate recovery. Passive regeneration often requires a long period that is not available to the athlete. Consequently, more active regeneration includes activities such as deep relaxation sessions (chapter 5), massage, meditation, yoga, water therapy, changing the workout environment, changing workout types and schedules, and possibly adding nutritional supplements. Biofeedback and neurofeedback can also be used to learn a deep relaxed state.

It is assumed in the optimizing performance and health model that motivation and commitment remain high but would be addressed if there is a concern. The other influences, such as the particular situation (opponents, facilities, coach, sleep, nutrition), are critical factors but will not be discussed here.

Self-Assessments in Sports

Because the mental skills necessary for high performance have been established, the authors routinely perform assessment of these skills. The assessments can be done in groups at training camps or one-on-one. The authors trust that athletes will give honest responses. This is particularly true with internationally experienced athletes, cooperative coaches, and favorable consultant/client rapport. In this section, two different questionnaires are presented.

There are standardized inventories available (O'Connor, 2004) to assess almost all of the mental skills thought to be important in sport. Athletes generally do not like completing extensive paper-and-pencil questionnaires, and it can also be expensive. Consequently, the first questionnaire we use is the Sport Psychology Mental Skills Assessment (see Table 3.1) because it is quick and covers all aspects of mental training skills. The athlete can provide more details of his or her perceptions during the interview of strengths and weaknesses. The results can be used for pre-post assessment as well as comparing perceptions between the coach and athlete. This inventory is later compared to the information gathered from the psychophysiological profile.

Athletes have different abilities and needs. With self-knowledge and coaches' feedback, one can select and train the skills necessary for the athlete. (If left alone, athletes tend to practice what they are good at, not what they need). Some athletes are natural competitive animals and need more practice using intent rather than controlling anxiety during competitions. Other athletes are dedicated practice animals who need significant control of their mind/body to maintain a proper mind/body state prior to their performance during competition.

Sport Psychology Mental Skills Assessment

Table 3.1: Sport Psychology Mental Skills Assessment©

Use the following scale to assess, in general, how well you are able to use your mental skills in ________________ (sport). Compare how well you perform the skills in practice and then under high-level competition.

Negative None/Low 1	2	OK Average 3	4	Positive Excellent/High 5

	Practice					Competition				
Motivation	1	2	3	4	5	1	2	3	4	5
Ability to relax	1	2	3	4	5	1	2	3	4	5
Ability to energize	1	2	3	4	5	1	2	3	4	5
Use of imagery	1	2	3	4	5	1	2	3	4	5
Self-talk	1	2	3	4	5	1	2	3	4	5
Focus of attention	1	2	3	4	5	1	2	3	4	5
Decision making	1	2	3	4	5	1	2	3	4	5
Level of confidence	1	2	3	4	5	1	2	3	4	5
Goal setting	1	2	3	4	5	1	2	3	4	5
Control of distractions	1	2	3	4	5	1	2	3	4	5
Keeping perspective	1	2	3	4	5	1	2	3	4	5
Relationships with team	1	2	3	4	5	1	2	3	4	5
Relationship with coach	1	2	3	4	5	1	2	3	4	5
Contribution to team	1	2	3	4	5	1	2	3	4	5
Time management	1	2	3	4	5	1	2	3	4	5

The objective of the assessment is to determine the strengths and weaknesses of the athlete in factors known to be important to high-level performance. If possible, we give the assessment to the coach to also rate the athlete to determine the congruency between athlete/coach on each of the mental skills. Discrepancies need to be objectively evaluated and agreements made between the coach and athlete as to how to best train the weaker skills.

Mental skills training enables the athlete to obtain a level of awareness and control of the following mind/body states, such that during high-pressure competition and critical moments, he or she may continue to perform the necessary sport tasks to the best of his or her ability. These psychological states have been identified as important to executing good performance:

- High self confidence
- High attentional focus
- Preoccupied with sport relevant thoughts/behaviors
- Lower anxiety
- Ability to park irrelevant thoughts or rebound from negative experiences

One skill that is often overlooked in sport psychology textbooks is the ability of the coach/athlete to maintain high levels of motivation for long periods of time. Often higher motivation can be obtained by simulating competition in practice. The state most often needed in practice is the ability to activate, rather than relax, and to focus attention to detail. The quality of the practice needs to be sufficient to maintain good skill development. If skills training is not simulated at a high-competition level in practice, the athlete may develop bad habits that surface during competition. The purpose of the endless hours of repetition in performance is over-learning, which is to make the skills automatic. Over-learned or automatic responses tend to withstand higher and longer periods of stress without breakdown in technique. Coaches assist in the process of over-learning at a high level by assuring the technical elements remain correct but also by making the skill drills challenging and fun while maintaining progress charts of the athletes' improvements. Visual progress charts are even more motivating than verbal reinforcement. We would contend that elite performance is based upon elite practice.

By extending the amount of time an athlete can maintain high-level skills in every practice, such as attending to every shot or skill or demanding technical excellence, the athlete becomes psychologically overloaded in the same manner as physiological overloading (Bompa, 1999). This should result in the athlete's capacity to tolerate increased amounts of psychological stress.

Cognitive and Somatic Anxiety Questionnaire

It is particularly important to know thyself when involved in the high-stress world of competitive sport. The reader may wish to fill out the questionnaire in Table 3.2 as a brief educational assessment of what mind/body responses occur during stressful times. Copyrighted©; permission is granted to use, with appropriate citation to V. E. Wilson, PhD, BCB, BCN, York University.

Table 3.2: Mind/Body Stress Response Assessment

This questionnaire allows you to become more aware of how your body and brain respond under stress. Rate yourself using the scale below for each question.

Scale: 4 Almost Always 3 Often 2 Sometimes 1 Almost Never

"When I am under pressure at important competitions or become anxious during critical moments, I...

______ 1. Tend to think of the negative things that are happening or may happen.

______ 2. Notice my heart rate and/or my breathing change.

______ 3. Feel as if I have little control over what is happening.

______ 4. Feel my muscles become tense and/or my hands tremble.

______ 5. Worry before a stressful event about how well I will do, and/or after the event is over, I replay the situation.

______ 6. Notice that I sweat or perspire.

______ 7. Become upset, distracted, or confused when many activities or ideas are going on at the same time

______

______ 8. Feel knots in my stomach or become nauseous.

______ 9. Become emotionally involved and cannot concentrate on the immediate task.

______ 10. Notice my hands and/or feet become cold.

Cognitive (or Brain Stress) Response Scoring

For questions 1, 3, 5, 7, and 9, add the total point score and put it here: _____

Low score is below 9, average score is 10–14, high score is above 15.

The average score for both male and female athletes (at approximately age 21) is 12.

Somatic (or Body Stress) Response Scoring

For questions 2, 4, 6, 8, and 10, add the total point score and put it here: _____

Females: Low score is below 9, average score is 10–14, high score is above 15.

Males: Low score is below 7, average score is 8–12, high score is above 13.

The average score for female athletes (approx. age 21) is 11.

The average score for male athletes (approx. age 21) is 9.

Technical note: The norms for this questionnaire were taken from more than 1,000 student-athletes. The scale correlated at .85 with Spielberger's STAI trait anxiety on a subsample of 150 university student-athletes.

An athlete can have a high somatic response and/or a high cognitive response or any combination of low, average, or high in body and mind responses. A few athletes have self-reported low mind/body stress but still have poorer sport performance under stress. Others have high levels of mind/body stress and perform well under stress. What is important is that the athlete is aware of and capable of controlling his stress responses, so they do not interfere with performance.

For athletes who are competing at very high levels and consistently need excellent performance—and especially those who do not perform well under competitive stress—we recommend a psychophysiological profile assessment. The profile assists the athlete in knowing what is occurring in the mind/body during performance and rest that is not always possible to know through self-observation. This is especially true when the athlete is focusing on performance and not himself. A comparison is made between the self assessment of the athlete and the more objective measures from the profile of how the mind/body responded during the stressors in the profile. A profile also helps to locate which systems may need fine tuning to maximize performance.

Working with athletes is different from non-athletes in that the outcome in the sport arena cannot be ignored. And generally, there is a shorter timeframe in which the athlete, coach, and parents expect to see progress. Fortunately, most athletes tend to have excellent motivation, commitment, and discipline, which translate into more practice at a higher quality outside the office setting. Normally, we involve the coach in the training process so the skills can be consistently practiced in the sport setting. As the coach is the controller of the life of most athletes, and most athletes and parents request coach involvement, all assessment and training results are shared with the coach. The coach typically provides information from his perspective on the nature of the sport problem and how well the mind/body skills are being integrated into practice and success of the techniques. This may create a conflict of interest that has to be professionally dealt with to avoid confidentiality problems (see Chapter 14 on ethics).

Psychophysiological Assessment of Body/Mind Systems

Clinicians should recognize that if everything were going well, the athlete would not be there. They have run into roadblocks they cannot find or fix, or they are concerned the opposition may be learning newer, better skills. Thus, it is important for the clinician to define what can and cannot be done for the athlete and the timeframe for developing the necessary skills. The authors' orientation is that of education, not therapy, with a focus on finding what is not working and providing skills to enhance performance and placing sport within the framework of the total life. All clinicians have the responsibility to refer athletes to appropriate sources of help in areas in which they are neither trained nor qualified.

Clinician modeling is especially important when working with elite coaches and athletes. Athletes expect the clinician to be able to demonstrate most of the skills that are being taught. Demonstrating hand-temperature increases, muscle relaxation, and lowering sweat responses are examples of biofeedback skills that show the athlete the clinician can walk the talk. It is also helpful for credibility and communication if the clinician knows the technical language of the sport.

Psychophysiological Stress Profile

The psychophysiological profile assessment is the cornerstone of our person analysis. The results from the profile are compared with the athlete's self-evaluation, others' evaluations, and where possible, with sport skill performance data.

Why measure the mind and body systems?

1. One can gain a holistic picture of what the mind/body of the athlete is doing at rest and during competitive tasks and recovery. While it is possible athletes have learned to control one or two systems (maintaining a poker face, relaxed muscles) this does not mean other systems are not showing signs of distress, which can interfere with their performance.

2. Because time is a crucial limiting factor to overall athletic achievement, it is imperative that only relevant training occurs. Pinpointing what mind/body system is not fully under the athlete's control saves time and increases the probability of sport performance improvement.

3. The profile helps to determine what system(s) is similar or different from other top performers and where to begin training for control of the mind/body. The profile can provide confirmation of being normal, and even more importantly, sharing strategies on how to obtain or maintain the necessary performance states that are common with other elite performers can be a confidence booster.

4. The results can be compared with paper-and-pencil measures, evaluations from the field, and the athlete's own self report. Particularly important is to find athletes who are incongruent—that is, those athletes who do not know how their mind/body is reacting.

Being able to see and actually participate in altering one's own mind/body systems often creates an "aha" experience (Wilson, Peper, & Gibney, 2004) that can motivate athletes to take more responsibility for their behavior.

For an athlete or coach that does not have access to psychophysiological profiling, the authors have devised a summary table of the different systems in disregulation, the health symptoms, and the signs that performance is being affected and how the coach or athlete can assess these without psychophysiological equipment. This "Performance and Health Assessment Summary" (see Table 3.3), also offers guidelines as to what system is in disregulation and would most benefit from biofeedback or neurofeedback training.

An example is when a coach or athlete notices that the athlete has tight fists and elevated shoulders while in competitions. This table suggests skeletal muscle tension is too high. If surface electromyography is available, the actual degree of muscle contraction can be measured. The athlete may show performance symptoms such as loss of flexibility or even health symptoms such as headaches. This suggests the athlete would benefit from training for awareness and control of muscles in the body.

Table 3.3: Performance and Health Assessment Summary©

	HEALTH SYSTEMS	PERFORMANCE SYSTEMS	ASSESSMENT: LABORATORY	ASSESSMENT: FIELD
PRIMARILY SOMATIC				
Skeletal Muscles	Tension headache, muscle tics, low back pain	Coordination, flexibility, postural changes	Surface electromyography (sEMG)	Elevated shoulders, grimace, tight fists, furrowed brow
Smooth Muscles	Migraine, stroke	Poor recovery, poor flexibility	Hand temperature, blood volume, pulse	Cold hands or feet, poor recovery from fatigue
Cardiovascular System	Irregular heartbeats, rapid heartbeat	Breathless, tires quickly	Electrocardiogram (EKG)	Rapid pulse, speech, and movement
Breathing	Hyperventilation	Fatigue, muscle tension, poor coordination	Spirometer	Sighs often, breathless
Immune System	Allergies, illnesses	Poor recovery, not reaching max training intensity	Chemical analysis (hormones, blood count, etc.)	Number of colds, flu
PRIMARILY COGNITIVE				
Cognitions (Thoughts)	Busy brain, personality problems (obsessive)	Forgetting, wrong skill or strategy selection	Intelligence test, attentional style test	Missing cues, attention to wrong cues
Affects (Emotions)	Anxiety, depression	Try too hard, give up	Tachistoscope, electro-dermal (EDR)	Over-reaction, short-tempered
Behavior	Poor lifestyle habits	Slow or poor decision making, nonperformance	Timed decision making tests, video	Poor strategy, slow to act

What to look for in the eight-channel profile recording: In general, we are looking for an atypical response for each of the psychophysiological systems assessed in the laboratory. “Atypical” is a relative measure. When an athlete has scores that are outliers relative to teammates or a database, the athlete is questioned as to whether the results are correct and whether they represent typical reactions in sport. Additionally, the athlete confirms what degree of relevance the response has to health and performance. If possible, measurements are taken during practice, and coaches are consulted. Unless there is a need to make changes, no action is taken. For example, if an athlete has very cold hands, reports no health problems, has a hand temperature that is not related to the required sport performance, and does not see a reason to have warm hands, then no temperature training is undertaken.

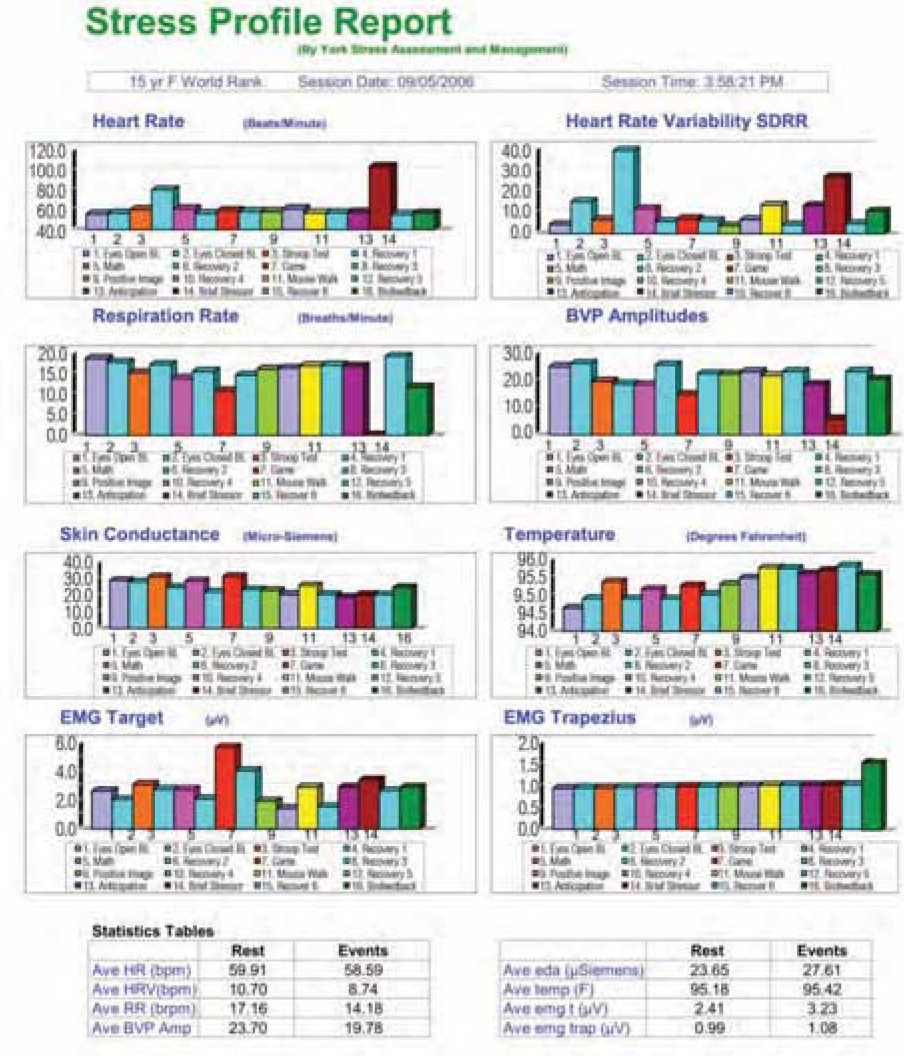
A more accurate measure of atypical can be determined by comparing each athlete’s response to his or her normal. For example, a track athlete consistently had very low electrodermal sweat responses during training or discussions of success or failure. Thus, one day when the athlete’s EDA was very high (compared to his normal response but low relative to other athlete’s responses), he was asked whether there were emotional issues occurring. There were. He was furious with the coach, and the issue needed to be resolved prior to leaving for world competitions.

Another example of an atypical response was an Olympic gymnast whose imagery of executing a vault with a high degree of difficulty generated high trapezius muscle tension. The athlete’s sEMG was then assessed in practice, and again, high trapezius muscle tension was noted. However, when the athlete actually performed this difficult vault with the feelings of tightness in his shoulders, his performance scores were high. Because the athlete was nearing Olympic competition and did not want to change his pre-competition routines, no attempt was made to change the high muscle tension for the one vault. However, during other gymnastic events, he believed high muscle tension interfered with his performance, and thus, he worked on sEMG biofeedback to maintain an optimal feel for shoulder relaxation during the other events.

The patterns of profile responses are equally as important as finding outliers. When does the athlete appear to be most relaxed? Prior to, during, or after the stressful event? Does the athlete consistently increase in stress across the session or show signs of focusing during activities and then recovering following the activity? The profile allows the sport psychology consultant to point out the responses to the athlete and determine if this pattern is typical of responses during sport and if it is relevant for the athlete's optimal performance. Figure 3.2 is a sample stress profile report obtained from an elite athlete.

Examples of responses that can be observed in the psychophysiological measures from the profile are any extreme responses relative to the age, gender, and sport of the athlete. In this case, the heart rate during the startle task is excessive with an increase from approximately 58 beats per minute to more than 100 beats per minute (this is displayed in event 14). Typical responses are in the 20 beats-per-minute range. The response suggests that this athlete activates easily, and in this case, it is confirmed by both the athlete and coach. For some situations, this may be beneficial, but in the case of this athlete, she overreacts, and it interferes with her sport performance. For a highly conditioned athlete, her respiration rate is high during rest (averages over 17 breaths/minute). This high respiration rate in a seated, non-activity task suggests either holding her breath earlier or an overreaction to the task.

Figure 3.2: Stress Profile Report



Another example is the high sweat response (EDA or electrodermal activity), which may be genetic or driven by anxiety as a result of new situations. Subsequent sessions showed a typical EDA response for her was less than one-tenth her initial response to the test setting. She confirmed high anxiety in new situations or evaluations. It should be noted that while her profile shows several atypical responses for an elite performer, this athlete remains in the top 10 in the world and responds exceptionally well under stress. The problem is that, on occasion, her performance is negatively affected, and there is a high emotional cost for the athlete and the coach when the athlete overreacts. **There is no single profile that can determine who will perform optimally.**

Guidelines for Interpretation of Psychophysiological Ranges of Profiles

Below are some ranges or averages the authors have found in their work with high-performance athletes and executives. Note: these averages are not research-based databases. **Perhaps, more important than numbers is the use of the data to ask relevant questions.** The authors recommend looking at overall patterns in all modalities and compare these with the self-report questionnaires and information gathered from the initial interview. Is the profile information congruent with the other athlete information and, therefore, strongly suggestive of where to begin the skill training? Or does the information collected not show a clear picture of what skill training is needed? In this case, further questioning is essential. For example, a first-year university basketball player was referred by his coach because he was not maintaining the high shooting average he had in high school. The coach believed the problem was related to anxiety. Yet the paper-and-pencil interview and psychophysiological profile did not consistently show anxiety under rest, stress, or recovery. Further questioning revealed the athlete was cognitively confused, not anxious. In high school, he was accustomed to receiving the ball and then shooting. The university coach wanted him to scan the environment for an open player under the basket, then look for a cutter, and finally decide if his guard was far enough away for him to shoot. Because the player had never practiced this *new* skill, he was slow, and the opposing defensive guards were able to disturb his shooting pattern. He did not need anxiety training but rather practice on how to scan and make quick decisions. What an athlete or coach perceives to be the problem, may not be the problem.

Body and brain profile responses at rest, under stress, and in recovery will be discussed with regard to the following:

1. Normal ranges
2. Changes from rest to task and during the task
3. Changes from tasks to recovery
4. Training

In general, multiple systems are evaluated when training. The training may only be conducted in one system initially, but monitoring is often done on many systems. The typical **order of training** is establishing abdominal breathing; lowering muscle tension; reducing emotional involvement; and sometimes, enhancing blood flow. This is then followed by neurofeedback training for attention and calming and then reduction of self-talk. If the athlete has only one reactive system from the profile, this system is trained first. Or if the athlete comes with specific performance requests such as being too tight or losing focus, the order of training is then changed to target his requests.

The **training goals** may include attaining average levels (if the baseline was outside this range), deep relaxation, and faster recovery to average/baseline and sport/activity-specific levels.

If there is **no response** in any one of the systems, check for good sensor contact or equipment malfunction such as improper connections. If sensors are OK and there continues to be no response, check to make sure the athlete is performing the task requested. It is also appropriate to check for the use of medication (including recreational drugs), a history of post traumatic stress disorder, or a history of having learned not to respond (i.e., athletes who suppress their emotions).

The psychophysiological measurements noted below are from the authors' clinical practice and are not based upon research findings. Caution is needed when interpreting measurements as equipment, environment, and other factors affect the actual measures obtained during each session.

Heart Rate (HR)

Using a photoplethysmograph monitor on the non-dominant thumb gives an indirect measure of HR (electrocardiogram chest leads can also be used). Under stress, the number of beats per minute (bpm) or HR should increase initially and then should decrease after the task is complete. Typically, athletes show much lower than average HR; however, genetics and the physical condition of the athlete determine the baseline.

Average HR Ranges at Rest

Note: there is a high genetic and fitness effect on baseline heart rates.

1. Normal non-conditioned individuals: Males, 72 bpm; females, 80 bpm. Highly trained athletes often have HRs of 45–60 bpm.

2. Look for missed beats or double beats. Cold hands, very low resting heart rate, or poor sensor placement may give such readings, so check for these variables. If abnormal readings do not appear to be equipment issues and reappear with repeated testing, refer the person to a physician. In our testing history, we have had two undiagnosed heart conditions in athletes that first showed up in our psychophysiological profiling.

HR Changes from Rest to Task

Note: The degree of heart rate change is associated with the type of task that is administered. HR is generally higher on tasks that are competitive.

1. Increases of 10 to 20 bpm are normal.

2. Check for hot reactors or athletes who have high increases in heart rate when the task does not call for such a change. This can be cross-checked with EEG for high beta activity. In this case, the athlete may over-respond to challenges, but on the positive side, she or he may typically have faster reaction times.

HR Changes from Task to Recovery:

Note: HR should decrease as the athlete lets go of the past activity.

1. HR typically returns close to baseline within a minute.

2. The athlete may return to baseline HR, but the pattern is more erratic, up and down. This may indicate he is more reactive or perhaps returning to thoughts about his performance on the last task. (Again, this can be cross-checked with other modalities and responses and by asking the athlete if he is still thinking about the last activity.)

Case Study

An orienteer (a competitor who navigates through the woods with a compass) was world-caliber but failed to break into the top 10, generally making one serious mistake in each race. The coach could not find a pattern for these mistakes. The athlete could not identify the thoughts or feelings that might explain what went wrong during these times. And while in our office during psychophysiological monitoring, we did not detect any problems during discussions with the athlete about the races. By putting heart-rate telemetry on the athlete during training competitions, we were able to notice the heart rate elevated significantly (over 185 bpm) above what would be expected but at different locations on the courses. Being able to probe right then, we found the athlete had momentarily lost concentration on locating the next route and had a lot of negative self talk: "I hope I don't lose now, I need to win this one, etc." This worry focus coming at the same time as heavy demands on the cardiovascular system (usually climbing hills) was enough to push him into a zone of not thinking, and decision errors then occurred. This is an important point, as the problem was not observable until the state of high heart rate from exertion was combined with an additional load factor of worry.

Training of Heart Rate

Personal heart-rate monitors are the norm for athletes training to remain within a specific heart rate range such as long-distance runners or skiers. Beyond this, the authors seldom train heart rate unless there is an extreme response to a stressor or a known problem. Rather, it is recommended to monitor heart rate and note unexpected changes from base rates and ask the athlete to monitor HR during training and competition if it is relevant to his or her sport. Typically, the authors focus on respiration training to lower anxiety, which usually lowers heart rate.

When working with athletes in the field, telemetry can be used to evaluate if there are any changes from a normal performance heart rate. When there are large increases, and they are not associated with increased physical activity, they often are related to worry or anxiety. In these cases, clinical work is related to identifying and addressing the causes and then to reducing the excess anxiety.

Heart Rate Variability (HRV)

The photoplethysmograph monitor can also record heart rate variability (HRV). Heart rate variability has been associated with better heart health and sport performance. In order to record heart rate variability, one needs data samples collected over a period of at least 64 seconds. The authors have just recently begun monitoring HRV in the sport setting as it is reported to be related to the ability to perform during critical moments (Carlstedt, 2004). Training of heart rate variability is discussed in detail in Chapter 6 and will not be presented here.

Respiration

For respiration training, a strain gauge is placed around the abdomen below the ribcage. Disregulation in breathing can often occur during tasks. In this case, the athlete uses shallow breathing (the shoulders, not abdominal region, are doing most of the work), holds his breath during tasks, and/or increases his respiration rate (breaths per minute or bpm). These responses have been associated with poorer performance during stress. Additionally, look for smooth, continuous expansion of the abdominal region with inhalation as a sign of more effortless breathing. The sEMG of the shoulders can also pinpoint whether the person is overusing shoulder muscles during inhalation and if the shoulder muscle tension is released during exhalation.

Average Respiration Ranges at Rest in Breaths/Minute (brpm)

	Male	Female
Slow	8–10 brpm	10–11 brpm
Average	11–12 brpm	12–13 brpm
Fast	12+ brpm	14+ brpm

Case Study

A 15-year-old sprinter had a consistent resting rate of 22–25 breaths/minute. This would increase with the excitement of competition, and she was often breathless in competition. Inquiry found that she had once suffered a broken back in another sport and spent six months in a body cast, spending much of her time lying flat on the floor. She had learned to lock her body and breathe shallowly, probably as a realistic mechanism to lessen pain. She was sent to physiotherapy to learn to unlock her entire trunk musculature and also to practice abdominal breathing.

Respiration Changes from Rest to Task

Note: Breathing rate is typically faster during tasks.

1. Normal breathing rates fall somewhere under 20 brpm. With individuals who have a high brpm to begin with (e.g., 15–20 brpm), we have seen these rates elevate to a range of 25–35 during tasks.
2. Check amplitude: If the athlete begins to shallow breathe, you will see a decrease in the amplitude of the wave on the graph. If there is essentially no amplitude, i.e., flatlined, the athlete is usually holding his breath. Short choppy waves suggest the athlete may be switching between chest/shoulders and diaphragm breathing, which can be verified by observation and checking trapezius sEMG levels.

Respiration Changes from Task to Recovery

Note: Typically, brpm decreases and the amplitude wave appears more rhythmical and smooth.

Respiration, heart rate, and muscles are usually monitored if not always trained in the same session. If shallow breathing is a problem, trapezius sEMG is monitored or an upper chest strain gauge is also used to detect when the athlete is trying too hard. Monitoring of the abdominal strain gauge is done during training of other modalities such as electrodermal activity or electroencephalography, and if the athlete is holding his breath or using shallow breathing, the training of the other modality is suspended until proper breathing is reestablished.

Breath training typically begins by having the athlete control the number of breaths per minute from normal down to 4–7 breaths while maintaining a continuous, smooth rhythm from the diaphragm. It takes time before the athlete acquires a breathing pattern that feels natural and effortless. This is followed by respiratory sinus arrhythmia (RSA) training in which the heart rate increases while the athlete inhales and heart rate decreases when the athlete exhales (see Chapter 6).

When performing with heavy exertion as in the explosive sport of wrestling, it is normal to gasp for air and/or use the upper chest, etc. Focusing on controlling the athlete's breathing while gasping has not worked well. Rather, the focus should be switched to the cue words that maintain good technique and low shoulder muscle tension. Then the athlete can return to slow, deeper breathing patterns.

When training an athlete for breathing rhythm, it should be checked with the timing of the activity, or poor performance may result. For example, a boxer does hold his breath before being hit. A swimmer cannot slow down respiration without consideration for the speed of the turn or speed of the stroke.

Home training of both brief and deep breathing exercises are recommended. (See the LSR Chapter 5 for an explanation of these exercises.) These skills can be practiced at home and in the sport environment, and often the athlete is also asked to practice the rhythm and slow rate of breathing using the home respiration-training software program (available at www.bfe.org).

Electrodermal Activity (EDA, also Called Galvanic Skin Response, or GSR)

The EDA electrodes are placed on the palmar surface of the skin of the non-dominant hand to measure changes in sweat gland activity. Under stress, the normal response is increased sweat activity; thus, it is an indirect measure of arousal. Peper and Schmidt (1983–84) report that gymnasts who had higher EDA responses had poorer competitive performance. They used EDA to illustrate how thoughts affect the body and performance, to monitor physiological relaxation, to identify stressful components of the athletic performance during imagery rehearsal, and to facilitate concentration training. They also used home trainers to help the gymnasts learn self-regulation of arousal.

Just as there are variations in patterns for some subpopulations, athletes who have been trained to suppress their emotions may show little or no response during tasks. This is not to be confused with individuals who may have had post traumatic stress disorders and who also show little or no EDA activity or response. This should be evaluated by the practitioner.

EDA Average Ranges at Rest

Note: There is no standard for determining who is a high or low sweat responder. EDA has a large genetic component based on the number of sweat glands and other factors that influence baseline levels and responses. Again, what is important is to look for changes that are not typical for each athlete.

Usually, we find dry-hand athletes around 1 microsiemens and wet-hand athletes above 10 microsiemens. Most EDA levels are between these two levels.

EDA Changes from Rest to Task

Note: The typical pattern is a quick increase, a leveling off, and a smooth decrease or decline across the task.

1. Extreme response: Check for extreme increases and responses that continue to rise as the task progresses. A doubling of microsiemens may be normal if the athlete has a low EDA baseline (1 to 2 microsiemens), but a doubling of a response, for example, from 5 to 10, is a large change.
2. Paradoxical response: Reduction in EDA during the task relative to rest may mean the athlete is more comfortable with things he knows (i.e., knows to follow directions to complete the task) and is more uncomfortable with the rest period. We have often seen this pattern in individuals who tend to worry, anticipate, or feel as they are being judged and constantly judge themselves.

EDA Changes from Task to Recovery:

Note: Return to baseline is typical.

If the athlete is slow in returning to baseline, and EDA is still elevated after one minute, it suggests the athlete is not able to emotionally let go of the past task and is probably still evaluating or judging the performance. If baseline is not regained, it will skew the next baseline prior to the next activity.

Case Study

A skater, referred after she had fallen at her first Olympic trial, had seen a traditional talk therapist, and yet, for months, failed to land that difficult jump in competition. Psychophysiological monitoring showed that when she was emotional, her EDA responses were high (20–30 microsiemens) compared to her relaxed EDA of 3–4 microsiemens. A program of relaxation, biofeedback, and self talk helped in her desensitizing to the past failure of the jump. Once she could see and feel herself relax while talking about or imaging the jump, her mental rehearsal of successful jumps in the upcoming competitions were practiced. Finally, simulations were done at the rink of the upcoming competition. No jump was attempted until the skater was able to demonstrate lower EDA levels. She was then able to compete for the remainder of the season without fear or failure on this jump.

Training of Electrodermal Activity

If the athlete has high electrodermal activity (EDA), which indicates emotional involvement, we ask about other emotion-related signs or symptoms such as gastrointestinal upset (butterflies), insomnia, anxiety, and rumination. The authors' experience is that high EDA responses are frequently found in athletes overly concerned with outcome (winning) or psychosocial dynamics (typically interactions with parents, coaches, or partners). EDA is monitored for athletes who tend to be very worried about winning (outcome) as opposed to the process for which they practice and can exert control (e.g., proper movement of feet, ready position, hiking the hip). Soon the athlete realizes EDA increases when the focus is on things that cannot be controlled (winning) and EDA drops when the athlete asks himself, “What do I do right now to get what I want?” This enhances self-awareness of mind/body reactions and helps shift attention to an action plan.

Visual and auditory displays are used as the athletes learn to increase (get more aroused for practice) and decrease (during stressful times) their EDA activity. This training includes the concept that other mind/body activities affect EDA. Using a baseball diamond analogy, you can get to first base in decreasing EDA by switching off muscle tension. To get to second base, lower the respiration rate to 4–7 breaths per minute using diaphragmatic breathing (Chapter 5). Continue to third base by shutting off negative self talk or clearing the mind. To hit a home run, shift your focus to a try-easier approach, which means passive awareness versus trying too hard. The athlete then tracks his progress with a GSR home trainer to see if changing the other modalities lowers EDA activity. The modality that affects EDA the most gives a clue as to what is contributing to the elevated EDA.

If initially the athlete has difficulty lowering EDA, the focus of training returns to slowing down respiration to 4–7 breaths/minute. The overwhelming majority of athletes will simultaneously lower EDA with a smooth, slower respiration rate. Further work continues using EDA biofeedback screens to help the athlete learn to lower his EDA response.

Continuously high EDA activity, even after the athlete becomes comfortable in the office setting with the clinician, or failure to lower EDA after sufficient practice may suggest underlying issues that need to be examined. For example, very low self esteem, past trauma (such as loss at a critical event), and unrealistic expectations for perfection significantly affect one's EDA.

In addition to practicing in the office with sophisticated EDA measures, the athlete can take home a portable GSR monitor for additional real-world training. The athlete is encouraged to practice when at home with annoying siblings, traveling to competitions, waiting in airports, and during pre-competition.

Hand Temperature (T)

Surface hand temperature is measured with a thermistor on the second or index finger of the non-dominant hand as an indirect measure of vasoconstriction during tasks and recovery. Constant cold hands may mean an unknown underlying stress response or medical condition is causing a decrease in blood flow to the hands. There are few documented performance problems directly attributed to cold hands (perhaps gymnasts grasping bars or smooth release of shots). However, it is important to emphasize temperature training for good blood flow for full recovery from fatigue.

Skin temperature is especially sensitive to physical activity and all the parameters of measurement change (typically higher) if the athlete has not had 1–2 hours of recovery before being monitored.

Average Temperature Ranges at Rest

1. Typical temperature (while seated in a room with room temperature in the 70s in degrees Fahrenheit(°F); during winter months, the athlete should be given at least 20 minutes to acclimate to the office setting before beginning training):

	Male	Female
Low	< 90°F	<85°F
Average	90–92°F	87–89°F
High	92+ °F	89+ °F

2. Gender differences: More women register very cold temperatures, in the 70s, and temperature will vary with hormonal cycles. Women will swear this is genetic and that they can never warm up, but within weeks of temperature biofeedback, most will increase their temperatures to the upper 80s.

3. Reactive temperatures: A few people have highly reactive temperature changes. We have not been able to associate this with any patterns, but there is evidence that temperature drops with hyperventilation and with the fight/flight responses.

Temperature Changes from Rest to Task

1. Temperature typically drops less than one degree Fahrenheit in one-minute tasks.

2. Pattern of response: Temperature may continue to drop throughout the entire task, or temperature stabilizes after the task begins.

Temperature Changes from Task to Recovery

1. Normal response: A normal response is indicated by a general increase in temperature during all the recovery periods following a brief delay of 15–30 seconds.

2. Consistent decline in temperature across the entire session: If the pattern of temperature is a decline during the entire session, of which the athlete is typically unaware, the athlete would be classified as a temperature responder (unless it was ascertained that the temperature change is due to hyperventilation).

3. If temperature goes down in some, but not all, recovery periods, check the nature of the stressor. Women may not show decreases in temperature to a math stressor any more than men do, but they may not recover after the math stressor, i.e., they may not be as confident in math and process it long after the task with negative self statements.

Case Study

A sailor received severe damage to his wrist and hand caused by an electrical accident, which rendered him unable to do small grasping movements. He was particularly frustrated by his inability to handle the lines of his sailboat and to participate in his favorite sport. Temperature was chosen, as the cold hand was uncomfortable; increases would suggest improved blood flow and possibly enhance healing and it is easily measured. For 14 sessions, he practiced temperature biofeedback and was able to increase his hand temperature from 77°F to more than 98°F. He reported being able to increase hand temperature at will after training. The planned surgery to repair the damage and remove the scar tissue was cancelled as his recovery was such that he no longer required it. That spring, he was out sailing on the lake holding the line in his damaged hand. (Bird, 1980).

Training of Hand Temperature

Inexpensive thermometers that measure to a tenth of a degree and are averaged across 8–10 seconds are available in most electronics stores. These thermometers are sufficient to indirectly measure the change in blood flow to the hands or an injured muscle area. The small hand thermometers that measure two-degree changes are not sufficient for training. They may be helpful for indicating when an athlete has cold hands, but for most athletes, it is too difficult to move hand temperature two degrees, and they become discouraged and quit.

The long-term goal of temperature training is to attain a fingertip temperature of approximately 96°F during deep relaxation training. Some athletes achieve this within a week or two, and others require more training time.

In the past, we have used thermometers with athletes with injured knees, shoulders, and ankles and were able to increase blood flow to each specific area. It should be noted that it is much harder to move blood flow to the feet and legs than the hands or arms. Therefore, it is advised to begin training with an area where the athlete can achieve success.

Typically, we measure the temperature on the first phalange of any finger (but maintain the same finger throughout training) of the non-dominate hand. If the hands are needed for actions in the sport, the probe is placed on the back of the finger.

Surface Electromyography (SEMG)

The sEMG can be used to locate atypical muscle responses to tasks or to identify failure to release muscles following a task. We have also found sEMG can be used when a skilled performer with some imaging ability is imagining a task. In this case, the athlete will find a similar muscle pattern between actual and imagined movements (Bird & Wilson, 1988). One sEMG lead is typically placed on a muscle group of interest to the athlete, such as monitoring forearm tension in an archer or a muscle recovering from injury. The second sEMG is placed on the shoulder on the middle third of the belly of the upper trapezius muscle of the non-dominant side. When assessing sEMGs, it is helpful for the practitioner to ask the following questions: Does the athlete habitually maintain above-average muscle tension? Does the athlete release muscle tension quickly and completely? Is he or she co-contracting incorrectly, causing loss of coordination or speed?

For athletes with muscle injuries, during the imagery task, the athlete is asked to imagine sport performance when he or she is completely free from injury and then imagine it with the current injury. Often, only the affected, injured muscle will show an increase in tension (relative to previous non-injured levels or relative to contralateral muscle measures) during imagery or discussions of the injury. Training can continue until the athlete becomes desensitized to tightening the muscles when imaging or thinking of the performance.

Average SEMG Ranges at Rest

1. Non-dominant shoulder (upper trapezius)
    a. Low: less than 1.5 microvolts (μV)
    b. Average: 1.5–5 μV
    c. High: above 5 μV
2. SEMG special sites: The placement of electrodes changes depending on the sport task in question. For example, forearm sEMG can be used for the grip on the tennis racquet.
3. When monitoring two sEMG bilaterally, or anterior/posterior, check to see if the microvolt levels are approximately the same. If there is a small difference, it is probably not significant. However, unexpected significant differences should be addressed with biofeedback. In some cases, the sport creates this imbalance, such as a larger forearm in tennis, and while we recognize bilateral symmetry will probably not occur, we continue training for balance in the musculature.

SEMG Changes from Rest to Task

1. SEMG increases in appropriate muscles. The practitioner should check to see that only the appropriate muscle is being used. For example, when practicing imagery (mental rehearsal), there is no need to use shoulder muscles in breathing. However, if the athlete is performing a keyboard task during the profile, we might expect to see some increase in the forearm but a lot less muscle increase in the shoulders.
2. The practitioner should check for exaggerated amounts of muscular effort sEMG during tasks, such as from 2 to 22 μV while the athlete performs the Stroop test.

3. Agonist/antagonist relationship. If motor skills are important, then check for co-contraction of agonistic and antagonistic muscles. If both sets of muscles use approximately the same degree of muscle tension throughout an entire movement, it suggests there is too much tension in the antagonist. The agonist (movers) should have more activation at the start of the movement, and the antagonist (brakes) should turn on more at the end of the movement. Coordination, rhythm, and smoothness are poor if the two muscles are not coordinated during action.

4. Bilateral symmetry. If the practitioner is monitoring two muscle groups for symmetry, such as in posture, the µv levels should be approximately the same. For example, right and left upper trapezii should be approximately the same at rest, or right and left paraspinal muscles should be the same when standing at rest and equally balanced on both feet.

SEMG Changes from Task to Recovery

1. Typically sEMG levels will return to baseline or will drop very quickly, within a few seconds, after a task. Often, the practitioner will see a rebound, or letting go, of tension to below the initial baseline, especially if the task involved some physical movement.

2. The practitioner should check for residual tension: Some athletes might have a quick release of muscle tension, but it does not return close to their previous baseline. Whereas, some athletes may return to baseline levels, but it takes longer to achieve the release.

3. The practitioner should check for rebound muscle tension: A few athletes will respond after-task with an increase in muscle tension.

4. Observe the degree of shoulder elevation with breathing: Some athletes may hold their breath during the task, and then during the recovery phase, they overuse the shoulders to reestablish breathing.

5. The practitioner should check for bilateral release if monitoring bilateral muscles.

Case Study

A 100-meter sprinter (considered by other runners as a world champion at 80 meters) would tie up or slow down in the last 20 meters, and his competition times were slower than his practice times. While performing imagery of the past race while attached to sEMG, the author and another runner noticed his shoulder tension significantly increased at the 80-meter mark. The athlete was asked to imagine running another race in which he tied up in the last 20 meters. Again, significant increases in shoulder-muscle tension was present. The athlete was shocked when we showed him the changes; he was unaware of the tightness nor had the coach observed his elevated shoulders. Following sEMG training in the office, a small, portable sEMG was used to practice staying relaxed during simulated races at the track. His times from competition then matched his training times.

Training of Muscle Tension (SEMG Biofeedback)

Most athletes report being too tight, and because most sports require flexibility and speed, the ideal place to start training is with muscle awareness and control. Athletes are unaware of small increases in muscle tension, but the difference between being a champion sprinter at 80 meters and at 100 meters may be the reduction of these small amounts of muscle tension. Even when performing imagery, excessive muscle tension can often be seen.

Several useful exercises to help the athlete become more aware of muscle tension are provided in the LSR chapter; however, sEMG training is faster and precise. Often, only one sEMG session practicing rising, lowering, and eliciting just right muscle activity is needed to sensitize the athlete. We typically begin with trapezius-muscle training. Occasional sEMG sessions to check and fine-tune the just-right level are needed to remind the athlete of just-right muscle levels in practice and competition. This is particularly true when the sport mechanics have been adjusted. Home trainers are often sent with the athlete, and a threshold can be set so sound biofeedback comes on when the athlete is not performing with the appropriate level of muscle activity. Telemetry is now available and will eventually become the standard tool for muscle training at practice, just as heart-rate monitors are used as the standard for maintaining the optimal zone for heart rate.

It is usually necessary to have the athlete assume the sport skill position when learning to control muscle tension. Maintaining control of muscle tension while sitting in an office chair is very different than maintaining the same control while on the swimming blocks or lying down on the bobsled. This must be practiced and reinforced for proper transfer of skills to competition.

Target muscles can be identified for each sport and athlete. If the athlete tends to grip the racquet too tightly or drops his elbow on an archery shot, the sEMG can be used to train awareness and control of the forearm or shoulder. Even athletes with years of experience can have improper posture/biomechanics without the athlete or coach noticing. Periodic muscle checks can help the athlete identify and alleviate these problems.

SEMG can be used when recovering from injuries. An injured muscle can be compared with the contralateral (opposite) uninjured muscle to determine symmetry during activity. (This presumes both muscle sets are similar in structure and sport function).

Identify and practice when and where to relax the muscles. Sitting on the bench between shifts, waiting for a free throw, or between points are when muscles need to be released. With telemetry, one can assess whether the athlete is complying with the training during practice, and by using home trainers that fit into the athlete's pocket, he can become more aware of and make fine adjustments in muscle-tension levels.

Coaching Hint

Athletes have consistently reported the benefits of being able to relax their muscles between performances and especially prior to critical competitions. This not only changes the focus of attention from outcome (and the worry that is associated with one's inability to control the outcome) to an action plan (in which activities relevant to the performance can be done). The action plan we found most beneficial is to begin with abdominal breathing at 6–8 brpm and then loosen and stretch the muscles. The slowing down and release of tension is typically accompanied by a mental "I'm ready." We find it beneficial to provide biofeedback-assisted booster sessions for high-skilled performers. In our lab, gymnasts requested the booster session about once a month, and professional tennis players have requested it every two or three months.

Electroencephalograph (EEG)

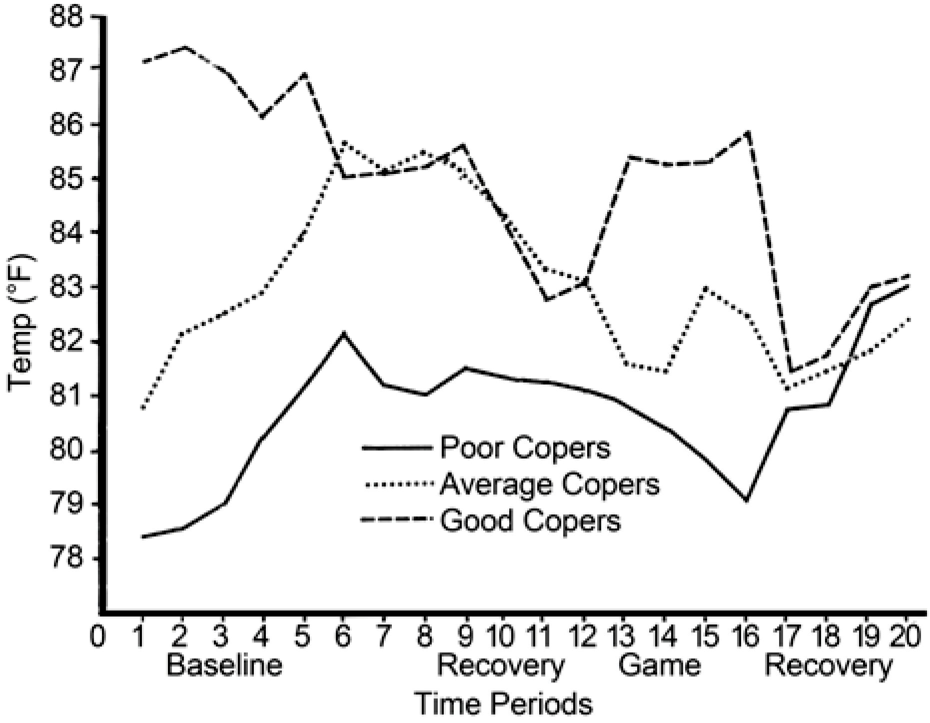
The electroencephalograph (EEG) is used to assess the amount and speed of electrical activity in the brain. It has mostly been used to assess and train individuals with epilepsy or attention deficient disorders but recently has become a tool of choice for the training of high performers (Egner & Gruzelier, 2003; Raymond, Sajid, Parkinson & Gruzelier, 2005). The use of EEG will be reviewed in more detail in chapters 7, 8 and 9.

Group Database and Reports

Sport organizations often request evaluations of team members to identify strengths and weaknesses. It has been useful to be able to compare an athlete with his or her peer group, which we do by maintaining group databases. An example of the usefulness of the data is illustrated in figure 3.3, which shows the reports given back to the coaches about their respective teams.

In figure 3.3, the coping ability of the 22 athletes was assessed by the head coach as their ability to perform in important competitions relative to their abilities demonstrated in practices. In addition to baseline differences, the athletes who had good coping skills in competition also increased their hand temperature in the track and field computer game. The authors have repeatedly found, with other sports, that the athletes who possess good coping skills tend to show more signs of stress following an activity (lower hand temperature in both recovery periods). With this information, the coach and athletes were more willing to target individuals who may benefit more from biofeedback-assisted relaxation training.

Figure 3.3: Temperature of university track-and-field athletes during a laboratory session of stressors and recovery. The data suggests athletes who had colder hand temperatures in laboratory baseline, stressors, and some recovery periods also were rated as not capable of coping as well with the stress of important competitions.



This is not an unusual group profile in that it is not an ideal profile (where athletes with good coping skills would be expected to increase temperature during recovery). If this pattern of appearing more relaxed during tasks versus the recovery period is also noted in the EEG and EDA measures, the consultant then needs to determine what the athlete was doing during the recovery period. When questioned, athletes will often respond that they are busy evaluating what they did and how they could improve it and often some negative self-statement. This pattern shows each profile is unique, and the clinician has to use *all* of the available information to understand what is really occurring.

Program and Session Design

When the practitioner has finished the assessment and is preparing to train the athlete, it is necessary to develop an overall plan as well as a within-session plan on how to best proceed. As noted in the beginning of the chapter, the sport task, the environment, and the personal skills of the athlete need to be considered before training commences.

One of the best published program guides was produced by Blumstein, Bar-Eli, and Tennenbaum (1997). It outlines a five-step approach using biofeedback to train arousal and then practice transferring this control to a more game-like setting. The steps include an introduction of self-regulation techniques; identification and experimentation with biofeedback modalities; training biofeedback responses with simulated competitive stress; transferring the preparation to the training conditions with portable biofeedback devices; live sport-specific films in the office; and checking to see if the skills are working in the competitive environment.

Our program is very similar to Blumstein's with a few modifications. Within each session which lasts 1–1.5 hours, we do the following:

1. Use a psychophysiological profile requiring less time (2 minutes) to identify which modality may need fine tuning and to set thresholds).
2. Structure the teaching and practice of the self-regulation skills that are needed for performance (brief, i.e., seconds), so they are differentiated from those traditionally taught (deep, i.e., 15–20 minutes), which are best for total relaxation and regeneration. See Chapter 5 on LSR for a description of brief and deep relaxation.
3. Structure the timeframe of the training, so it matches the timeframe and requirements of the sport. For example, if the average time of a tennis rally is 25 seconds, we practice biofeedback/EEG training for 25 seconds with many repetitions.

4. Incorporate EEG training along with the other psychophysiological modalities.

   Also incorporated within each session are:

   a. Homework check up. A skill to be performed during practice that week is designed to match the skill learned in the office setting.

   b. Review of LSR sport skills. For example, heart rate variability is usually checked each session.

   c. Training of new skills or fine tuning with biofeedback/neurofeedback (typically combined).

   d. Assignment of new homework and reinforcement of the skills learned.

In conclusion, research has shown certain psychophysiological states are associated with improved performance and can be trained. Much remains to determine exactly which biofeedback or neurofeedback training is most efficacious in improving actual sport performance. With the use of telemetry, psychophysiological assessment and training during actual performance is now possible. When we know what is occurring within the mind/body of the athletes in their actual performance in the gym, field, court, or arena, then we may more directly answer the question of how much of an impact any skills-training program, including biofeedback or neurofeedback, has upon their performance when it counts.

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Peak Performance:
A Systematic and Integrated Approach to Mental Training
Chapter 4

by

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Abstract

Athletes can develop the mental competencies that significantly increase the chances for delivering exceptional performance. This chapter covers a systematic approach to peak performance that integrates the science of performance psychology, advanced sensory feedback technology, and personalized coaching not only for elite athletes, but also for military professionals and business leaders alike. First created at the U.S. Military Academy at West Point by the author and since significantly advanced and adapted for a broader audience, the program consists of a Peak Performance Center and accompanying training protocols that focus on mastering the five peak performance competencies: Goal setting, positive-effective thinking, stress management, attention control, and visualization and imagery.

Chapter Outline

I. Introduction

II. Peak Performance: A Systematic and Integrated Approach to Mental Training

   a) A tale of two moments: The locker room
   b) The problem: Unrelenting challenges and impossible expectations
   c) Peak performers and self-leadership
   d) The solution: Learning to deliver consistent, exceptional performance
   e) How does it work?
   f) Reaching your full potential: Learn to achieve peak performance

III. References

Introduction

Peak performance is about performing at your very best when it matters the most—and it matters the most in critical situations where one action changes everything. Knowing what that is and when to do it is the key to success in sports and life. Peak performance can be learned. But most performance training today is inadequate and too narrow in focus to enable lifelong learning to be achieved for a person to develop on-command, peak-performance behaviors.

Training and development in today's world consists mostly of renaming, reframing, and repackaging techniques that are 20 to 30 years old. We call this knowledge the "know" and the techniques the "do" of development. While many of these techniques are essential to start to learn how to be an effective person, they only provide short-term change and benefits. They do not address the core foundation of personal development.

The foundation of personal development comes from within—the ability of an individual to adapt to the circumstances, think effectively under pressure, and develop focused solutions while communicating efficiently with others. We call this the "be" of personal performance. It is about who you are as a person and as an athlete.

Perhaps you are facing a critical juncture in the sport you have chosen. Or perhaps it is the championship game or a world record that is on the line. In all these situations, there are moments that require your best performance. These moments often define success or failure. How well you perform at this moment is not a function of whether or not you know what needs to be done. It is about trusting your intuition and your heart, using adaptive thinking and bringing that to bear on the right action. This is the foundation and the edge that the best performers have over simply good performers. Why is this foundation missing in today's training? The simple answer is that it is difficult to develop using traditional methods, and there is no magic pill or class that will lay the foundation.

By developing people to think more effectively and to control their emotional and physiological responses, peak-performance training helps people achieve resilience, self-confidence, adaptability, and mental agility. A unique approach is to develop and measure these skills using advanced sensory biofeedback technology along with a proven systematic process originally created nearly 20 years ago at West Point.

Ultimately, improving these skills results in more positive and effective thinkers who can control their emotional and physiological responses to any high-pressure situation. This, in turn, yields enhanced overall outcomes through better personal interactions as a member of a team, improved decision making and innovative problem solving. This is how you learn to be the person you need to be. This is what peak-performance competency training is all about.

Peak Performance: A Systematic and Integrated Approach to Mental Training

A Tale of Two Moments: The Locker Room

Imagine playing in the Army-Navy football game in 1992. It's the fourth quarter with two minutes and 40 seconds remaining. You are the field-goal kicker for the Army team, which has just delivered a remarkable fourth-quarter comeback to bring the team within two points of a return from a 14-point deficit. The crowd goes absolutely wild. Army has the ball and is driving down the field but gets stalled on the 27 yard line with 49 seconds remaining. It is fourth down. A field goal is the only chance for winning the game. It is up to you. You have kicked a 44-yarder only once previously during the season.

The ball is snapped. It is in the air, and it is good. The stadium erupts in wild celebration. Your teammates rush onto the field. You have beaten Navy in the most important moment of your life as a West Point athlete. But wait—there is a flag. Delay of game by Army and a five-yard penalty. Kick it again. But now it is a 49-yard kick. You have never even attempted that distance before. The ball is snapped. It is in the air and travels dead center through the uprights with yards to spare. Army wins 25–24. You have delivered an extraordinary performance.

This athlete enhanced his ability to perform at his absolute best under tremendous pressure by engaging in a systematic training program that developed critical mental skills needed for this kind of performance. Such training and preparation for peak performance is much more accepted today than it was in the recent past. The preparation for and execution of exceptional performance as described by peak performers are much the same across many sports. The key ingredients are finely honed peak-performance competencies that enhance mental preparedness. Too often, successful people feel they do not need any special training or preparation to be at their best. Instead, they believe their past experiences and successes will carry the day.

The Problem: Unrelenting Challenges and Impossible Expectations

Every day, athletes face seemingly endless challenges brought on by external forces and events and often-unrealistic expectations. Today, athletes are in the game all the time. To be successful, both individually and organizationally, they must be at their best every day. Consider the following summary of everyday challenges for today's athlete:

- Top-level competition
- Grueling schedules
- High demand to be the best
- Pressure from media and spectators
- Balancing the sport and family life
- High team expectations

The cumulative effect of all of the above is a lot of pressure and stress. The problem is that these factors will not suddenly disappear. In fact, they will continue and become even more pervasive in the athletes' lives. To be able to not only survive, but to thrive under these conditions, athletes realistically have only three courses of action:

1. They can always opt out of the situation, and sometimes they do.
2. They can attempt to eliminate the causes of the stress, which most of the time is out of their control or not possible.

3. They can significantly improve the way they personally respond to the pressure and stress—physiologically, mentally and emotionally. These responses will determine their level of performance and, ultimately, their overall success.

The Myth of Motivation

Too many teams seek out motivational speakers, pseudo-psychologists, and self-help books for answers when the real performance advantage comes from within. Ask any peak performer. Be wary of books that teach how to motivate athletes. You cannot. Real motivation is internal. It is something individuals must develop for themselves. It is all about inspiration and passion. Coaches can influence the likelihood that their players will find the inspiration, drive, and passion to excel, but they cannot motivate. It is certainly their job to help. But ultimately it must come from within the athletes themselves. This is why self-awareness, self-control, and self-management are so critical in achieving exceptional performance. The competencies in the integrated peak performance model are at the heart of self-awareness, self-control, and self-mastery.

Peak Performers and Self-Leadership

Elite performers are leaders—of themselves and others. Leading yourself is about knowing who you are. You cannot successfully lead others until you have learned to lead yourself, and leading yourself is all about self-mastery—mastery over what you think, say, and do. After all, these are the only things you can directly control. Too many athletes mistakenly pride themselves in saying they exercise control over myriad activities, events, and people. In truth, other than what they think, say, and do, not much else is in their direct control. That is not to say they do not exercise influence, but influence and control are distinctively different. Once athletes accept this basic tenet, real leadership of oneself and others can occur.

BE, KNOW, DO

Self-leadership needs a framework to guide the education, training, and experiential activities supporting it. A useful model for such a framework, adapted to a self-leadership concept, is the U.S. Army's BE, KNOW, DO. It is simple yet elegant (See Figure 4.1). Traditional learning approaches focus primarily on the KNOW and DO (i.e., education programs to increase knowledge and training programs to change behavior). But few approaches have addressed the BE. We have found in many organizations and teams there is a reluctance to even address this element of development. Yet, self-leadership is all about the BE. It is all about knowing the essence of who you are: how you think, what you say, and what you do.

Figure 4.1: U.S. Army Be-Know-Do Leader Development Model

By using a leadership framework such as the one depicted in Figure 4.1, organizations and teams can focus much more on developing the Be part of training and development. Peak performance competencies are life skills. Once mastered, they become a key part of who you are and how you function, in your sport, at home, and in your personal life.

Self-Leadership Is About Inner Control

We have seen, for some time now, that elite athletes compete against each other with relatively equal skills and abilities. Yet some dominate the field and repeat as champions over and over again. The major differentiation is mental preparedness—the ability to be in the zone, to focus on the present with no thought of the past or future, concentrating only on what you are doing, not on how you are doing. This is especially challenging for organizations who constantly face questions from media and owners about how the company is doing. It is, of course, very important to keep an eye on other factors for the long term, but in the day-to-day performance of an athlete, the best results are obtained with total focus on the performance requirement at the moment. Elite performers are exceptionally good at this. The key aspect of superior performance is inner control—control over the mental, emotional and physiological states that are present in every performance situation. That control is exercised through well-developed peak-performance competencies. Without mastery of these competencies, athletes cannot hope to repeat and sustain exceptional performance under pressure without the inevitable negative consequences on individual effectiveness; team and organizational performance; and ultimately, their own health and welfare.

The Solution: Learning to Deliver Consistent, Exceptional Performance

A Systematic and Integrated Approach

Of course, most successful athletes do learn to adapt and adjust to achieve effectiveness under trying and changing conditions. But in these times of unparalleled athletic competition, the question has to be asked, "Is being effective good enough?" Without competition, it is. But competition changes everything. Everyone has to perform to his or her very best. Just being effective is not enough in today's competitive world of athletics. The human spirit is such that people want to excel. It is not common to meet someone who wants to be just ordinary. Athletes can develop the mental competencies that significantly increase the chances for delivering exceptional performance. For the past 16 years, we have developed and applied a systematic approach to peak performance that integrates the science of performance psychology, advanced sensory feedback technology, and personalized coaching not only for elite athletes, but for military professionals and business leaders alike. First created at the U.S. Military Academy at West Point by the author and since significantly advanced and adapted for a broader audience, the program consists of a Peak Performance Center and accompanying training protocols that focus on mastering the five peak performance competencies depicted in Figure 4.2.

Figure 4.2: APEX Performance Model™

As in any training-and-development process, quality and accurate feedback are essential for learning. Because peak performance competencies are internal, learning to master them is best achieved with advanced biofeedback and neurofeedback technologies that measure covert activities—heart rate variability, respiration, blood pressure, brain activity, etc.—once deemed the domain of clinicians and biofeedback therapists. We now use these technologies to provide accurate and measurable feedback as the individual learns to master control over mental, physiological, and emotional responses to demanding and challenging events.

Biofeedback and Neurofeedback

The use of biofeedback for relaxation training, muscular control, and increased awareness of one's psychophysiological state is not new. What is new is the sophistication with which this technology can be used currently and what it represents. For example, recent discoveries of how the brain and the heart interact and communicate with each other uncovers a more scientific and practical way of viewing the mind-body interaction. The use of EEG measurement for training altered states of consciousness and attention has become very sophisticated. In our program, we use several technologies in varied and effective ways to support the five-point Peak Performance Model.

Heart Rate Variability. The emWave developed by HeartMath is a relatively simple yet elegant biofeedback tool for showing sympathetic and parasympathetic balance (coherence) through HRV measurement and training. It is used to train the athlete to get in "the zone" via a combination of deep breathing, relaxation, heart-brain connection, and a care and appreciation feeling. Being able to make the brain and the heart work together is a key element of what athletes have commonly referred to as "the zone." Our protocols call for a structured and measured process for developing skills that allow athletes to recreate the feeling and the mindset that allow them to achieve a calm and collected state in addition to a heightened sense of alertness and concentration. The technology utilizes heart rate variability (HRV) as the trigger for reaching this state (For further information on HRV, please refer to Chapter 6 by Strack). Research (See Science of the Heart, Institute of HeartMath, Boulder Creek, CA, 2001) has shown that when the brain and the heart are working together in harmony and in coherence, athletes are in a much better position to achieve a mind-body state that will give them their best performance.

General Biofeedback. For the more classic biofeedback training that takes advantage of multiple sensory modalities, we have been using Thought Technology's ProComp Infiniti as feedback mechanisms for training relaxation, HR control, and respiration. It has an excellent respiration template that athletes follow with their breathing until they can duplicate the rhythm displayed on the screen. We have found this to be a very useful tool to teach the proper breathing that is so critical in attaining high coherence. Other uses follow fairly standard protocols used by most sport psychologists who use biofeedback as a training tool.

Neurofeedback. Neurofeedback has become a new and popular tool for mental training in sports. Recent advances in EEG measurement (ease of use, simplicity of application, and creative screens) have made it much easier to use neurofeedback as a powerful tool for training altered states of consciousness and, in our case, for attention control. The systematic use of this technology helps athletes understand the attention mechanisms and alter their ability to refine focus and concentration. We utilize Thought Technology's ProComp Infiniti neurofeedback capability and emphasize training on how to pay attention, not just what to pay attention to. Focusing on the how requires access to cortex measurement since attention is a function of the frontal lobes.

Training attention control supports the Peak Performance Model, rounding out the other mental skills. The ProComp Infiniti provides a very useful tool for developing enhanced skills in focus and concentration via frontal lobe and PFC reward and suppression. We have been working with athletes and business executives on their attention skills as part of our broader peak performance training program. By providing situations and scenarios as input for the neurofeedback training, we have been able to demonstrate measurable improvements in their ability to attend in crucial performance situations.

How Does It Work?

Goal Setting

Oliver Wendell Holmes once said, "The greatest thing in this world is not so much where we are, but in what direction we are moving." A journey starts with knowing where you want to end up. This is especially true for anyone who wants to begin the journey to becoming a peak performer, to reaching one's full potential. Setting goals is relatively easy. Making them happen is not. A key part of any lasting goal-setting process is the idea of a mission. Knowing and living a mission provides the motivation and perseverance to forge ahead when the going gets tough. It is much more than having a goal.

Much has been written about goal setting and goal-setting techniques. Our approach to setting the target is not so much about a technique as it is a process for identifying what one really wants to accomplish, the inclusive smaller steps needed to get there, and the positive mindset necessary for ensuring enduring determination. Stopping with a list of goals and objectives is not enough. It does not activate the energy needed to see them through to completion. They must be deliberately connected to our daily thoughts and self-talk. Transforming objectives, which in their simplest form are actions, into affirmations connects what we are doing with what we are thinking. After completing our goal-setting process, a CEO of a $3 billion health-care company said, "I have done goal-setting exercises before. We in business do this all the time. But taking it to the next levels is something I had not done before. The power of this process is truly remarkable."

Positive-Effective Thinking. Confidence.

Confidence is the ultimate determinant of success. We see and hear this all the time in sports. Yet our experience in working with athletes has shown us confidence is still very much an issue. Confidence comes from within. No one can give it to you. It reflects how we view ourselves and our preparation for future challenges.

We become what we think about most. People carry around mental images of themselves—of who they are and how they perform. These pictures begin at birth and continue throughout the life cycle, capturing all of our experiences. These experiences reflect both the successes and failures and the manner in which they are interpreted and stored. Much of this self-image is driven by our thoughts (positive and negative) and maintained and reinforced by our self-talk. Given the basic negativism surrounding our lives, being positive and having trust and confidence in one's ability is hard work.

In his book *Learned Optimism*, Martin Seligman writes about the power of optimism over pessimism for being successful. He explains how we all develop an explanatory style as a way to refer to the cause of events. Our styles say a lot about how we will react cognitively and emotionally in a given situation. The development of our styles comes directly from how we think and what we think about and from the repetitiveness of these patterns of thought over time and in situations. Seligman has identified practical implications of his work that have been incorporated into our peak performance training. Leaders cannot rely on intuition about the optimism of their people. It needs to be measured in a way that they cannot, and Seligman's Self-Perception Inventory does exactly that. It measures how people explain to themselves the cause of an event and has three dimensions for those explanations: Permanence, Pervasiveness, and Personalization. [See Seligman, M.E., 1998.]

We train people to shift from negative to positive patterns of thinking and to control self-talk. Recognizing that people need to take responsibility for their cognitions (thoughts), we provide training that helps them achieve that control. Based on Seligman's work and other recent scientific evidence grounded in how children learn language at home, positive-effective thinking can be systematically developed. The use of affirmations that the individual develops and recording them on an individualized CD applies the methodology derived from these research findings. It is an effective tool for transforming negative thoughts to positive ones and moving from a pessimistic to an optimistic mindset. Mastery of this competence can transform a person into an exceptional thinker.

Stress and Energy Management

Stress and energy go together. Anyone can perform well when everything is going just right. But what about when conditions are unfavorable, when things are going against you, when the pressure is on, when things are not going according to plan? Who really delivers then? There are performers who actually thrive under these conditions. They welcome the pressure. It drives them. It gives them energy and desire coupled with the ultimate satisfaction of having overcome all odds while doing something exceptional. These are your peak performers. The debilitating effects of stress on the individual and the organization have been well documented in recent years. There is little debate, for example, that for teams, stress is a major factor that reveals itself as diminished performance and increased injuries.

One of the major stressors for teams and organizations is relentless pressure to deliver results through higher and higher levels of performance. Many organizations offer stress management seminars in hopes of raising awareness about the effects of stress and providing simple coping mechanisms. However, research on high performance in sports and the military has shown the ability to handle oneself in high pressure and demanding situations is less about the stressors and more about the individual's response to them. The solution lies in a more systematic and integrated approach to providing the necessary tools for actually thriving under pressure, not just surviving. We couple traditional stress management techniques with innovative uses of the most recent sensory feedback technologies to develop the ability to manage stress and energy levels. We agree with John Eliot who points out in his book Overachievement that exceptional performances are not about being relaxed. They are about being energized and excited and impassioned but always very much in control. Understanding how stress works from a neurophysiological perspective; having means at your disposal for altering its effects; and receiving quality, hi-tech feedback on how you are doing are powerful tools for learning how to thrive in pressure situations and for living your life.

Attention Control

In their insightful book *The Attention Economy*, Thomas Davenport and John Beck discuss how in today's attention economy "the new scarcest resource isn't ideas or talent, but attention itself." The demand for our attention in modern society is unparalleled in both scope and intensity.

Yet the way in which we attend has not significantly changed over time. We still primarily learn to attend to the right things at the right time through trial and error and, if fortunate, through good coaching by parents, teachers, coaches, etc. Through this method, we learn what is useful for our attention and what is not as we encounter new situations. However, given today's stimulus-rich environment, with many things competing for our attention, this is not the most efficient and effective way to learn to attend. The resultant attention deficit threatens to seriously cripple the athlete. We have provided athletes and others with a more innovative and scientific approach to addressing this attention challenge. Our attention-control training combines a simple but robust framework for understanding how attention works, a means for navigating that framework, and new brainwave (EEG) technology that provides accurate feedback about how one is paying attention—the key to improving focus and concentration directly.

Visualization

Achieving a really challenging goal is to see it already accomplished. Imagery, commonly referred to as visualization, is a powerful tool for doing exactly that. It involves using all the senses to create or recreate an experience in the mind. Everyone has an inherent capability but how well it is developed is a function of his or her developmental experiences. We all use imagery in one form or another all the time. We differ, however, in its sophistication and effectiveness. Some visualize very effectively with no formal training while most do so only after systematic training and practice of the skill. How well we do it is a function of our developmental experiences. The early and consistent use of imagination in play and work helps build the brain “muscles” for visualizing. Imagery maximizes potential for performance by helping to develop greater confidence, energy, concentration, and feelings of success.

In our five-point Peak Performance Model, visualization and imagery are developed as a specific peak performance competency as well as an integrating mechanism. The first step is assessing how well an individual’s visualization skill has developed. We have discovered through biofeedback and neurofeedback instrumentation that high-quality visualization is characterized by a deep physiological and mental coherence coupled with an optimal level of alertness and concentration. The power of imagery comes from the confidence gained by seeing and feeling successful performance in the mind before it actually happens. The common description of this experience is “I have been here before.”

Reaching Your Full Potential: Learn to Achieve Peak Performance

Achieving sustained high performance in today’s competitive and pressure-filled sports environment can be a very daunting task. Traditional solutions for meeting these challenges have not produced the desired results in performance improvement and competitive success. These methods have typically focused on the more peripheral issues and have not addressed the heart of the challenge, which is how to fundamentally change the manner by which people approach their own performance and tap into their full potential.

The military has joined the sports world in demonstrating the effectiveness of such programs via the U.S. Military Academy’s Center for Enhanced Performance. Elite athletes, of course, have demonstrated for decades the relationship between their success or failure and their mental training and preparation. We are combining the best results from the military, athletic, and business experiences to produce a state-of-the-art training program. Sustaining exceptional performance levels can only be accomplished through deliberate and systematic training in those peak performance competencies that most directly impact what we think, say, and do in ways that unleash our capabilities and full potential in any performance situation. It requires the honesty to admit that we do not know everything coupled with a willingness to learn and change. If you do what you have always done, you'll get what you have always gotten.

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Mind/Body Control in Sport: Learned Self-Regulation Chapter 5

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Abstract

Learned self-regulation (LSR) is a term for scientifically based skills that are effective in reducing stress, increasing relaxation, and enhancing performance. When performed, LSR skills are typically deep (approximately 20–30 minutes), for initial learning, recovery from stress, illness, injury, and fatigue, or brief (seconds), for use in performance situations, interruption of nonproductive behavior, lowering body responses, and refocusing the mind. The LSR skills in this chapter have been refined across 30 years by four different instructors in four different environments. Long, slow, and low breathing has been the most popular and effective skill for assisting athletes in the performance field and typically leads to increased heart rate variability (HRV). Muscle awareness training is then incorporated with breathing, for relevance to improving flexibility, smoothness, and speed of movement. Attentional focus and, in some cases, temperature increases or electrodermal decreases are practiced. As with all skills, LSR is first learned in a non-stress situation, incorporated with the sport skills in the actual setting, and finally practiced in the competitive environment and critical situations.

Chapter Outline

I. Learned Self-Regulation?

   a) How LSR is related to enhancing performance
   b) Signs of stress
   c) Training LSR skills

II. II. Two Major Types of LSR: Deep versus Brief

III. III. Deep Learned Self-Regulation Techniques

   a) Effective breathing
   b) Controlling muscles
   c) Enhancing blood flow

IV. Brief Learned Self-Regulation Techniques

   a) Breathing
   b) Brief muscle awareness and training—Quick releases
   c) Ahhsome
   d) Putting it all into practice

V. Summary/References

This chapter is adapted from the copyrighted 2004 CD *Owner's Manual for Self-Regulation of Your Brain and Body* ,V. E. Wilson & M. Cummings, YSAM Inc., Toronto.

The ability of the body/mind[1] to operate without conscious thought is obvious. One does not have to constantly tell the lungs to expand and contract to move air in and out of the body or the heart to beat to move blood around the body. The body/mind has built-in mechanisms to not only keep the body operating without us paying attention, but to do so efficiently. Cannon (1963) called this ability of the body/mind to be aware of its own condition and operate efficiently "the wisdom of the body." Regrettably, we develop bad habits or allow stress to interfere with this natural ability, which results in health problems or poor performance. Thus, we need to unlearn our bad habits or relearn how to return the body/mind back to the most efficient operating states (homeostasis).

Learned Self-Regulation (LSR)

Learned self-regulation involves the skills of being aware of mind and body states, choosing to lower or increase mental and emotional activation, and changing attention and focus as needed. It encompasses the ability to relax, to energize, to manage stress, to fine tune performance, and to enhance deep recovery or return to homeostasis. The premise of this chapter is that LSR is a skill that most individuals can learn if properly instructed. LSR is neither magical nor mystical nor requires a special mindset or philosophy or location or instructor. Rather, LSR skills are skills—just as learning how to ride a bike or drive a car are skills—and are based on scientific principles of how the mind and body operate. If incorporated into the athlete's sport practice and lifestyle, they will provide benefits to health and performance.

[1] The term "mind/body" or "body/mind" is used throughout the chapter to signify the equally important relationship between the two. What affects one, affects the other. Based on Gary Schwartz's pioneering theories of health, we have coined the word "Cogsmotions" to mean thoughts, feelings, and bodily reactions are all one and the same. You cannot have a thought or a feeling or an action without affecting the other.

How LSR is Related to Enhancing Performance

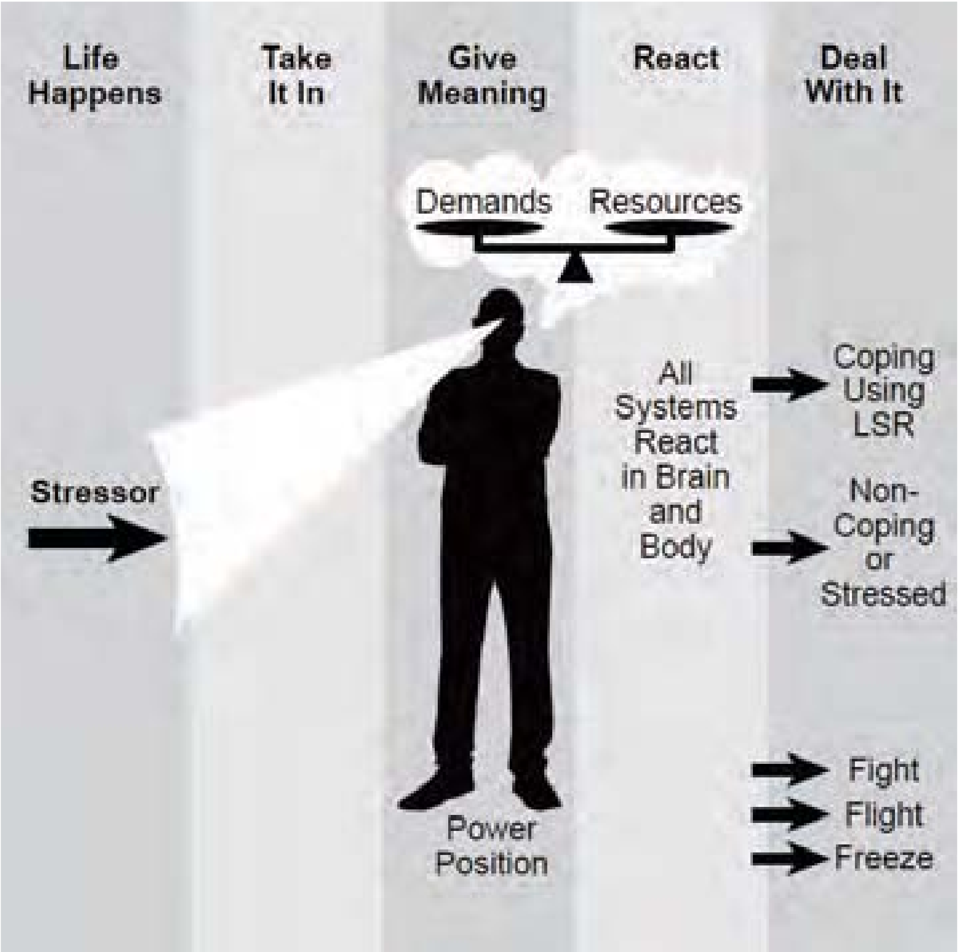
It is proposed by coaches and elite athletes that the ideal performance state after an athlete has once learned the skills is to not think, but merely let the pre-learned performance unfold. While ideal, this is not the normal state for most performances, nor does record-breaking performance require the ideal state. For most athletes for much of the time, they need to have some awareness of how their mind/body are responding—at least enough awareness to know when a system is not operating properly. This allows the athlete the choice of what to change and how to change it, which is essential during extremely stressful times.

Research has shown that athletes actually create a lot of their stress, which often interferes with their performance. In one sense, athletes are capable of being their own worst enemy. The good news, however, is that the very power that our brains have to create negative consequences in stressful situations can also be used to reduce or even eliminate them. The first step toward changing any thought or body reaction that detracts from performance is first to become aware of the problem that needs to be changed. Improved self-awareness can lead to greater self-control. As the athlete develops improved self-control over his mind and body, he will become more self-confident. Greater self-confidence is a known key factor contributing to both enhanced health and performance.

Figure 5.1: Interaction between self-awareness, self-control, self-confidence, and enhanced performance.

A simple model of how one perceives and reacts to events is presented in figure 5.2. This model will be used to explain how your brain and body work in order to use them more responsibly.

Figure 5.2 Coping and stress model



Life happens, and the athlete must take this information in through the senses at both a conscious and unconscious level. The athlete reacts to those situations based upon meaning he gives them, how he relates this situation to past similar situations, and what he imagines might happen in the future. The meaning of a situation or the demands placed on the athlete in a given situation is compared with his assessment of his ability or resources for dealing with that situation. If he perceives that his resources (R) are greater than the stressor demands (D), he will not disregulate or become unduly stressed. When he views the demands (D) as greater than his resources (R), he will shift out of balance and become stressed or disregulated. For example, a black-belt martial arts instructor who has more resources (R) will react differently compared to an average person dealing with a confrontational situation (D).

Athletes deal with stressors by using some variation of avoidance (flight), confrontation (fight), or both of these at the same time resulting in a freeze response. These responses have become part of our neurological wiring through the evolution of dealing with life-threatening situations, such as hungry lions, but are no longer effective for most of the demands of today's society. For example, a flight response in sport might result in avoiding a tactic because the athlete wants to play it safe—such as not going into the corner when playing hockey or faking an injury or illness to avoid playing. A fight response might be expressed by needlessly changing tactics when the probabilities of success are low, but the athlete wants to do something now or perhaps by aggressively arguing with the officials about a call that goes against him. Finally, a freeze response is what many athletes call "deer in the headlights" or the inability to think or move properly as they are overwhelmed by stress. For example, an athlete may become indecisive before committing to a strategy for defensive coverage in football. In fact, if any of these evolutionary reactions are called upon, they can become habits, which not only can impair performance, but can create dis-ease (discomfort) and, if serious enough, may lead to disease (breakdown in one or more systems in the body).

Have you ever overreacted to some minor event? A coach may criticize a minor strategy choice, and the athlete suddenly breaks down in tears or blows up and throws the racquet. One comment may have set off an accumulation of frustrations/anger from a previous pattern of dispute with the coach or with a parent or partner. Some theories suggest every life experience is stored and organized by the brain at an unconscious level. The athlete's reaction to a present situation might be strongly affected by an event that happened in childhood. Figure 5.3 illustrates the accumulation of stressful events and their impact on performance functioning.

Figure 5.3: Emotional chains triggered by past events

Past events that are connected with a particularly uncomfortable emotion such as fear from a loss at an important competition can be stored and organized in emotional chains resulting in accumulated emotional baggage. A present event can trigger one of these chains, causing an emotional reaction that is much more intense than the present situation warrants.

Once the athlete acquires learned self-regulation skills, it is expected that some unloading of emotional tension from past events will occur. However, if the LSR skills do not minimize overreactions after a reasonable period, the athlete will probably need to determine if and how past emotional baggage is interfering with performance and life. It is usually best to do this with a sport psychologist or other mental health professional.

The skills in this chapter will directly impact the athlete's control over the systems of the body, such as muscles and blood flow, and indirectly by teaching the brain to operate more effectively (i.e., proper intentions, images, or self talk). These LSR-based approaches work because there is no significant division between the mind and body. To demonstrate, try this exercise to understand how powerful the pictures we make in our minds can be.

Exercise

Give yourself a moment to imagine taking a cool, ripe, juicy lemon out of your refrigerator. As you know, a fully ripened lemon is that much juicier with a stronger lemon smell and taste. Feel the cool moistness of the condensation forming on the lemon as you hold it in your hand. Now imagine taking a knife and cutting the lemon in half, watching the juice drip down the side. Now, cut the lemon into quarters and take a cool, moist piece in your fingertips, noting the beads of lemon juice glistening in the light on its surface. You might smell the fresh lemon scent as you place it between your teeth and bite down, feeling the cool, tart juice squirt throughout the insides of your mouth. Do you notice any changes in your mouth? Does your mouth water a little bit? Are you puckering a little? Now where is the lemon? The lemon is only in your mind, but if you imagined it vividly enough, your body probably responded as if it was actually in your mouth.

Signs of Stress

The effects of stress may show themselves in different ways such as in your brain, body, behavior, and sport performance. It is normal and healthy to have some signs of stress, but too many signs of stress, extreme stress reactions (such as migraine headaches, irritable bowel syndrome, etc.), or chronic stress are all problematic. Use the checklist in Table 5.1 to help determine your signs of stress.

Table 5.1 Signs of Stress

Place a check mark next to the stress signs that you usually experience.

Brain

______ Can’t concentrate
______ Can’t remember
______ Easily confused or distracted
______ Frequent mood swings
______ Easily overwhelmed

Body

______ Headaches
______ Upset stomach
______ Muscle aches/pains
______ Teeth grinding/RSI
______ Immune dysfunction (colds, flu, etc.)

Behavior

______ Short fuse
______ Poor performance
______ Can't sleep

_______ Hardening of the attitudes (My way or the highway)

_______ Poor diet

_______ Increased substance use

_______ Become socially isolated or emotionally distant

Performance

_______ Tight, not moving as well as usual or slower than usual

_______ Thinking too much or blanking out at times

_______ Rushing shots or skills

_______ Feeling fatigued with no reason, no energy or enthusiasm

_______ Can't stay warmed up, cold hands/feet

_______ Mind keeps going back to winning/losing, not on the present skill

Athletes typically report four to five signs of stress from the checklist above. If the symptom or sign does not affect your performance or health it can probably be ignored or tolerated. If it does interfere, then prioritize it as a goal to be worked on and mastered.

Your Performance Autograph

What are the two or three signs that you are most aware of that let you know your stress or actions are interfering with your performance at either practice or during high-level competition?

Practice Interference

____

____

What do you need to do to perform optimally at practice?

____

____

Competition Interference

____

____

What do you need to do to perform optimally during competition?

Training LSR Skills

Because our approach to teaching LSR is one of skill training, applying principles based on research in learning can often increase the athlete's speed of learning, effectiveness, and consistency of performance. The following concepts can be applied whether the athlete is training just sport technique/skills or incorporating the LSR skills with sport skills:

Intention leads attention to action: Begin each training session (LSR and daily sport practice and fitness routines) with a specified intention (see examples on intention/attention in chapter 8). Ask yourself, "What is the specific purpose of this exercise?" To develop speed, power, smoothness, etc. Specific intentions change the manner in which we respond and enhance our performance

Recency & primacy principle: Individuals tend to remember best what is presented first and last. Begin and end your session with whatever is the most important skill at that moment. For example, if shoulder tension is interfering with one's stroke or speed, then releasing the relevant muscles should be emphasized at the beginning and end of that training session. It is to be integrated throughout the daily session, but special emphasis should be highlighted at the beginning and end of that session. If eliminating negative self talk is the main focus, then that session should begin with saying appropriate cue words to properly focus attention to either positive statements or relevant tasks to be performed.

Progression of skills: Begin with very simple skills, and then progress to more difficult skills. Using the above skill examples, the athlete first learns how to contract and then properly release the majority of the muscle tension in the shoulders. Then he or she learns how to release the tension without the contraction. This is followed by building awareness of small changes in tension in the shoulders before they begin to interfere with flexibility and speed. Practicing building awareness and releasing the shoulder tension in the appropriate sport position would be next. Sufficient trials need to be correctly executed to ensure it will be there automatically when the athlete needs it. It is our experience that most athletes perform better under high-stress conditions if they have first gone through a progression.

Specificity & generalization: Once the beginning skills are understood and some learning has occurred, LSR skills should be rehearsed in the location and environment that they are to be used. For example, learn to perform LSR when off the field or court, then on the practice court, then in competitive settings when the outcome is not important, and finally practice using them in stressful competitions. A person has to learn to generalize from one sport context to another. This is also facilitated by the intent to generalize training in the actual setting. Make the LSR skill one of the goals for the upcoming practice or competition. Rate it as you would all the other goals you have set. Also, obtain outside feedback as to the effectiveness of your LSR skill. Did you remember to breathe or drop your shoulders or say your cue word? In our experience, most athletes forget to practice the moment they get into high-level competition. It has to be a priority, or it will not be practiced. If you did it, how well did it work? If it is not working, how does it need to be changed to facilitate your performance?

Variability of practice: Research suggests that practice should vary. Not only locations, but the amount of time, the types of skills, the order of the drills, etc. should be varied. In the long term, the athlete needs to be flexible and able to adjust to different situations and, thus, variable versus constant practice is recommended.

Non-judgmental attitude: Trying hard to relax can actually cause your muscles to become more tense. Think about what happens if you really try hard to hit a golf ball or try hard to go to sleep. You often get the opposite response by hitting the shot poorly or lying in bed wide-awake. Surveys of track and field athletes found that those who rated their running at 80 percent effort resulted in achieving 100 percent performance. It is important that the athlete approach the self-regulation exercises with a passive or try easy attitude. Once the athlete has learned the skill, it is often more effective to let it happen automatically. Only in simple gross movements does the so-called 110 percent effort work. True elite performance is the ability to maximize performance each time. If you do not feel like your performance is automatic, experiment with what percentage of effort provides you with your best results.

Practice with feedback is required: Like any motor skill, practicing LSR with feedback is necessary. If possible, obtain immediate feedback on how well the athlete is performing. For example, if you are practicing reducing your shoulder tension, feel the shoulders relax, and see if you are faster. Or have the coach give a rating, or use a camera, to see if the shoulder relaxation is occurring and if it is associated with faster times. If you are near a university or your sport association has someone qualified in biofeedback (see www.bcia.org for certified members), try using portable electromyography (sEMG) equipment or telemetry during practice and competition.

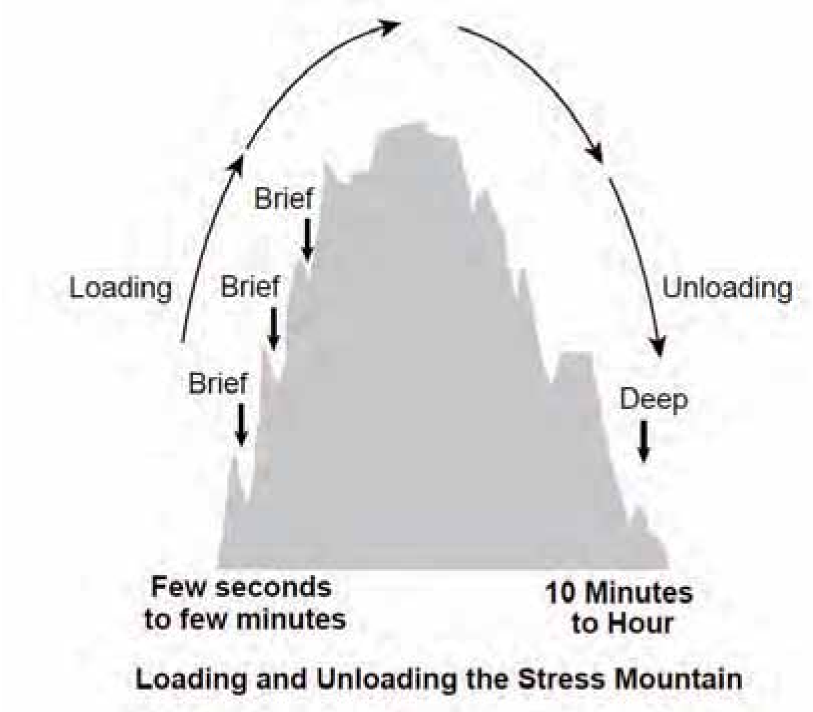
Amount of practice: After four weeks of practice (8–10 sessions), most individuals report noticeable changes in their awareness and control of their brain, body, and behavior. It takes much longer to be able to make the skills automatic. Think about how much time and how many trials you have completed already with your sport skills. With LSR techniques, you need to practice the skills when you do not need them, so they are there at that crucial time when you do need them.

The next section will cover the two types of LSR. We recommend doing the brief (10 seconds to one minute) LSR whenever it makes the most sense within the sport practice setting. Examples might include stoppages in action, timeouts, or before self-controlled skills such as serving in volleyball, etc. When not practicing your sport, do brief LSR 10–20 times per day when working out, in school, at home, in social settings, or in an imagery session. This is a time commitment of one minute 20 times per day for brief LSR. Deep (15–45 minutes) LSR can be done prior to going to bed to allow the body and brain to more fully relax prior to sleep and to allow the day's learning to be consolidated. As athletes become more skilled, they will often report doing Power Hour (discussed later) midday exercises for 10–15 minutes in order to maintain energy for the remainder of the day.

Two Major Types of LSR: Deep Versus Brief

A basic program for performance enhancement and health maintenance would include both brief and deep self-regulation techniques, as well as specific positive lifestyle behaviors (sleep, diet, outside activity, etc). The Stress Mountain that is shown in figure 5.4 is used to show why both brief and deep self-regulation techniques are used to manage stress build-up throughout the day.

Figure 5.4 The Stress Mountain



Stress levels grow throughout the day as you **load** or accumulate small amounts of stress in the same way as you would climb a mountain, step by step. If you stop frequently for small rests, as with the brief self-regulation techniques, the rate of stress build-up slows, and there is an element of a small recovery. As you move higher on the Stress Mountain, the air becomes thinner and both your health and performance can be impaired. The brief LSR techniques are used frequently during the day as they take very little time (10 seconds to three minutes) and can be performed anywhere without special preparation to lessen the mountain of stress that has to be unloaded that night.

At the end of the day, ideally, you unload the normal stresses of having been active all day. This is often accomplished during sleep; however, not everyone totally unloads during sleep. It is possible that you can load up more stress than can be unloaded at night, and then the use of a deep self-regulation technique is highly recommended. This is especially true for periods when a stress overload in the brain or body is being experienced (during training periods of high physical load or periods of intense competition) or the quantity of sleep is less than needed or the quality of sleep is poor. It is this regular lack of proper recovery from the day's stressors that produce system breakdown or stress-related disorders. A deep technique which facilitates the quality of sleep can be performed 20–40 minutes before sleep, or it can be performed during the day. As you become experienced with deep LSR, some athletes note regeneration in 12–20 minutes.

While the particular technique may work on the same system (e.g., muscles) for both brief and deep purposes, you cannot expect the same feelings of rejuvenation from a brief technique as with a deep technique. It is perhaps best to use the brief techniques as often as possible to keep from loading as much stress and therefore slowing your ascent up the Stress Mountain. The deep self-regulation techniques can then be used to finish unloading the daily stress and perhaps begin to reduce any chronic buildup of stress carried over from past days or months. Lowered chronic stress levels can contribute to both enhanced health and performance levels.

In sport, most sport psychologists present only the deep LSR skills. We will present these first, as they are important to recovery/regeneration and easier to learn while in a quieter, less demanding environment. We also recommend brief LSR is learned first in a less demanding environment and then practiced within the sport setting at practice and competition. If one does not practice in the needed environment, one cannot expect the skill to work when called upon during critical moments.

If you have any medical (epilepsy, asthma, etc.) or psychological (dissociation, depression, etc.) disorders you should discuss with your health professional the advisability of whether and how to practice deep learned self-regulation techniques.

Deep Learned Self-Regulation Techniques

The basic skills for achieving deep LSR include controlling breathing, muscles, blood flow, and attention, which we combine in one technique called Power Hour. Once learned, Power Hour takes about 12–20 minutes to achieve a deep state of relaxation where most of the systems of the body have returned to their normal homeostatic and healing levels.

Effective Breathing

Why Is It Important?

Proper breathing probably has the greatest impact, is the most widely used, and is the best lifelong LSR skill for sport and life. The inability to breathe properly is the basis for unnecessary fatigue, choking, failure to recover, busy brain or paralysis by analysis, and changes in the athlete's attentional states. Proper breathing is also necessary to maintain optimal health, particularly in the cardiorespiratory systems.

If there is one skill that, when mastered, has the greatest positive impact on the athlete's ability to perform, it is breathing, more specifically, maintaining good breathing to either slow or activate the mind and body.

Objectives

1. Practice healthy breathing:

- Maintaining a healthy rate of breathing of about six breaths per minute (brpm, especially for static tasks, e.g., free-throw shots or putting in golf) without periods of breath holding.
- Using the diaphragm muscle during inhalation.
- Maintaining at least an equal ratio of time for inhalation and exhalation or if relaxation is desired, more time for exhalation.
- Coordinating your heart rate and respiration (see chapter 6 on HRV/respiratory sinus arrhythmia).

2. Avoid unhealthy breathing:

- Holding your breath often or unnecessarily.
- Using chest and upper back muscles instead of the diaphragm muscle.
- Forcing air in or out rather than letting the air naturally move.
- Breathing more rapidly than necessary, especially at rest.

How to Do It

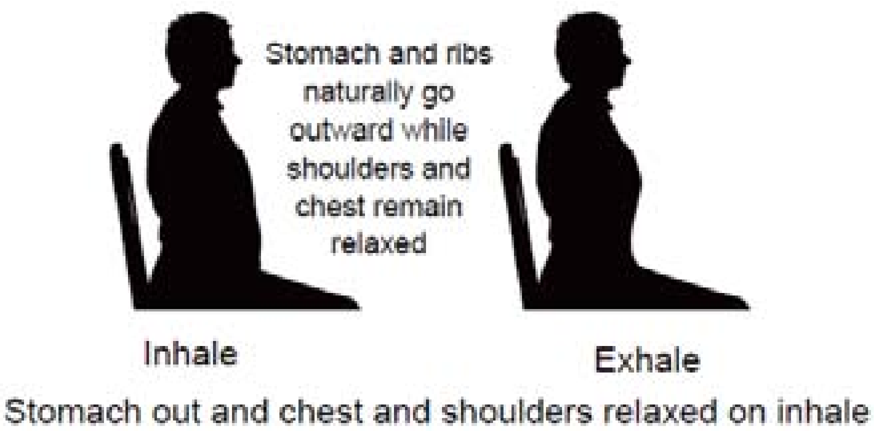
1. Relaxed breathing

- Is when you make the exhalation longer than the inhalation to slow down the bodily systems (such as heart rate) and calm a racing mind.
- Is approximately six brpm at rest with approximately four counts in and six counts out.

2. Brief diaphragmatic (deep) breathing

The diaphragm muscle is what most effectively controls inhalation and exhalation. You can determine if you are using your diaphragm by checking for proper movement in the upper abdominal region (see figure 5.5).

Figure 5.5: Example of using the diaphragm muscle to facilitate proper breathing



Using your chest and upper back muscles while breathing can cause muscle tension in shoulders. This can cause reduced flexibility and even slower foot speed, muscle fatigue, muscle tension headaches, and feelings of anxiety.

3. Nose or Mouth Breathing

It is important to breathe in through the nose when possible as the air taken in is moisturized, cooled, and cleaned in this manner. You may exhale through the nose or by slightly parting your lips as you let the air out smoothly. Keeping the lips and teeth apart promotes relaxation of the jaw muscles.

When under heavy exercise, the body will automatically call upon the mouth to open to bring in more air and the chest and upper back muscles to be used as needed. If you focus on keeping the shoulders relaxed and maintaining good posture, then breathing will occur at its most optimum level during these periods of heavy exertion.

Stop the breathing assessment and training if you feel dizzy, breathless, or feel any other negative effects. To lessen dizziness or negative effects, only practice the breathing techniques for two or three cycles (a breath in and out is one cycle) until you become skilled; then you can practice for progressively longer periods using more cycles.

Deep diaphragmatic breathing for long time periods is not recommended.

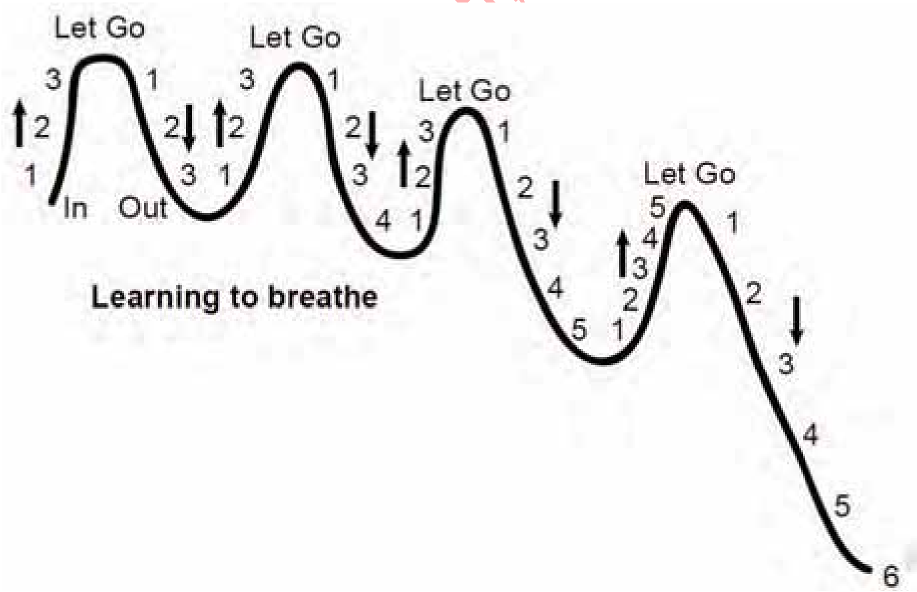
It takes years of practice to properly achieve 20–30 minutes or more of the deep breathing that is often reported in yoga or martial arts texts. However, becoming proficient at deep breathing does not guarantee your muscles will be relaxed and your mind will not race. That is why we recommend learning how to control multiple systems of the mind/body.

Performing 10–20 seconds of slow, deep breathing with longer exhalations several times a day probably holds greater benefit for sport performance than lying down for 20 minutes to just breathe. Try doing at least one cycle of slow breathing per hour when away from the practice arena and during every opportunity of downtime in sport practice. For example, before serving or hitting a ball, try doing one cycle of deep breathing progressing in cycles at time outs. During stoppages in play, try doing a deep, slow breath while dropping your shoulders as you exhale. The goal is to over-learn the proper way to breathe, so when you need it during very stressful times, it will be more automatic and done properly.

Breathing Exercises for Relaxation

- Slow down your breathing rate. Gradually slow your breathing to 10–12 breaths per minute.
- Roller coaster or wave breathing (see figure 5.6). Slow down your breathing rate by practicing breathing at about six cycles per minute (about six breaths/minute). This is about four counts in, slight natural pause for a count, then four or five counts out. This takes about 10 seconds. It is like going up a roller coaster, pausing for a moment before letting go, and then going down, wherein, there will be a longer pause.

Figure 5.6: Roller Coaster or Wave Breathing

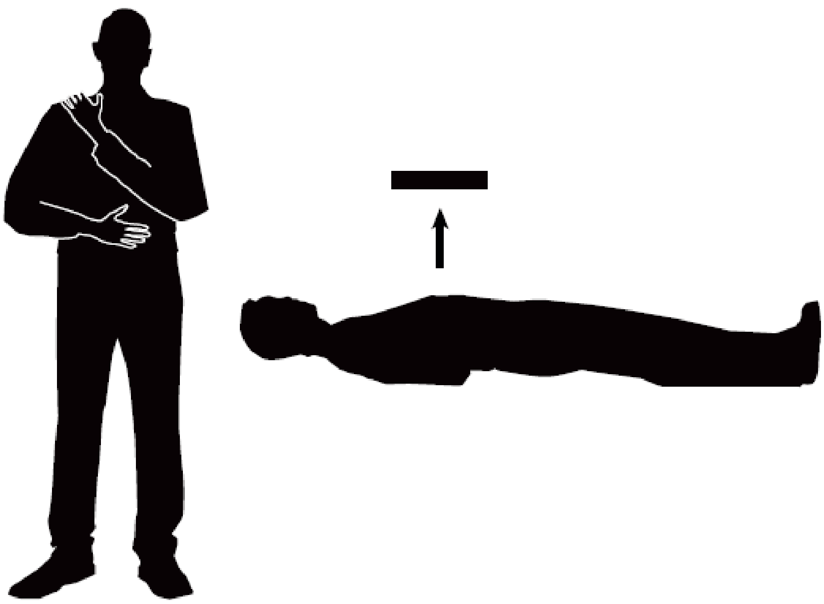


As a beginner, three counts in and three out is natural. As you become more skilled, during relatively quiet times, progress to about four seconds in and six seconds out. The pause at the end of the inhalation will be a natural pause, and the pause at the end of the exhalation may be longer.

Go to www.BFE.org to download a pacing device that reminds you to practice and visually guides you to a respiration rate of approximately six breaths/minute breathing practice.

Practice breathing with one hand on your upper abdominal region and the other hand on the opposite shoulder, or you can place a heavy book on the stomach area when lying down. Try to produce most of the movement in the abdominal region with very little movement across the chest and little or none under the upper hand (see figure 5.7). If you are having difficulty feeling exactly where your breathing originates, put a book on your abdomen, and see if it moves up when you inhale. This is a form of weight lifting for the diaphragm. If you are having difficulty breathing and are using a lot of chest movement, put a heavy book or rock on your chest and keep it motionless while you breathe with the diaphragm moving only your upper abdominal region. The shoulders should stay down throughout the exercise. Remove the heavy object and notice how you can breathe with a greater range of motion.

Figure 5.7: Example of proper breathing technique



Temperature-focused breathing: Inhale air through your nose, allowing yourself to feel the cool sensations of the oxygen and energy as it moves through your nostrils down into your lungs. Exhale through your mouth, feeling the warmth and moisture of the air as it passes over your tongue and lips and as it hangs around and out in front of the lips. Continue this breathing pattern, fully feeling and being aware of the temperature sensations.

Biofeedback for breath training: If a certified biofeedback practitioner is available, it is advantageous to have your breathing rate and quality assessed using a respiration strain gauge, shoulder electromyography, and a heart rate monitor. This is especially important as we find many of the athletes who choke or consistently fail to achieve their potential tend to have breathing irregularities—unknown breath holding, shoulder involvement, or hyperventilation. Efficient breathing is easily assessed with the aforementioned equipment, and it only takes one or two sessions of training for athletes to learn good breathing techniques.

Breathing in Special Sport Situations

Swimming

Swimmers need to time their breathing to the speed of their stroke. If you practice slow breathing for anxiety control on land, it will probably slow your speed of swimming in the water. You need to practice switching from the slow, deep breathing on the deck to the correct ratio of breathing in the water. Counting as you stroke through the water helps maintain the ratio for some swimmers.

Endurance Training: Running, Swimming, Skiing, Etc.

During long-distance training, athletes can time their inhalation/exhalation speed to the pace and pattern of their foot movement. When you begin to fatigue, however, your breathing ratio may change. You can try to maintain your breathing, but in most cases, a runner is more successful at maintaining proper mechanics by relaxing the jaw and shoulders, maintaining proper posture, and keeping the arms pumping to the appropriate place. A simple cue for shoulder relaxation when running is to keep the elbows as low as possible during the arm swing. Remember; when you are tired or anxious, keep the jaw, shoulders, and hands relaxed and let the breathing occur on its own.

Boxing and Contact Sports

Most boxers adjust their breathing such that they cease breathing and tighten the abdominal muscles when they are about to be hit. Short-term holding of the breath is neither dangerous nor interferes with performance. It is when it becomes a habit, and the boxer unnecessarily holds his breath for long periods of time, which changes oxygen and carbon dioxide levels, that it becomes detrimental to both health and performance. To facilitate recovery, the boxer or wrestler can do relaxed breathing while walking to the corner or if there is a timeout for injury. Because boxers typically have damage to the nose, it is understandable that they mouth breathe, and no attempt is made to include breathing through the nose during activity.

When there are breaks in the action, the boxer should make sure to take a deep breath and exhale longer than he inhales. In our experience, boxers develop a tendency to hold their breath when it is not required such that they have inefficient breathing throughout the day away from the sport. They must become more sensitized to this altered breathing pattern and then practice returning to normal breathing.

In sports such as hockey that utilize short and intense playing periods, it is helpful to use diaphragmatic breathing as soon as possible upon returning to the bench to recover faster for the next shift. There are also moments in the game, such as timeouts, fouls, etc., when the athlete can reset the mind/body to build up the energy reserves for the end of the game.

Controlling Muscles

Why Is It Important?

Your muscles allow you to move and put into action ideas and plans created in your brain. Your muscles generally make up most of your body weight, and there are more than 500 muscles in the body, so inefficient use of even a small percentage of these muscles wastes a lot of energy and brings on premature fatigue.

Excessive muscle tension can lead to:

- Unnecessary fatigue.
- Muscle pain, tightness.
- Poor flexibility or loss of coordination.
- Poor motor skills.
- Increased incidence of injuries.
- Tension headaches, grinding of teeth, stuttering or stammering while speaking.
- Difficulty sitting still, muscle twitches.

Objectives

- Athletes should be aware of how their muscles feel in order to achieve effective control over them. By systematically contracting and then releasing tension in the body, it is possible to learn the degrees of variation in tension and relaxation in the muscles. You can then progress in your awareness, so you are able to let go of muscle tension without having to first contract the muscle.
- To be able to use the muscles to quickly activate the mind/body to heightened states of arousal/activation.

How to Do It

Muscle Awareness Training® (MAT) is a deep relaxation technique based on Jacobson's Progressive Muscle Training but with some changes that reflect newer psychophysiological concepts and research. (See brief Muscle Awareness and Training (MAT)—quick releases later in the chapter.)

If you have difficulty with spasms or pain:

- Do not contract that muscle group.
- Just contract the muscle a little bit.
- Don't hold the tension for more than a few seconds.

Our clinical experience has shown that most individuals are reasonably accurate in estimating percentages of contractions whether measured in force (dynamometer) or number of muscle action potentials (sEMG). The entire range of muscle contraction awareness should lead to a better awareness when changes do occur. If the athlete only practices a strong contraction and a zero or a full release of that contraction, it is less probable that he will know when a 5 or 10 percent contraction is occurring during the sport. But that small percentage may make a large difference in being first or fifth or making or missing a shot and even managing fatigue levels. Find the percentage of tension that represents what you tend to hold when performing under stress (it probably is not 50 percent, but more likely 5–10 percent), and in the relevant muscle group (shoulders, hands, etc.), and practice going to that level and then releasing that level. You are developing awareness for when the muscle tension begins to creep up and not waiting until you have pain in your neck or cannot react as quickly as you wish.

Muscles generally work in pairs, agonist and antagonist, or in groups of related muscles. It often is the tension in the antagonistic muscle that results in performance decrements. However, few performers are trained to become aware of these muscles. If you are in a fine motor sport where small movements are important, then it is important to become aware of and then practice releasing muscle tension in both the agonist and antagonist. For example, in throwing a ball, if there is tension in the triceps, then the aim of the ball and its speed will be affected.

If the purpose of MAT is awareness, then the contraction should be held at a sub-maximal level and for a very brief time. Muscles begin to fatigue under high loads in a few seconds. Thus, the maximal contraction of muscles or holding sub-maximal contractions for long periods of time (10–30 seconds) produces fatigue and restriction of blood flow, not awareness of muscle sensations. Most commercial relaxation tapes encourage fatigue and emphasize feelings of recirculating blood, not muscle awareness. This awareness is critical for sport performance.

If the athlete merely wants to totally release muscle tension, such as prior to going to sleep or when highly anxious, he may find greater benefit in doing a strong contraction and then holding it for 20–30 seconds followed by an initial release and then releasing a second time. This causes fatigue and concomitantly more muscle relaxation. This does not fine tune muscles but rather unloads built-up tension. With practice, the athlete can become aware and then release without first contracting. This is an individual preference, and the athlete should experiment with the various techniques to see which one helps the most.

The order of presentation of muscle groups may affect the speed and effectiveness of acquiring awareness of muscle tension. The amount of area in the motor cortex in the brain required for the control of each muscle group is largest for the hands and face. Thus, beginning with tensing and releasing the hands and fingers is easier for athletes to notice the difference between various degrees or amounts of contraction. The ending muscle group is the tongue or lips as once again the effect should be large. In sport, it is often the hands or the face that can be contracted and relaxed without affecting sport performance. This feeling of letting go in these muscle groups often lowers anxiety in some athletes.

The most important failure in sport is typically when the muscles become too tight, and the athlete is not aware of the change, which typically occurs in the shoulders. Athletes need to practice recognizing small changes in muscle tension (and the ability to release it) during practice and competition.

Electromyography Biofeedback

The use of portable or telemetry surface electromyography (sEMG) assesses muscle action potentials, e.g., tension, is now sufficiently inexpensive such that clubs, teams, organizations, or individuals may purchase them or, alternatively, can find a practitioner that can provide these services.

For sports where fine motor skills are critical, it is effective and relatively easy to teach an athlete how to locate and let go of unnecessary muscle tension while performing. Within the office, most athletes can learn to release muscle tension or fine tune it to an optimum level in the first session. Once this is accomplished, the athlete should move to the practice setting and perform the skill with the correct muscle activation level. The next step is to have the athlete practice maintaining the ideal muscle tension level while performing under pressure during practice. Finally, the athlete should apply the skill in competitions although some sports do not allow monitoring during competitions.

For sports where foot speed is important, placing sEMG on the shoulders can show the athlete how the tightness there actually slows down the movement time of the feet. For distance sports, set the muscle tension threshold such that the sound indicator does not activate unless the athlete unnecessarily raises his shoulders, and then watch how quickly he learns to release unnecessary tension.

Enhancing Blood Flow

Why Is It Important?

Arterioles are blood vessels and are like elastic straws; they can expand or contract like a balloon. By letting go mentally or emotionally, the athlete will have a greater chance of controlling the autonomic nervous system responses that allow the arterioles to expand, which brings more blood to the muscles and organs. Because it is controlled on a subconscious level, the athlete needs to keep practicing by letting go and letting it happen. If you put your hands to your face, you may notice that your hands become warm while letting go. With practice and feedback, you can quickly learn the difference between good blood flow and poor blood flow.

Good blood flow:

- Brings in nutrients and removes waste products throughout the body.
- Is responsible for healing.
- Assists in rejuvenating the body during sleep.

Poor blood flow:

- Is related to migraine headaches, cold hands.
- May indicate emotional tension.
- May impede performance.

- Lessens recovery in muscles.
- Slows healing from injury.

Objective:

- Recovery & regeneration: Learn to fully open the arterioles to produce good blood flow to bring in nutrients and take away waste products.

How to Do It

Pay attention to whatever sensations are present as you repeat the words let go. There is no single feeling or sensation that is correct; whatever you feel is OK. Remember to try easy. Some athletes find it helpful to look at anatomy texts to actually see the location of arterioles that supply blood throughout their body. This can enhance the athlete's experience in sensing and feeling blood vessel dilation.

- Imagine (see, feel, or just give permission) the arterioles in the arms opening up (see figure 5.8) and blood flowing more freely from the top of the arms, forearms, hands, and fingers. Let go, and let the blood flow to your fingertips. It will automatically be returned.

Figure 5.8: Cross-section of an arteriole opening up

- Imagine letting go of the arterioles in the trunk, even though you usually cannot feel them. Let the blood flow to the chest and upper back, through your middle back, abdominals, and down into the hips. Let go, and let it flow.
- Imagine blood flowing more easily through the muscles of the upper legs, down through the knees, the calf muscles, ankles,

feet, and toes. The blood will automatically be returned. Let go, and let it flow.

Exercise: Beach Imagery

Imagine lying on a beautiful sandy beach, perhaps wiggling in and feeling the warmth of the sand on your back. Hear the quiet lap of the waves in the background, and smell the salty air. Feel the warmth of the sun shining right inside your arms and legs. Let the warmth penetrate through your skin into your bones. Let the sun warm your body from the top of your head down through to your toes. Your forehead remains pleasantly cool. As you allow your body to sink further into the sand, you now feel one with the sand.

Modified Autogenic Standard Exercises: Heavy and Warm

Modifications of Luthe's (1969) Autogenic Standard Exercises are designed to control attention and allow the body to self-generate the homeostatic state. While it was not developed as a relaxation technique, a common side benefit is often increased blood flow. Remember to allow, not direct, the following phrases. Some people benefit more if they see, say, or feel the statements. Remember, the main objective is to let go and allow the body to self-regulate. Some individuals prefer to have these phrases on an audio tape or CD and to listen to them instead of reading them.

Exercise: Heavy and Warm

1. Find, feel both arms. Repeat silently and slowly to yourself in a relaxed, nonjudgmental manner a phrase such as "My arms are pleasantly warm." It should take about as long to say as it would to write it on a piece of paper (about 10 seconds). Repeat, "My arms are pleasantly warm" six to eight times.
2. Find, feel both legs. Repeat, "My legs are pleasantly warm" six to eight times. Find both arms and legs, equally and simultaneously. Repeat, "My arms and legs are pleasantly warm" six to eight times.
3. Find, feel both arms. Repeat, "My arms are heavy" six to eight times. Find both legs. Repeat, "My legs are heavy" six to eight times.

4. Feel both arms and legs, equally and simultaneously. Repeat, "My arms and legs are heavy" six to eight times. Feel both arms and legs equally and simultaneously. Repeat, "My arms and legs are heavy and warm" six to eight times.

Remember, the purpose of Autogenic Standard Exercises is to control attention, and even if the beneficial side effects, such as becoming more warm or feeling heavy, do not occur, there are positive changes occurring in the brain.

Temperature Biofeedback

Inexpensive thermometers, which measure to a 10th of a degree and are averaged across 8–10 seconds, are available in most electronics stores. These thermometers are sufficient to indirectly measure the change in blood flow to the hands or an injured muscle area. Typically, half of our clients will be able to increase the temperature in their hands within the first relaxation session. One quarter will not change temperature, and one quarter will actually decrease in hand temperature (these are usually the ones who try too hard).

The small hand thermometers that measure two-degree changes are not sufficient for training. They may be helpful for indicating when an athlete has cold hands, but for most athletes, it is too difficult to move hand temperature two degrees, and they become discouraged and quit.

In the past, we have used the thermometers with athletes with injured knees, shoulders, and ankles as well as a burn and were able to increase blood flow to that specific area. It should be noted that it is much harder to increase blood flow to the feet and legs than the hands or arms.

Brief Learned Self-Regulation Techniques

Brief LSR techniques can provide a small degree of relaxation and can fine-tune the body's systems to help maintain an optimal level of arousal for good performance. These techniques should be incorporated into your sport sessions as well as your daily activities. The more trials you do each day, the more likely they will become automatic. We recommend practicing brief LSR techniques about 20 times per day.

We have developed a brief skill, called "ahhsome," that takes about 10 seconds to perform, and we recommend doing it twice if possible. The exact skill will be presented at the end of this section. Ahhsome controls several systems in a short period: breathing, blood flow, muscle tension, and attention. For individuals who have difficulty relaxing, it is probably best to learn and then practice each of the components of ahhsome before doing the entire skill. If you have no difficulty in quickly relaxing most of the systems, you may wish to skip right to the skill of ahhsome.

Breathing

1. Maintain slow breathing. Make sure you have an in/out rhythm that matches your exercise level. Exhale on work phases (i.e., when throwing a pitch in baseball).
2. Roller coaster (see Figure 5.6). Make a pause at the end of each inhalation and exhalation like the top and bottom of a roller coaster. The breath should be natural and effortless.
3. Make the number of counts breathing out twice as many as the number of counts breathing in. When exercising at a high intensity, make sure you fully exhale even if you cannot do twice as many counts out.

Brief Muscle Awareness and Training (MAT)—Quick Releases

MAT can be used to become more aware of the various degrees of tension held in different muscle groups and to release excessive tension.

- Shoulder release: Gently pull your shoulders halfway up to your ears and pull your shoulder blades together. Also, pull your head back as if a string were on the middle of your neck (chin stays parallel to the floor). Stay in this position 5–10 seconds. Then, let go of the tension in the neck, shoulders, and upper back and notice how much more comfortable it is when you release muscle tension and allow the muscles to lengthen and relax. Repeat the thought of letting go but in this order: let go of the jaw muscle and smooth the facial muscles, drop the shoulders and elbows, and let the hands relax and become warm or softened.

- **Muscle scan:** Quickly scan the body for any excessive muscle tension and then mentally and consciously allow the muscles to let go of the tension. There is no scientific reason as to whether you should relax from the top of your head to your toes or vice versa. Try to do it in the same order each time. Muscle scans work best when you release tension twice (one release right after the other). This technique becomes much more effective with regular practice of deep self-regulation techniques (MAT), which create enhanced awareness of what a deeply relaxed muscle feels like.

- **Segment release:** Different body segments can be paired with numbers and then relaxed as you say the numbers to yourself. For example, #1 = arms and shoulders relax; #2 = trunk muscles from shoulders to groin relax; #3 = legs and feet relax; and #4 = face, head, and neck relax. If you have a tendency for one muscle group to tighten, such as the right arm, it can be given a number and then released. With practice, you can release the muscle quickly by repeating the number when you are in the stress of competition.

Ahhsome

The purpose of ahhsome is to relax several systems quickly, which will facilitate a faster and smoother movement response. The objective is to release tension in key muscle groups, stimulate effective breathing, enhance good blood flow, and focus attention for a brief moment. This brief quiet period is what allows the athlete to go into automatic, try easy, or 80 percent effort-100 percent performance. These states are when an athlete has a greater chance of performing well without interference.

1. Take in an easy, deep breath. As you exhale slowly, let go of the muscle tension in your jaw, shoulders, elbows, and hands.

2. As you take a second easy, deep breath, slowly exhale. Let go of tension in your jaw and shoulders. Open the arterioles and let the blood flow freely down your arms to your hands.

3. Allow your awareness to be grounded in your hands and face as you refocus with a question such as “What do I have to do here to get what I want?” or a cue word of the action that is required to perform well, such as “bend” or “bounce,” etc.

Muscle Activation or Energizing Exercises (Cortical Activation)

Figure 5.9: The motor cortex of the brain.

The picture in Figure 5.9 describes the degree to which the different parts of the body are represented in the motor cortex of the brain (the part of the brain that gives you control and awareness of your muscles). Certain areas of the body are enlarged in this picture because they have greater sensory representation in the brain. By moving and stimulating areas of the body that have large representation, it is possible to bombard the brain with sensory stimulation to quickly create a much more awake and energized state. A more relaxed state can also be created by relaxing and reducing stimulation in areas of the body that have large representation.

1. The 30-second activation/wakeup exercise:

First, notice how awake you are, the relative level of energy you are experiencing, and perhaps even notice the relative brightness of the room.

Begin by shaking, massaging, or quickly moving your fingers, hands, feet, and toes. Then progress to include simultaneously moving your face and tongue rapidly to bombard the brain with stimulation for the next 30 seconds.

Take a moment now to notice if you feel more awake or energized than you did 30 seconds ago.

2. Energizing through breathing

Do not do this exercise if you have asthma, epilepsy, or any condition that is exacerbated by hyperventilation. At any time that you feel dizzy, stop the exercise and return to six breaths/minute.

Puppy pants: The athlete can quickly increase the heart rate and energy level by hyperventilating. Care must be taken not to do it too quickly or too long, or the athlete may not be able to think properly, may become dizzy, shaky, disoriented, or feel air hunger. If this happens, the athlete should return to normal (equal counts in and out) or slow breathing (four counts in, six counts out).

For 5–15 seconds, pant quickly like a puppy while shaking the hands vigorously. You may want to hop quickly at the same time. Your heart rate will shoot up rapidly, your visual field tends to narrow, and your reaction times are improved. The reaction does not last for a long time but can offset sluggish movement and inattention.

We find this skill is most often needed during practice (or studying) when one is low in motivation or becoming tired. Experiment with how long you need to do puppy pants to feel energized without it interfering with your thoughts or performance.

3. Power punch to energize

Another quick activation exercise involves the following steps:

- Stand tall with head and eyes up.
- Take a deep breath and let your jaw and shoulders drop.
- Make a quick power move (punch the sky with clenched fists) at the same time you forcefully say a power word (OK! or YES! or YEAH!).

4. Sport power moves with puppy pants

Use a drill that is relevant to your sport if it requires short quick movements: Hopping, quick flicks, or footwork drills are examples. This drill should be performed very quickly. Then perform brief hyperventilation (puppy pants); then perform the drill again. The objective is to become as fast as possible. The puppy pants help speed up the brain. This is typically needed when motivation is low in practice or fatigue sets in during long sessions.

5. Wake-up slaps.

Slap the back of each hand (softly) and each side of your face (softly).

Putting It All into Practice

Performance Preparation Plan: P3

There are three components to the success of most individuals. First is being knowledgeable about what needs to be done to succeed. Second is to do the plan with a high level of quality each time. Third, is being prepared with a strategy for when something unexpected occurs.

Preparing for Performance P3: The Plan

Before every skill, both in practice and competition or life, the athlete should follow a predetermined relevant plan. The plan should involve the following:

Prepare: Getting to the right arousal level or readiness state for performance (breathing, muscles, heart rate, etc.).

Plan: Intention or seeing or saying cue wording that gives the outcome you want—see the ball going into the basket or cues to the process to get to that plan (snap of wrist).

Play: Letting go and letting the skill happen—play.

Practice the Plan

Time should also be set aside to react to simulated events in your sport. The athlete needs to learn to make quick judgments and react. Additionally, athletes need to trust that they have sufficiently trained their mind/body and that the speed and accuracy of the over-learned responses are typically better than on-the-spot processing. Emergency and military personnel make a living out of practicing potential situations.

A fighter pilot will practice, “What if the guns jam, the engine catches fire, etc.?”

A fireperson will practice “What if the ceiling collapses, the room explodes, etc.?”

An athlete will practice “What if ...

- I am behind in the last part of the game?”
- I am ahead in the last part of the game?”
- My equipment malfunctions?”
- My skill is not coming automatic and I am struggling?”
- I am tired, sick, in love, sore, etc.?”

It is also important that an athlete recognize it is not possible to plan for everything, so it is necessary to be prepared for the unexpected or for situations that are not predictable. Here is one example of that plan:

Preparation for the Unexpected

Short-Term Reaction

This could be using the same skills as above if the requirement is for a fast short-term reaction. Again, a coach can have athletes practice these skills by occasionally presenting a new unexpected problem and rewarding athletes for responding correctly and quickly. Typically we teach the athletes to take a deep breath and ask, "What do I have to do now?"

Long-Term Unexpected Event

There are times when an event occurs that does not require a short, fast reaction, but the event creates great discomfort or distress, which usually interferes with the entire life of the athlete. This could be a car accident of a loved one or a loss at a major competition or an injury or illness. Athletes can be assisted if they have a plan for unexpected events.

Survival: Go to as neutral a place in your mind as you can and continue doing what is necessary to survive. For example, if you lost the competition or job, take a period of time doing what is necessary. You want to obtain some time before you make a judgment or talk about what needs to be done next. Writing about your feelings or talking with another who has gone through a significant event is very beneficial (maybe it will become a movie one day). Trust that you will get through it even if you have no clue now as to how. The time period cannot be specified as it varies for each person. If you feel stuck, try to find someone who is willing to walk with you into the next stage, which is regaining perspective and moving forward.

Perspective: What do I want? What do I have to do to get it? Adjust your long-term perspective to the new information, make new arrangements, and look for new resources to help you.

Process: Get back into a routine or process that leads you toward where you want to go. This is where monitoring actual progress, especially visually, is very helpful. Keep records, etc.

Summary

Learned self-regulation skills applied in a systematic and sport-specific manner can enhance performance and health through increased self-awareness and self-control of the body and brain states. This generates greater self-confidence and better performance. The use of deep LSR skills plays an essential role in recovery and regeneration of both the athlete's body and brain to the ideal homeostatic state. Regeneration is necessary for continued health and the athlete's ability to tolerate increasing physical and mental demands.

One of the key elements for successfully applying LSR in the sport setting is to ensure the skills are over-learned in a purposeful routine (P3). This allows for better integration of brief LSR skills into the practice setting and provides more assurance that they are still available under the pressure of critical moments.

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Getting to the Heart of the Matter: Heart Rate Variability (HRV) Biofeedback (BFB) for Enhanced Performance
Chapter 6

by

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Abstract

In this chapter, we review our modern knowledge of how heart rate and breathing patterns work together to facilitate performance. In particular, we will explain in detail the recent developments of a new biofeedback modality called heart rate variability (HRV) biofeedback. Heart rate variability is a normal fluctuation in heart rate patterns that can be produced, voluntarily, by the athlete by breathing in a slow, controlled, systematic way. For example, when the athlete breathes in, his heart rate will speed up, and when he breathes out, his heart rate slows down. A fluctuating heart-rate pattern, when guided by systematic breathing techniques, is not only a sign of good physical well-being, but can produce harmony or balance in the athlete's body and mind and can maximize readiness to perform. High HRV is a sign of a healthy cardiac system and can generate calmness in the body; mindfulness; and a steady level of concentration, mood, emotional control, and improved performance.

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Introduction

A calm breath and heart is commonly associated with being under control and having mental and emotional poise during performance. On the other hand, racing heart rates have been associated with the jitters, butterflies, poor performance, hyperventilation, and other physical symptoms. High performance demands may also produce a busy mind or excessive mental chatter. In this chapter, we review our modern understanding of how heart rate and breathing patterns work together to facilitate performance. In particular, we will explain the recent developments of a new biofeedback modality called heart rate variability (HRV) biofeedback (BFB).

Several definitions that will be used within the chapter are provided below. This will be followed by a simplified understanding of the three systems in the body that are most responsible for HRV BFB. The chapter also provides an overview of HRV and performance research and the assessment and protocol phases for using HRV BFB with athletes.

Definition of Terms

Heart rate (HR): Number of complete cardiac contractions (heartbeats) per minute.

Heart rate variability (HRV): Changes in the distance between one heartbeat and the next. High HRV is a sign of good health, whereas, low HRV is associated with increased health problems and even mortality. HRV represents the differences in the interval between sequential R-waves in the electrocardiogram (EKG), summarized across time (often five minutes). HRV can also be expressed as 1) a standard deviation of the R-wave to R-wave interval; 2) the difference between the highest heart rate and the lowest heart rate (or how far it is from a person's maximal HR to minimal HR, typically in the course of one-minute tracings); and 3) a distribution of the total variation within frequency ranges (spectral analysis).

Hyperventilation (HV): Excessive breathing beyond the athlete's metabolic needs, resulting in lowered carbon dioxide (CO2) levels in the body.

Respiration rate (RR): Number of times the athlete breathes per minute.

Respiration ratio: Ratio of the amount of time it takes for the athlete to inhale and exhale during one breath.

Respiratory sinus arrhythmia (RSA): Refers to the normal slowing down of the heart when the athlete breaths out and speeding up of heart rate when the athlete breathes in (inspiration).

Resonant frequency: The frequency at which heart rate variability is at its greatest. Resonance can be obtained when the athlete achieves a calm mental state, breathes slowly using the diaphragm muscle (between four and seven breaths/minute), and eliminates excessive worry or cognitions.

Very low frequency (VLF), low frequency (LF), and high frequency (HF): The three frequency bands in the spectral analysis (spectral analysis is one method that can be used to quantify the amount of heart rate variability that exists in a given recording).

The following paragraph describes, in simple terms, how HRV training can be used with athletes (Lehrer, P. M., Vaschillo, E., & Vaschillo, B., 2000):

"Your heart goes up and down with your breathing. When you breathe in, your heart tends to go up. When you breathe out, your heart tends to go down. These changes in heart rate are called 'Respiratory Sinus Arrhythmia' or RSA. RSA triggers very powerful reflexes in the body that help to control the whole autonomic nervous system (including your heart rate, blood pressure, and breathing). We will train you to increase the size of these heart rate changes. Increasing the size of these heart rate changes will exercise these important reflexes and help them to control your body more efficiently. As a part of this treatment, we will give you information about the swings in your heart rate that accompany breathing. That will be the RSA biofeedback. You will use this information to teach yourself to increase your RSA. If you practice the technique regularly at home, you will strengthen the reflexes that regulate the autonomic nervous system. This should help you manage your health and every day stress" [and sports performance].

How Is HRV Displayed on the Computer Screen?

Before we discuss the details of HRV BFB, we need to explain some of the technical aspects involved in how HRV is determined and observed using biofeedback technology. With proper recording devices, we can observe the athlete's beat-to-beat heart rate (HR) and breath-by-breath respiration. By observing these patterns, we can see how HRV or RSA training operates to help the heart, lungs, and brain work together. This is important for athletes because good performance is most likely when these systems work together.

To avoid any confusion during our explanation of HRV training, let us refer to a few graphs that show the physiological patterns of interest to our topic. Figure 6.1 demonstrates approximately one minute of a respiratory rate (RR) trace together with a heart rate (HR) trace in the top panel of the graph. In the beginning phases of HRV training, the athlete is taught to coordinate or synchronize the HR and RR lines that move across the screen. This synchronizing can be optimized (referred to as the athlete's resonant frequency). Notice that the two lines in figure 6.1, respiration and heart rate, are not synchronized. These two lines should rise and fall together taking on the shape of rolling hills. An example of rolling hills or proper coordination of breathing and heart rate can be seen in the top panel of figure 6.2.

When respiration and heart rate are synchronized, we will see another process taking place on the computer screen—this time, in the form of a single mountain peak, which can be seen in the bottom panel of the figure (compare figure 6.1 and 6.2). This part of the figure that shows the mountain ranges (spectral analysis) represents a mathematical computation of where the heart rate frequencies are coming from and is a good overall indicator of homeostasis in the athlete's body. The mountain graph can be broken into three separate frequency ranges, representing different biological components of HRV and/or sources of variation in HRV: left, middle, and right or very low frequency activity (VLF), low frequency activity (LF), and high frequency activity (HF), respectively. We have observed that the LF and VLF ranges are most relevant for performance-enhancement training. Each of the frequency ranges and their relevance to performance are discussed below:

- The mountains to the right-hand side (labeled high frequency activity or HF 0.15–0.4Hz) represent heart rate oscillations typically linked to respiration or RSA (i.e., frequency ranges of 12–20 breaths per minute). When the athlete implements slow diaphragmatic breaths, the mountain activity in this area should disappear or look flat (or shift and superimpose onto the middle mountain range near 0.1Hz).
- The middle mountain peak (labeled low frequency activity or LF 0.08–0.14Hz) represents heart rhythms reflective of blood pressure oscillations and both the sympathetic and parasympathetic systems. Low mountain activity in this area is undesirable for performance and is reflective of disregulation in the body or being out of the groove (In figure 6.1, too much mountain activity is on the right side, which can serve as a visual prompt to remind the athlete to breathe more slowly). One of the goals in training is to teach the athlete to create a single mountain peak near 0.1Hz or in the middle range (LF activity), which can be seen clearly in figure 6.2. When this is created, a harmonizing or balancing effect occurs in the athlete's body that may optimize concentration, relaxation, emotional control, and performance.
- The mountain area on the left-hand side (labeled very low frequency activity or VLF .001–.07Hz), whose meaning is still debated, is most likely related to a vascular wave reflective of anxiety or arousal. When this area is active (high mountain activity, see figure 6.1), we have observed athletes tend to have more mental chatter or a busy mind. The goal of training is to minimize this activity by quieting the mind (as can be seen in the mountain area in figure 6.2).

Figure 6.1. A pre-training physiograph trace of heart rate and respiration over a one-minute interval. The top panel represents HR and respiration, and the middle panel is a frequency analysis of the various rhythms inherent in normal HR. Notice the lack of synchronization between HR and respiration and lack of a mountain peak near 0.1Hz.

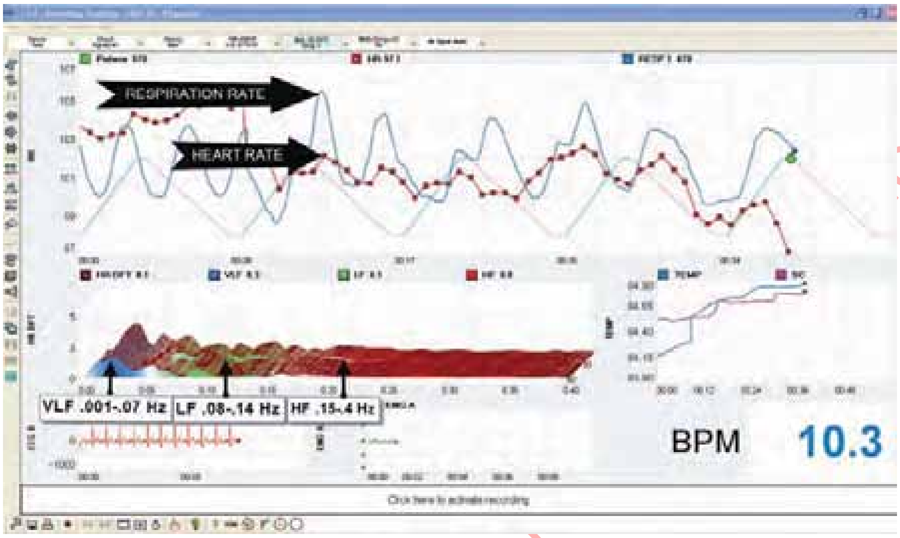
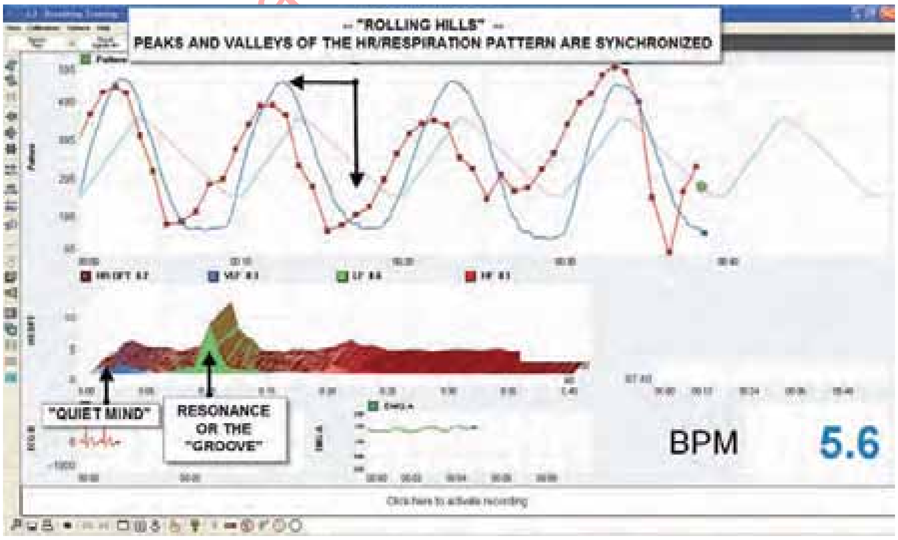


Figure 6.2. Here is the desired pattern that emerges after training. Notice in the top panel the desirable coordination between breathing and HR and in the bottom panel a single mountain peak near 0.1Hz indicating physiological resonance. The left and right sides of the mountain graph are flat, indicating the athlete has a quiet mind and is breathing slowly.



Summary of the Systems Involved in HRV Training

The techniques used to enhance performance through the cardiac system involve three systems that need to be recruited in very specific patterns. These are the respiratory system, the autonomic nervous system (ANS), and the central nervous system (CNS) (cortical or brain centers).

The Role of Respiration

The respiratory system is unique in the body because it is largely under involuntary or automatic control but can also be regulated consciously by the athlete. One response of the system that usually occurs automatically but can be controlled is hyperventilation. Hyperventilation is defined as excessive (beyond metabolic needs) tidal volume of air (the amount of air breathed in or out during normal respiration). Over-breathing or hyperventilation typically happens when the athlete breaths too fast, too deeply, sighs, yawns, or gasps for a breath after a breath hold. When this happens, profound physiological effects can be seen. The effect of greatest interest to our topic is called the Bohr Effect. With the Bohr Effect, the athlete loses too much CO_2 from his body, and the result is over-binding of oxygen to hemoglobin, which causes poor transportation of oxygen throughout the body. Because CO_2 plays a key role in allowing oxygen release to the brain and the heart at the proper level, a large loss of CO_2 could have negative effects on not only performance, but also the athlete's functioning in general. Even subtle hyperventilating can produce dizziness, anxiety, shortness of breath, muscle tension, and a host of other symptoms, all detrimental to good performance. When hyperventilation occurs, the athlete often reports losing control, things going too quickly, paralysis by analysis (thinking too much), or even choking during performance.

A simple questionnaire, the Nijmegen Questionnaire (van Dixhoorn & Duivenvoorden, 1985), can be used as a screening tool for detecting chronic hyperventilation in athletes. It is shown in table 6.1. The cutoff score for hyperventilation is 22.

Table 6.1: Nijmegen Questionnaire. Subjective symptoms associated with hyperventilation.

	Never	Seldom	Some-times	Often	Very Often
Chest pain	0	1	2	3	4
Feeling tense	0	1	2	3	4
Blurred vision	0	1	2	3	4
Dizziness	0	1	2	3	4
Confusion or loss of touch with reality	0	1	2	3	4
Fast or deep breathing	0	1	2	3	4
Shortness of breath	0	1	2	3	4
Tightness across chest	0	1	2	3	4
Bloated sensation in stomach	0	1	2	3	4
Tingling in fingers and hands	0	1	2	3	4
Difficulty in breathing or taking a deep breath	0	1	2	3	4
Stiffness or cramps in fingers and hands	0	1	2	3	4
Tightness around the mouth	0	1	2	3	4
Cold hands or feet	0	1	2	3	4
Palpitations in the chest	0	1	2	3	4
Anxiety	0	1	2	3	4

The Role of the Nervous System

The autonomic nervous system (ANS) is composed of the SNS (sympathetic nervous system) and the PNS (parasympathetic nervous system) branches. In general, the SNS activates the body when it is under performance stress, like pressing on the gas pedal of your car, while the PNS deactivates or acts as a brake. We are all familiar with the signs of sympathetic overload: racing heart, butterflies in the stomach, sweating, rapid breathing, tight muscles, and so forth. Adrenaline (or epinephrine) is usually thought to accompany the SNS response as a backup or prolongation of the fight/flight response. We even have phrases such as "adrenaline rush" in our vocabulary to describe the feeling (even though the effects of adrenaline are largely the same as the SNS effects). So a simple-minded intervention for performance anxiety might be the use of techniques to lower the SNS response. While this is, in fact, valid to a degree, modern theories also involve the rest/digest/brake branch of the ANS, the parasympathetic nervous system (PNS). The PNS is actively involved in controlling and relaxing the body's target organs, not so much as an accelerator, but as a brake. When an athlete uses proper breathing techniques, he can greatly influence how well the PNS functions under performance stress.

Parasympathetic nuclei in the brain stem dampen the parasympathetic brake during inhalation, but return to braking when the athlete breathes out or exhales. Thus, the system can be compared to driving a car with the brake and accelerator on simultaneously. Whenever the athlete breathes in, it is like slowly removing your foot from the brake (speeding up), and when he breathes out, it is like putting his foot back on the brake pedal (slowing down). It turns out that by mastering certain rhythms of breathing in combination with mental calmness (or a quiet mind), the athlete can greatly enhance respiratory sinus arrhythmia (RSA). This appears to have a number of very powerful effects on the body. First, it seems to strengthen the feedback loop between blood pressure and HR. This is called the baroreflex. Its job is to maintain blood pressure (BP) by slowing the HR when BP is elevated and speeding the heart when low BP is present. This reflex is known to be associated with healthy cardiovascular systems and better self-regulation. Second, the specific rhythm, at a specific frequency (which we call a resonant frequency), seems to counter overactivity in the SNS, thus producing a calming, centering effect. Third, the enhanced RSA is associated with positive emotions and a sense of time, sometimes called flow states or being in the zone (Lehrer, P., 2007; Lehrer, P.M. et al., 2003; Vaschillo, E., Lehrer, P., Rishe, N., & Konstantinov, M., 2002). When the systems described above are synchronized through HRV training, athletes might benefit from greater emotional control and a centering of their attention. HRV can most easily be learned or improved by using heart rate and respiration rate biofeedback.

Interestingly enough, this is a brand-new idea that is 2,500 years old. Almost all meditative traditions encourage slow, calming breath rhythms with the promotion of a non-judging calm mind. Despite its long pedigree, we have only recently discovered the scientific basis of the phenomenon. The understanding came from Dr. Richard Gevirtz's lab at Alliant International University in San Diego and Dr. Paul Lehrer's lab at the University Medical and Dental Center of New Jersey. Both labs were using HRV biofeedback to treat a number of stress-related disorders. Dr. Lehrer happened to encounter Dr. Evgeny Vaschillo in Russia where he had been studying the heart-rate patterns of cosmonauts. He developed a theory that showed at certain breath rates, a resonance is created in the chest organ systems that operate like any physical resonant system. Once stimulated at the proper frequency, it produces large persistent responses at the same frequency. Obtaining resonance, he reasoned, exercised the baroreflex and produced positive effects. Based on these early studies, researchers now believe there is some support of the resonant frequency theory.

HRV and Performance

Theoretical Origins

The growing evidence of the positive health effects of HRV training in the field of health psychology has triggered an interest in the related field of performance. Although the research on HRV and performance is limited, results of initial studies look promising. Anecdotal reports from various practitioners and researchers suggest additional support for HRV as a performance intervention. HRV biofeedback as a tool for training performance has its origins in the Russian laboratories of Evgyny Vaschillo, who has provided anecdotal reports of success using HRV training with athletes (Vaschillo, E., 1998, personal communication). He found Olympic wrestlers who trained with HRV experienced improvements in performance, reaction time, attention, and concentration.

Current Research

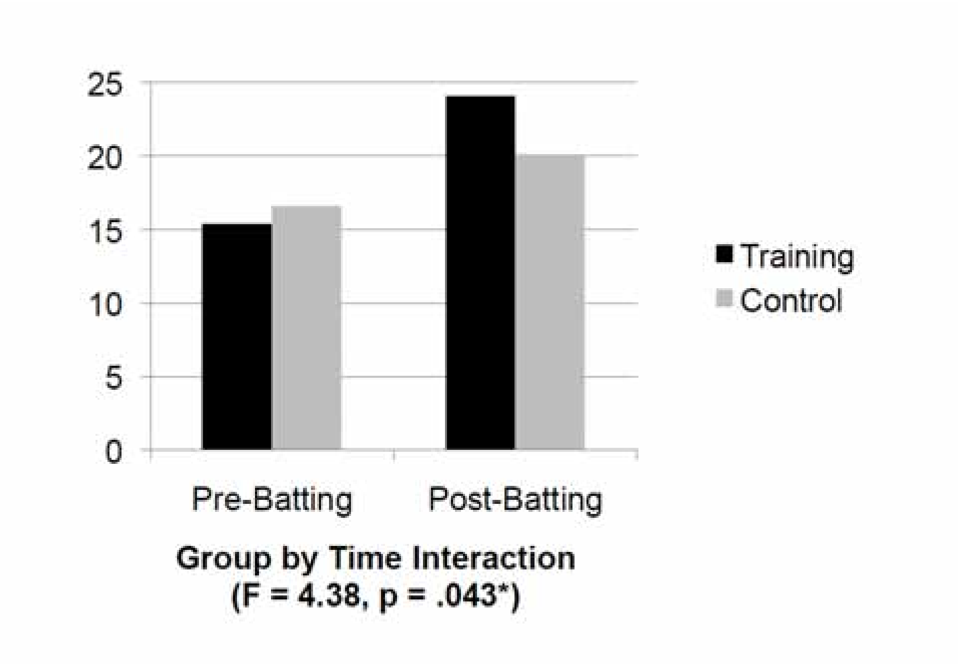
A study indirectly related to HRV/RSA revealed athletes who were trained in slow diaphragmatic breathing experienced performance improvements, decreased anxiety, and reduced autonomic activity (Bessel, 1997). Bessel found both breathing retraining and a cognitive intervention improved performance in female gymnasts. In this study, gymnasts who learned breathing maneuvers with a capnometer (device that measures over-breathing or hyperventilation) improved performance over eight weeks by eight percent compared to a psychological coaching technique at three percent.

A later study conducted by Strack (2003), was the first to examine the impact of HRV BFB on the performance of high school baseball players. Forty-two high school baseball players were randomly assigned to two groups. The HRV intervention group received six 30-minute training sessions. As demonstrated in figure two, the athletes maximized the peaks and valleys in their HR pattern and synchronized them with the peaks and valleys in their breathing wave on a computer screen. The control group was monitored physiologically; however, no physiological feedback was provided. Both groups received 10 minutes of time to practice in the batting cage at the end of each session. Cage time for the control group was supervised, but no instruction was provided. In contrast, hands-on guidance was provided for HRV participants in the batting cages to help them apply the breathing strategies. The guided practice for the training group focused mainly on when and how to use the diaphragmatic breath in between pitches to maintain resonance and to channel or minimize cognitive activity and rumination produced by negative results in the batting cages. Subsequent to the training segment, judges blind to the experimental design rated participants' performances in a batting contest before and after the HRV intervention was implemented. The performance measure (a measure of quality contact or how well the ball was struck by the hitter) was constructed and validated by current and former professional baseball players. The measure was validated with inter-rater reliability of more than 80 percent.

Improvements in batting performance occurred in both groups; however, greater improvement was demonstrated by the HRV BFB group (see figure 6.3). The amount of true variance accounted for in batting performance was nearly twice as much for participants who received HRV BFB training. BFB trainees demonstrated a 60 percent improvement in batting performance, and the control group improved only by 21 percent. The HRV group also improved in low frequency (LF) activity (dominant spike in HRV at around 0.1Hz), indicating greater physiological harmony (homeostasis) in the body during training.

Reports from Strack's study also showed HRV training had a positive impact on game performances. According to Strack (2003), HRV BFB improved focus, relaxation, and the ability to stay within themselves during at-bats in game situations. Additional gains were reported in hitters' precise timing of live pitches and their ability to differentiate between pitches that were balls versus strikes (i.e., improved pitch selection due to better concentration).

Figure 6.3: Mean pre-post batting performance scores. The bar on the left for each of the pre- and post-batting scores represents the performance outcomes of the HRV training group. The height of the bars, i.e., 0 through 25, indicates the average number of points per group awarded by judges for quality contact or how well the ball was hit by participants in a batting contest.



This was the first HRV intervention study in sport to examine the impact of LF activity on sport performance. It appears that increases in total LF power are associated with improved batting performance.

Studies from other performance venues provide additional evidence of the positive benefits of HRV BFB. Raymond et al. (2005) found performance-enhancing effects with ballroom and Latin dancers using a 10-session HRV protocol similar to Lehrer, Vaschillo, and Vaschillo (2001). Another study conducted by Garet et al. (2004) showed swimmers at the individual level recorded their best performances when global and parasympathetic indices of HRV were highest as indicated by nocturnal ANS activity (on nights with maximum RSA, next-day performances improved). The researchers reported a strong relationship between the changes in performances and the changes in HRV (the larger the rebound/recovery in ANS activity, the better the swimmers performed).

More recently, Lagos et al. (2008) developed and implemented a virtual reality–assisted HRV biofeedback program with collegiate golfers. The 10-week program, conducted at Rutgers University, consisted of breath training and physiological monitoring, according to the protocol set forth by Lehrer, Vaschillo, and Vaschillo (2000) with the addition of four virtual-reality golf sessions. Golfers received a nominal fee to participate in the study. The golf sessions, which took place at a virtual-reality golf center and occurred during the first, fourth, seventh, and tenth weeks of training, were aimed at helping golfers learn how and when to implement breathing skills to manage sport-related stress. The main objective of the study was to determine the extent to which HRV biofeedback influenced golfers' moods, physiological control, and sport performances. While the outcome data are in the process of being analyzed, preliminary results indicate virtual reality–assisted HRV biofeedback was a feasible adjunct to sport practice. All golfers completed training and reported more than 90 percent compliance with at-home practices of two 20-minute breathing sessions per day using the StressEraser device from Helicor, Inc. This research follows a case study (Lagos et al., 2008) that explored the impact of HRV biofeedback on the mood, physiology, and sport performance of a 14-year-old golfer. Acute increases in total HRV, low-frequency HRV, and in the amplitude of oscillation at 0.1Hz occurred during biofeedback practice and became stronger across sessions. Further, these HRV changes were accompanied by improved golf performance, suggesting HRV biofeedback training may help the athlete cope with the stress of competition and improve neuromuscular function.

Implications of HRV Training for Athletes

HRV biofeedback may have other performance-related benefits:

1. ***Improved vision.*** Vision and concentration seem to have an intricate and critical link. Motor learning research supports that a still eye is associated with enhanced performance (Harle & Vickers, 2001). Baseball-specific software programs that train visual motor skills are available for home training (see www.slowthegamedown.com for a free demo). These programs, combined with HRV BFB, may help hitters improve their ability to identify seam rotation, pitcher's wrist action, and arm angles, thus potentially leading to better pitch identification and selection.

2. ***Focus and concentration.*** HRV is a normal fluctuation in heart-rate patterns. A fluctuating heart-rate pattern, when guided by systematic breathing techniques, is not only a sign of good physical health but can produce harmony or balance in the athlete's body and mind and can maximize readiness to perform. Typically, when we try to explain or associate a great performance experience with a state of mind or a feeling, we use descriptive words such as steady, stable, or calm and not fluctuating. Ironically, fluctuations in heart rate are a sign of a healthy cardiac system and can produce calmness in the body and a steady level of focus and concentration.

3. ***Regeneration and recovery from injury.*** When the athlete breathes at his resonant frequency (typically 5.5–6.0 breaths/minute), there is a characteristic increase in hand/finger temperature. The gradual warming of the hands is indicative of increased blood flow to the body's extremities, which is important for healing and recovery after injury or long strenuous workouts.

4. ***Managing emotions.*** When the athlete obtains resonance, it is thought that cognitive anxiety (worry) is minimized and the autonomic nervous system is better regulated (Lehrer, 2007). Research has also indicated flow states (effortless, thought-free action or reaction) cannot occur when the athlete is anxious (Jackson, 1998). HRV BFB can serve as a useful tool to help athletes balance and control competition mood states.

5. ***Adaptability.*** A difficult and strenuous training regimen, both mental and physical, is commonplace among competitive athletes. HRV can be considered an index of the adaptability or readiness of the athlete's nervous system to take on physically demanding tasks. By increasing HRV, the athlete becomes more equipped to deal with high-stress competition.

HRV Assessment

Hyperventilation

Before an effective intervention can be launched and HRV BFB can begin, it is wise to first assess the systemic aspects of the athlete's respiratory system, specifically for an indication of over-breathing (hyperventilation, HV). To accomplish this task, a number of handy tools are available. As mentioned earlier in the chapter, the Nijmegen Questionnaire is easy to use (see table 6.1).

A device called a capnometer is also very useful for assessing hyperventilation. It measures the amount of CO2 in the expired air (called end tidal CO2 or ETCO2). Normal values of 40 Torr (mmHg) would indicate a healthy gas exchange, but lower values might indicate problems with hyperventilation. If problems are apparent, a course of breathing retraining is often useful. Breathing retraining techniques have been described in detail by a number of authors (Fried, 1987; Gevirtz & Schwartz, 2003) and in other chapters of this book.

Baseline Measures: HRV/RSA

Once hyperventilation has been ruled out or corrected, the HRV training can begin. To assess the athlete's baseline levels, we measure beat-to-beat HR, skin conductance (SC), forehead muscle activity (sEMG), and finger temperature. This should be done for at least five minutes. It is advisable to distract the athlete with an audio tape or CD of neutral material during this time. After a sufficient baseline is established, a stressor is applied. Counting backwards by sevens out loud usually works, but discussing personally relevant stressors may also work. Afterwards, a recovery period is recorded. The most relevant aspects of this task are 1) baseline levels of SNS arousal (SC, temp, and HR), 2) baseline levels of RSA, 3) activation levels in response to stress, and 4) recovery from the stressor. RSA can be gauged by counting the difference between the lowest and highest HR in a breath cycle (about one minute). For young, healthy athletes, these levels should be above 15 beats per minute. For athletes over 60 years old, levels of about 10 beats per minute are typical. Reduced RSA can be thought of as indicating vagal withdrawal or, perhaps, prevailing worries or stress. These levels should only be assessed when the athlete is breathing at a normal rate (above 10 breaths per minute) with normal tidal volume. Forehead muscle tension should be reasonably low (below 4 µV) as well. Facial muscles seem to be a good indicator of overall arousal and, in some situations, are preferred over muscles on the trunk (Porges, 2003). Although measuring facial muscle tension is helpful for gaining information about the athlete's emotional experience, many athletes tend to brace their shoulders during performance. In such cases, EMG sensor placement on the trapezius muscle (shoulder) is preferred.

HRV/BFB Protocol: Using the HRV Technique

Training Procedure

HRV/BFB is described in detail by Lehrer, Vaschillo, and Vaschillo (2000). In this section, we add a few details that we have found useful for athletes:

1. The basic procedure involves taking the athlete through a series of paced breathing rates to determine the resonant frequency for that person. Starting at seven breaths per minute and progressing by halves (i.e., 7.0, 6.5, 6.0, 5.5, etc.), a few minutes of data is collected. At one particular frequency, the peaks and valleys will be at their greatest. That is usually the training pace for the client for home practice. At this point, checking for hyperventilation (HV) is often useful before proceeding (see Nijmegen Questionnaire, Table 6.1).

   Instructions for determination of resonant frequency: *"On the computer screen you will see your breath wave, your heart rate updated every beat, and a breath pacer. Try to breathe at the pace of the pacer, but keep it as effortless as possible."* (Refer to figure 2 for example of training screen.)

2. Set the breathing pacer at 7, 6.5, 6, 5.5, 5, and 4.5 breaths per minute. Use 2–3 minutes for each interval. Observe the following: a) peak valley differences in beats/minute (B/M), and b) low frequency power or relative power. Write down maximum values for each of the above. For example, 24 beats per minute (B/M) and .4 ms. The primary goal in training is to gradually increase LF power as much as possible. It is also important to continue to watch for signs of HV.

3. Once the athlete's resonant frequency is determined, the instructions in the beginning of this chapter can be used to continue to guide initial training.

Sample Athlete Training Protocol using HRV

The early phases of learning a sport require the athlete to think and analyze to reach task proficiency. The mechanics of the action, timing, coordination, and repetition all require careful consideration. However, it is necessary, at some point, to simplify one's thoughts and intentions in order for a task to be completed automatically or without hesitation. Having a psychological skill/technique that simplifies the sport task allows the athlete to more easily generalize sport psychology principles from the lab to the field (see chapter 12 for details on transferring skills to competition). Therefore, it can be quite rewarding for an athlete to discover a strategy that facilitates the ability to trust or let go, allowing thoughtless action or reaction. HRV BFB is, perhaps, one of the most promising biofeedback techniques that can tie together the mind, body, and optimal performance.

There appears to be a reciprocal relationship between HRV BFB and increased focus such that when the athlete is in a resonant state concentration improves and vice versa; when the athlete concentrates (minimizes mental chatter and facilitates a positive emotional state), HRV improves. Here is an example of an athlete who used the concepts learned during HRV training in a creative manner to enhance his concentration and performance.

Case Example

Following four sessions of focused HRV BFB with a young elite baseball player, the athlete experienced a moment of mental clarity. This player (hitter) was plagued with the not-so-uncommon paralysis by analysis at the plate. He experienced high somatic (body) and cognitive anxiety as a result of self-applied pressure and pressure from coaches which led to hesitation and freezing while batting. Much of his worry was driven by fear of not advancing to the next level and not wanting to disappoint anybody. A classic people-pleaser mentality combined with perfectionist thinking made him a good candidate for relaxation and HRV training. To minimize over thinking and over breathing, he chose a focal point to rehearse the HRV training while batting (usually a clump of dirt on the ground outside the batters' box, which he used as a mental prompt or trigger to remind him to breathe. This was his method for obtaining a quiet mind which he coined “the dirt-clod approach”). [Note: It is our experience that encouraging athletes to label or personalize their psychological approach can strengthen their commitment to using it in competition.] This method served two purposes: 1) It was a centering point for his attention between pitches, which was initially trained in the biofeedback lab by teaching him to decrease very low frequency activity. Second, it reminded him to maintain physiological poise, which was trained in the lab by increasing low frequency activity—that is to say the left-hand side of the mountain peak is reduced in favor of a single middle peak (see figure 6.2). He referred to this as a simple, brainless approach. It was simple, yet it was a powerful strategy for this particular athlete. It provided a focal point or go-to strategy for gathering his thoughts. It also served as a way to mentally pace himself throughout his batting performance, so he did not get too high or low emotionally.

Session-by-Session Protocol

Here is a six-session breakdown for HRV training with a baseball hitter. Although 10 sessions are recommended for clinical populations, a six-session protocol may be adequate for athletes (Strack, 2003). Further research is needed to determine the number of HRV BFB sessions required to optimize sport performance.

Session 1

Practitioner introduces and socializes the athlete to HRV BFB and equipment. The athlete is instructed to breathe at his resonant frequency which involves a discovery process when the athlete finds his target breathing rate (typically, 4–7 BPM), as previously discussed in the assessment section. The athlete is provided instruction on how to use proper diaphragmatic breathing. Learning the mechanics of breathing in the first session can be challenging. Some athletes learn the technique quickly, whereas, others have some difficulty.

Training tips:

Check for forced breathing on the inhale or rapid inhale that leads to dizziness or lightheadedness. Breathing too deeply may produce hyperventilation. Breathing should feel natural and comfortable.

If the athlete feels dizzy, stop training and have the athlete rest before continuing.

Find a customized breathing style for each athlete to help him obtain resonance. For example, vary the length of inhalation versus exhalation. In some software programs, this is expressed in a percentage of time spent inhaling or exhaling during each breath cycle. In addition, some athletes like to pause at the peak of their inhale before exhaling; other athletes prefer the opposite (i.e., pausing at the end of full exhalation), and other athletes prefer to roll through (no breath pause) the transition from exhale to inhale.

Homework assignments are given to the athlete to practice breathing at home (typically 10 minutes twice daily) and then in competition as part of a performance routine.

Session 2

Resonance training continues for as many sessions as necessary or until the athlete can reach his resonant frequency at will. Again, breathing styles should be customized to the individual needs of the athlete, so comfort and ease of breathing and consistency is maximized. If the athlete is having difficulty learning the mechanics of breathing, imagery or mental rehearsal can be used to facilitate the process. For example, have the athlete imagine a balloon expanding upon inhalation and contracting upon exhalation. It is also helpful to have the athlete place one hand on his chest and the other hand on his abdomen to assure that the diaphragm muscle is being used, not the chest or shoulders, during initial breath training.

Developing a quiet mind (lowering VLF activity) or single-pointed focus is a key ingredient accompanying resonant training. The various techniques offered throughout this book can be used during HRV training to supplement or aid the concentration patterns of the athlete (e.g., thought stopping, task-specific or personal mantra, EEG training). Specific to the HRV technique and the training of concentration, we have found feedback of the VLF wave can be very useful for teaching the athlete to eliminate mental chatter. Sessions 1 and 2 should incorporate techniques to facilitate calm, controlled, focused awareness.

Session 3: Distraction Control

Practice Environment

Once the athlete feels confident that he can obtain resonance at will, the practitioner can begin to help the individual transfer the skills to various task specific scenarios or practice situations (e.g., the batting cage or the playing field, etc.).

Strategy: Many hitters incorporate behavioral routines while batting. As they step in and out of the batters' box, have them rehearse their breathing while quieting their mind. The breath can be used as the point to refocus when distraction occurs or the mind wanders to irrelevant thoughts. Have the athlete draw his attention to the sensation of breathing slowly. Say to him, "try to become totally absorbed in the sensation of your breath...feel your abdomen expand as you inhale...as your attention is drawn to your breathing, your focus will become effortless and simple...once you feel that you are in the moment with your breathing, refocus your attention to the task at hand" (i.e., reading the ball out of the pitcher's hand).

Office Environment

For generalization of skills from the office to the sport environment, the practitioner can turn aside the computer and have the athlete try to obtain resonance without feedback from the computer. Ask the athlete to identify when he thinks he is in the zone (quiet mind or minimal very low frequency activity, and maximal low frequency activity) and then reveal the results. This gives the athlete a reference point for how it feels to be in a state of resonance.

Strategy: The length of time to reach a state of physiological resonance may vary depending on the individual. Using a stopwatch to time how long it takes to obtain maximum LF activity (amplitude—spectral activity at 0.1Hz) can be a good way to test the athlete while under time pressure. In our training clinic, we have observed many athletes are able to maximize LF activity within 60 to 90 seconds. Subsequent sessions can be used to challenge the athlete to beat his best time.

Strategy: Introduce auditory distractions (e.g., the athlete's voice recording of his negative self-talk, "I can't hit this guy," "I couldn't hit water if I fell out of a boat.") and teach him to block out these distracting thoughts while obtaining resonance. Have the athlete write on a piece of paper a list of negative words or statements that he often uses when performing. Once the athlete maintains resonance for a brief period (three to four minutes), the consultant can try to distract the athlete by reading the list out loud (or playing back the athlete's voice-recorded sound bites of his negative self-talk). Instruct the athlete to manage the distraction in the moment while he attempts to maintain resonance.

Special considerations: Overweight athletes may have some difficulty developing proper breathing mechanics. The breathing pattern of these athletes is often shallow and should be addressed by the practitioner. Placing the athlete in different positions (standing versus seated versus lying down) may aid breathing retraining. Changing the athlete's posture during seated breathing may help (placing pillow behind his back while seated upright in a chair as hunching over can make breathing shallower). Similar adjustments in posture might be necessary when training within specific sports and sport skills (e.g., boxing versus cycling). Use the following exercise to emphasize the importance of finding the correct style and posture for breathing:

Exercise: Raise your arms directly over your head...reach as far up to the sky as possible, then try to take in a deep breath. Was it difficult to breathe? Most likely the answer is yes, because your diaphragm muscle in your abdominal region is constricted and your breathing is shallow. Now try breathing with your arms and hands relaxed on your lap. The mechanics of this deeper breath allows for full oxygen intake. Shallow breathing may cause hyperventilation and lack of oxygen and blood flow to the brain, which may negatively impact concentration (See the LSR chapter for more breathing exercises). Note: The style and pace of breathing is different for many sports. An athlete must learn to modify his breathing to match the sport requirements (e.g., swimming versus boxing, etc.). Cyclists, for example, may find it more challenging to breathe properly when they are hunched over the handlebars of their bicycle. When training the athlete, it is helpful to vary posture and positioning to mimic the performance requirements. Try training the cyclist's breathing while he is on a stationary bike and seated in a racing position.

Session 4: Building "Endurance" in LF and VLF

The athlete's resonance endurance can be tested and discussed. The strategy in session three discussed using a stopwatch to record how long it takes to obtain resonance. We also want to keep track of how long the athlete can maintain resonance and his current resonant endurance. Instruct the athlete to maintain resonance for as long as possible. Keep written records of his progress (i.e., amount of time that passes before he loses resonance). This can be used in future sessions to challenge the athlete to beat his time. A journal chart or visual graph of the athlete's progress can be a helpful tool to keep the athlete motivated to advance his skills while training. Also discuss the implications of poor endurance within the context of the athlete's sport. In this way, the athlete begins to discover productive and unproductive patterns of emotion management.

Strategy: Use highlight tapes or video footage from competition. The practitioner may introduce prerecorded video of the athlete's live at-bats from a game situation and have him obtain resonance while watching the video. The athlete can be rewarded for staying in resonance; the longer he maintains resonance, the more time he is given to watch the highlight clips. Once resonance or concentration is lost, the practitioner can turn off the video until the appropriate physiological and psychological state is recovered. Once the desired state is recovered, the video can be turned on again.

Using portable HRV equipment or devices (see appendix): Small portable or wireless devices are excellent tools for the athlete to practice in vivo. The practitioner can have the hitter stand in the batters' box during a pitchers' bullpen. The athlete can practice reading pitches while associating states of resonance with the most accurate pitch identification (this should be done without swinging the bat to minimize movement artifact). Similarly, outfielders could practice reading balls coming off the bat of hitters during batting practice.

Session 5: Combining HRV Training with imagery

Imagery is a powerful mental skills strategy (chapter 5). Because biofeedback provides many visual details (line graphs, art graphics, and images) of the body's responses to focused and unfocused states, it can be valuable for the athlete to use visual memory recall of the computer graphics (breathing metronome...a green dot that moves across the display screen and is used to pace the inhalation/exhalation of each breath). This type of playback of visual information can be used as part of an athlete's routine during or before performances (mentally taking the biofeedback equipment with you to the game). The athlete can take the images from HRV training sessions and easily use them as a mental prop to rehearse or pace their breathing when hitting in live games. This can provide a creative manner in which athletes can condition themselves to obtain a state of resonance when in competitive pressure situations.

Session 6: Applying HRV to other tasks within baseball

Base stealing: Base stealing requires excellent timing, reaction, and anticipation of pitchers' movements, similar to a sprinter awaiting the gunshot at the starting block. Becoming too anxious with anticipation and reacting slowly can lead to a poor jump (delayed reaction when cued by the pitcher to steal the base) with the risk of the runner being thrown out by the catcher or picked off by the pitcher. We have observed that many athletes learn to harness a very poised and in-the-moment state with resonance training. Such calmness and readiness can maximize the runner's chances of getting an explosive jump.

Pitching: It is a common mistake for many pitchers to lose their tempo and rhythm during a game, especially in pressure situations. Obtaining a state of resonance before each pitch delivery can be used to harness the pitcher's focus and energy. The dirt area of the pitching mound can be used as a symbol representing his place of resonance. The pitcher should step onto the dirt area only after he is confident that he is in a state of resonance and under emotional and physical control.

Outfield play: With the average Major League baseball game lasting approximately three hours, the flow of the game can become stale very quickly, especially when there is a good pitching matchup. HRV and resonance frequency training can be used by outfielders for energy management during long games. The best time to conserve energy is between pitches when the player can calm his mind while maintaining resonance. The player can, essentially, fade out mentally between pitches and then quickly obtain a highly focused state to maximize preparedness.

Coaches' Corner

HRV and breathing training (RSA training) is a great way for coaches to help their players implement psychological skills in their pre-performance mental routines. In addition, a coach can effectively train the athlete how and when to appropriately use the technique (e.g., between free-throw shots in basketball or between serves in tennis). With many psychological techniques, e.g., visualization, the coach is unable to observe whether the athlete used the technique properly or even at all. With breathing, the coach can easily observe the athlete's breathing patterns and then provide useful feedback to the athlete about his/her observations. "It looked like you were holding your breath long before you served the ball." The coach can then work closely with the athlete on correcting for and adjusting to an appropriate length of breath holding to avoid hyperventilation and, potentially, any lost concentration before serves.

Summary

In the past 10 years, research and technological advancements have made it possible to train and observe changes in the heart rhythms of athletes. Although HRV BFB is a relatively new modality, evidence has outlined the powerful effects this method can have on creating overall homeostasis in the athlete's body (and mind). Several inexpensive home training and portable devices (See appendix) are available for practitioners and athletes. Many of the home-trainers are user-friendly and have the capability of recording data (HRV and respiration) to track progress and monitor homework assignments given to the athlete. Finally, with continued research efforts, HRV will likely prove itself as a key training strategy in sport psychophysiology.

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Appendix

Recommended HRV home training devices:

Stress Eraser (www.stresseraser.com)

Resperate (www.resperate.com)

Emwave (www.heartmath.com)

Introduction to EEG Biofeedback (Neurofeedback) Chapter 7

by

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Abstract

This chapter provides a very brief history of electroencephalography EEG (electrical activity of the brain) with the major terms defined, location or areas of the brain involved in different activities, and the speeds of the brain that are primarily associated with different mental tasks (e.g., slow speeds are linked to inattention; very fast speeds are linked to anxiety or a busy brain). A summary of the findings of the research using EEG is provided, so readers can appreciate the activity of the brain when the athlete performs skills well as compared to what occurs when the athlete is not performing well. Based upon the research, recommendations are given for neurofeedback (NFB) or training the EEG. The future of NFB in sport, we believe, includes the integration of sport simulation with NFB training as well as the use of telemetry (miniature equipment that can be worn while the athlete performs), so the athlete can be assessed and trained in the heat of competition.

Chapter Outline

I. Introduction

a.) a.) History and Definitions

II. EEG/Neurofeedback training

a.) Traditional ADD/ADHD

b.) Classical and operant conditioning

III. EEG research in sport

IV. EEG/NFB training in sport

V. References

This section will present an introductory overview and the historical background of EEG biofeedback or neurofeedback (NFB) applications in sport psychology. Individuals experienced in EEG or those who are not interested in the mechanics of how EEG works or its history of research may wish to skip to the next section.

Electroencephalographic (EEG) feedback, usually called neurofeedback (NFB), is a technique that involves a brain-computer interface that monitors the electrical activity of the brain and gives virtually instantaneous feedback to the athlete concerning his brain activity. The activation patterns in various brain regions at any given moment determine how a person performs in a specific task.

Different brainwave patterns are associated with different mental and somatic activities or states such as focused attention, daydreaming, ruminations, or fatigue. Neurofeedback involves the placement of electrodes on the scalp to obtain information concerning the electrical activity of the brain at that location. The electrical activity is typically measured in the height (amplitude, measured in microvolts [μV]), speed (cycles per second, called frequency, measured in Hertz [Hz]) and shape (morphology) of brainwaves from different regions of the brain. By providing this information to the athlete, athletes can learn to control the electrical activity of their brain and thereby alter and better control attention, thoughts, feelings, and thus, performance. NFB has its origins in research labs but advances in computers and instruments now make training accessible to clinicians, consultants, and coaches.

Brief History and Terminology of EEG Biofeedback

The development of neurofeedback as it is currently being used in sport is based upon work by Hans Berger, a German physician, who had a lifelong interest in how humans communicated. He was the first to develop an instrument to measure electrical activity generated in the human brain. In papers published in 1929, he documented the nature of the electrical waves in a systematic manner, giving the term electroencephalogram (EEG), literally meaning electrical brain writings, to the field.

In earlier work, computers were not fast enough nor could they store enough data to record the speed of the brainwaves in one-hertz frequencies, so the waves were grouped into categories or bandwidths comprising several frequencies and given names. There is no standardization around the world regarding the frequencies of each bandwidth, but the names and order of bands is the same. Table 7.1 lists commonly accepted frequencies for each bandwidth name as well as correlated mental states. Standardized electrode placements for recording have been established (originally by Jasper, 1958 and later revised) and is known as the International 10–20 system. Figure 7.1 shows the international names and locations where electrodes are placed for EEG recording. Figure 7.2 shows areas of the brain and their currently accepted major functions.

Figure 7.1:

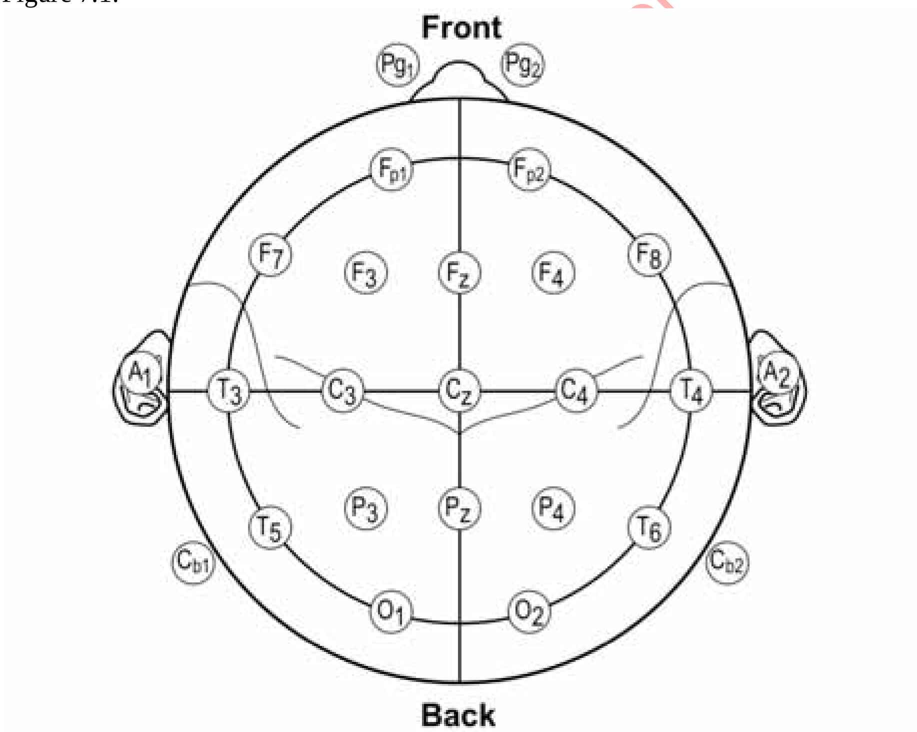

Figure 7.2:

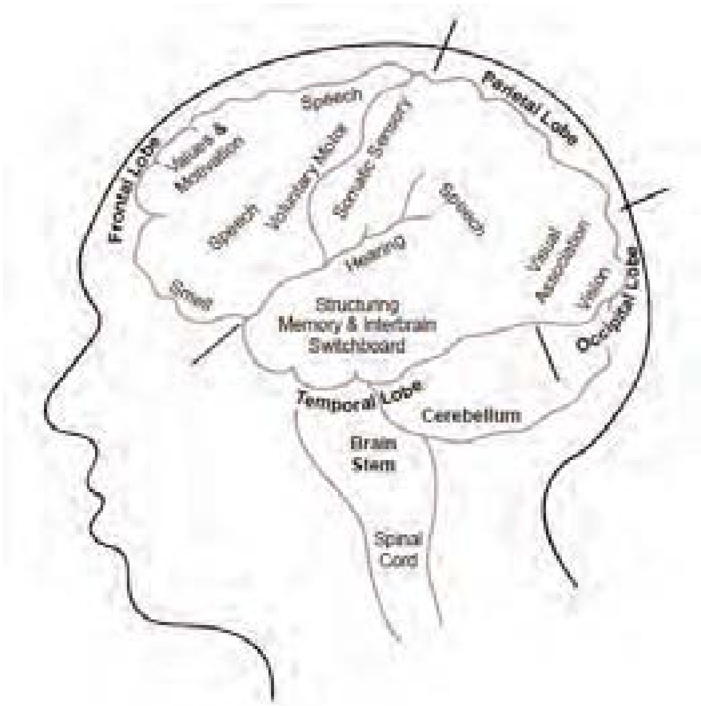

Table 7.1: Simplified summary of EEG bandwidths and correlation to mental states. Adapted from Thompson & Thompson (2003).

Frequency Bands	**Correlations at Cz & FCz**
1–3Hz Delta	Dominant activity in stage IV sleep. Electrode movement, eye movement, or eye blink artifact all mimic Delta. May be increased in awake EEG in those with brain damage and in learning disabilities.
4–5Hz Low Theta	Tuned out. Sleepy.
6–7Hz High Theta	Internal orientation, may be creative but will not recall ideas for very long after emerging from this mental state. Not focused on external learning, such as reading or listening. Important in memory retrieval. Visualization is associated with 7–10Hz activity.

8–10Hz Low Alpha	Internally oriented. Increases during some types of meditation.
11–12Hz High Alpha	Correlates with a very alert, broad awareness state. Seen especially in high-level athletes when in the zone. High intelligence associated with higher peak alpha frequency plus higher amplitude (at rest) and greater desynchronization when on task.
13–21Hz Beta	Broad band of Beta. Used in Theta/Beta power ratios for ADHD evaluations.
12–15Hz Sensorimotor rhythm (SMR) when measured across the sensorimotor strip (C3, Cz, C4)	Correlates with inhibition of motor output and sensory input combined with a mental state that maintains alertness and focus. A calm state with decreased anxiety and impulsivity and improved immune function.
16–20Hz Beta	Correlates with active problem solving and cognitive or motor activity. For most people conscious thinking/problem solving is associated with 16–18Hz activity. More Beta is present when learning a task than when it is mastered.
19–22Hz High Beta	Correlates with emotional intensity (which may, in some cases, be anxiety). Trying too hard is often reported by athletes when in this state.
23–36Hz High Beta	Correlates with a busy brain. This can be related to cognitively processing many ideas, or it may represent negative ruminating in some individuals. It may be the most important area of distraction in elite athletes. Elevated mid-20s activity may correlate with family history of alcoholism/addiction.
40Hz (sheer rhythm) Gamma	Sheer related this to attention and cognitive functioning—a binding rhythm. Increasing it may help learning disabilities. A burst at 40Hz occurs as one regains balance of a stabilometer.
45–58Hz	Range often monitored to reflect scalp, jaw, and neck muscle activity. EMG inhibit range. (Use inhibit at 53–59Hz in Asia, Australia, Europe).
60Hz (50Hz in Europe, Asia, and Australia)	Usually electrical interference.

In the 1960s, Joe Kamiya documented that individuals could become aware of and show control over the brain state called Alpha. (Alpha refers to sinusoidal EEG waves in the frequency range between 8–12Hz associated with an area of the brain while at rest and most prevalent over the occipital area or the cortical area where vision is processed when the person is not activating the visual system and closing the eyes). His widely reported results encouraged other researchers to begin exploring the frontier of controlling the brain through neurofeedback. Independently, Thomas Mulholland and his student Erik Peper explored the process of visual attention and occipital Alpha feedback and showed that occipital Alpha was always attenuated when the subject focused or accommodated his vision or gave efferent motor commands (telling the muscles what to do) (Mulholland & Peper, 1971).

Below are additional definitions for terms that are used in the chapter:

ADD attention deficit disorder: There are many ways for one's attention to be atypical or different from the average for one's age and gender. The atypical responses include an inability to select what to attend to, maintaining attention when required, or may be a difference in the ability to focus one's attention.

ADHD attention deficit hyperactivity disorder: A form of attention deficit disorder in which the individual also has excessive motor activity (hyperactivity) and impulsivity.

LORETA low-resolution electrical tomography assessment: A mathematical process that looks at the surface EEG and infers what activity is occurring deeper in the structures of the brain.

Evoked potentials (EP): Slow potential EEG. Equipment that measures very slow waves that indicate when the waves shift between positive (P) and negative (N) when repeatedly measured from a timed stimulus. Caution in that the naming of P- and N-wave deflection is not the same worldwide. Some places call a displacement upward as P; others call it N.

Quantitative electroencephalography (QEEG): The analysis of EEG, recorded in digital form, using accepted mathematical and statistical techniques. QEEG is the measurement and quantifying of the electrical activity occurring at specific frequencies typically from electrodes placed across the entire head. Results are often compared with a large database of normal and abnormal readings to detect brain abnormalities which correlate with certain diagnosis and obtain individualized neurofeedback protocols.

Coherence: A measure of the amount of association or coupling between two different regions of the cortex. Hyper (increased) or Hypo (decreased) coherence refers to disruptions of connectivity within the cortex.

I. ***Hyper-coherence*** between regions is an abnormality that results from a lack of differentiation between functional regions. This can negatively affect one's ability to efficiently perform multiple tasks simultaneously. It can lead to poor decision making when fast responses are needed.

II. ***Hypo-coherence*** indicates disconnection syndrome (an area of the brain is not communicating as it should with other regions). For example, poor communication within the right frontal region negatively affects mood and attention. Frontal hypo-coherence is a common finding following head injury such as concussion.

Phase: A binding or synchrony within a network of neurons. This measure is independent of the amplitude of waves.

Virtual reality: A technology which allows a user to interact with a computer-simulated 3D environment.

Thresholds: The amplitude setting on a display screen that the athlete must stay above or below depending on whether the goal is to enhance or inhibit a frequency. The threshold determines if the athlete will be rewarded for achieving the brain state requested. This measure can be changed as the athlete is working with the display and determines how hard or easy it is for the athlete to obtain success. Typically set around 66 percent success rate for beginners and 50 percent for more advanced.

Barry Sterman conducted animal research involving EEG in the 1960s and noted while training cats that there was a momentary stillness before the performance of a bar press for food. During this period, bursts of spindle-shaped, synchronous EEG activity occurred across the sensory and motor areas (a band across the top of the head above each ear). He labeled this very specific rhythmic pattern sensorimotor rhythm (or SMR). It was a specific brainwave signature associated with being motorically still and mentally alert, ready to perform. Sterman and one of his graduate students were the first to publish on operant conditioning of brainwave activity (Wyrwicka & Sterman, 1968). These findings led to further research that established increasing SMR activity correlated with a decrease in the frequency, duration, and severity of seizures that have a motor component. His research group subsequently moved from pure animal research to include work with humans, teaching individuals with epilepsy how to use the SMR to control seizures. Sterman later used the same EEG measurement techniques to assess mental functioning, the ability to pay attention of Air Force personnel, who included top-gun fighter pilots (Sterman, 1995).

Joel Lubar pioneered the use of SMR and other EEG state training to teach individuals with attention and hyperactivity disorders (ADHD) how to achieve behavioral stillness and improve attentional states and was the first to publish on the successful training of a hyperactive child (Lubar & Shouse, 1976). Joel Lubar pioneered the use of a ratio of Theta to Beta magnitudes to identify persons with ADHD compared to normal. He and Judith Lubar have published and taught extensively in the area of neurofeedback since that time. For a review of other work in biofeedback and neurofeedback see Schwartz (2003) or, for a journalist's review of the field, Robbins 1998 book *A Symphony in the Brain*.

It is beyond the scope of this chapter to detail the extremely complex physiological processes that underlie our ability to pay attention. With the use of functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and whole brain EEG (using up to 256 electrodes) and the subsequent quantitative analysis of the digitally recorded EEG data (QEEG), new research is investigating specific questions such as location for images, sustained attention, perception of movement, etc. For the neurophysiology and research, see the classic article "The Attention System of the Human Brain" by Posner & Peterson

(1990), and the newer book *Attention in Action* by Humphreys & Riddoch (2005). In addition, the articles by Vickers (1996) and Janelle et al. (2000) provide research examples of the specificity of attention in sport, as do the EEG and attention chapters that follow in this section of the book.

EEG/Neurofeedback Training

Electroencephalography (EEG) or the brain's electrical activity has specific correlates to cortical perfusion (Cook et al., 1998) and is, hence, a good measure of the level of perfusion (cells using blood flow when active) at various brain sites. Therefore, EEG is an excellent candidate for identifying brain states that correlate to success and failure at any task that require those brain areas to be active.

Traditional ADD/ADHD

Cognitive states such as mental focus, arousal, and calmness have direct psych-physiological correlates. For instance, in disorders such as ADHD, the frontal lobe may present with hypo-perfusion as evidenced by slow activity (often in the Theta range) or with the idling rhythm of Alpha. Because the frontal lobe is known to be the executive brain and is responsible for very important higher cognitive functions such as attention, impulse control, and motor regulation, the symptoms such as hyperactivity, impulsivity, and poor sustained attention and concentration are natural correlates of the hypoactivity of this region.

Early research has shown the EEG of animals can be modified using a behavioral technique called operant conditioning and was successfully replicated in humans for the treatment of epilepsy (Sterman, 2000) and later in ADHD, epilepsy, and other disorders (Monastra et al., 2005; Schwartz & Andrasik, 2003; Thompson & Thompson, 2003; Linden et al., 1996; Lubar, 1995). This process, which came to be known as neurofeedback, allows the clinician to help shape a number of variables in the EEG of the subject over time by reinforcing real-time changes in brain functions as measured by EEG. There are now a few decades of research experience on this methodology. Other studies have explored the utility of this methodology for attaining optimal performance by training musical performers (Egner & Gruzelier, 2003). As asserted by Williams (2006), when it comes to sports performance enhancements, self monitoring and regulation of states such as arousal, attention, self talk, and imagery are extremely important. Because neurofeedback can be very effective in training these states, its use in sports performance enhancement is a very natural extension. There are also case studies reporting successful outcomes in training Olympic athletes using neurofeedback (Beauchamp, 2010; Patton, 1996).

However, it must be noted that each sport may require a different set of physiological and psychological states to be triggered in order for the individual to perform at his best in that specific sport. Landers et al. (1994) have reported that training an individual with an inappropriate protocol can lead to diminished performance. The authors were unable to locate any report that suggested NFB had created either poorer performance or health issues for athletes. While there may be some similarities in peak performance states across the board, there are significant differences in brain and autonomic system dynamics from sport to sport. Training for soccer, for instance, may require a totally different set of networks in the brain to be activated as compared to golf. Therefore, assessment of the athlete's EEG, using QEEG or other techniques, and during each sports performance is beneficial when individualizing or customizing neurofeedback training to optimize success.

In addition, individual differences in brain and autonomic functions and their correlates to peak performance cannot be overemphasized. Using a clinical example here may help clarify this further. In looking at the EEG brain profile of children with ADHD for instance, we find there are subtypes and individual differences in the way their brains function and that their performance in the real world (actual neuropsychological screening of attention, memory, and other cognitive domains) may lead to totally different and individualized patterns that are correlated with their specific brain dynamics. This is why some clinicians emphasize the new concept of personalized medicine, and we believe the concept of customized protocol integration should be extended to a personal peak performance model. While some of the generalized and one-size-fits-all protocols may prove to be helpful with a percentage of individuals, it is suggested peak performance evaluation and training in sports will ultimately need to be personalized to take into account individual differences in baseline brain functions, event-related brain dynamics as related to the demands of that specific sport, and the appropriate autonomic changes as related to each state.

Regulation of a number of physiological, cognitive, and emotional states is required for peak performance in sports. Although the regulation of these states comes more naturally to some individuals, monitoring brain and autonomic nervous system changes during peak performance states provides an opportunity to identify and promote these specific states by training the brain and the nervous system to enter into those specific states. This is where neurofeedback can play a major role, on the one hand, by promoting optimal states of attention and focus and, on the other hand, by reducing anxiety, negative self talk, anger, and unnecessary sympathetic arousal.

Operant, Classical, and Contextual Conditioning

Neurofeedback operates on the principles of operant conditioning. Operant conditioning deals with the modification of voluntary behavior where a new behavior is learned and maintained through a desirable consequence or reward that increases the chances of the target behavior reoccurring. B.F. Skinner first coined the term in 1938 in his book *The Behavior of Organisms*. With conventional neurofeedback, a change in behavior, for example controlling brainwave activity, elicits reinforcement of that behavior, for example improvement in concentration or a specific performance outcome such as properly executing a shot in golf. However, strictly speaking, operant conditioning requires the pairing of a voluntary change in behavior with reinforcement. However, changes in the central or autonomic nervous system are not voluntary. Therefore, if we use the traditional definition of operant conditioning, only the types of biofeedback that reinforce voluntary changes (such as changes in muscle tension) can be considered operant conditioning.

In contrast, the principles of classical conditioning describe an involuntary or automatic response to a stimulus. This type of conditioning is also referred to as respondent conditioning or Pavlovian conditioning based on the famous Pavlov experiment with dogs early in the 20th century. The distinctions among the two types of conditioning are not as black and white as they once were believed to be. For instance, it appears that even involuntary responses can also be conditioned. For example, Neal Miller (1978) has demonstrated that involuntary responses, such as heart rate, can be modified through operant conditioning techniques. It now appears that classical conditioning does involve reinforcement. And many classical conditioning situations also involve operant behavior. In this kind of conditioning, one learns associations among different stimuli. In other words, there is a predictable relationship among the events, and the person learns from the response to the first event and adjusts the response in anticipation of the second event.

In this case, the involuntary response (alterations in brainwave activity or heart rate) is recognized and reinforced by the paired stimuli condition. It follows that, once the association is made, learning will take place. When exposure to the pairing of two conditions is repeated, eventually, pairing will take place. To simplify, a golfer learns the desirable brain state (as evidenced by assessment of the individual's task-related EEG profile) is paired with the contextual cues, and then a more accurate putt can be learned.

Review of EEG Research in Sport

The initial demonstration of improvement of attention from NFB came from research and training for individuals with attention deficit disorders (ADD) or epilepsy as they learned mastery of attention, arousal, and thought control (Lubar, 1995; Linden et al., 1996; Thompson & Thompson, 2003; Monastra et al., 2005). These studies typically report an 80 percent clinical improvement using different EEG frequencies for Theta and Beta with electrode locations primarily at Cz, C3, and C4 (Monastra et al., 2005). The Thompsons (1998, 2003) have reported higher improvement by combining neurofeedback training with cognitive training during tasks. The decades of research and clinical treatment in ADD suggest strategies and approaches that can be helpful in the assessment and training in sport.

Research in sport and EEG has become more available, but the majority of research is in the assessment and not the training of athletes. Research on the use of NFB for training athletes, however, has generally been case studies or non-controlled group studies. The major findings from EEG assessments are summarized and simplified below. For detailed reviews see Leonards, 2003; Vernon, 2005; Hatfield et al., 2006; and Hammond, 2007. Most of the following synopses are from a review by Hatfield et al. (2006):

1. Studies in sport have shown a decrease in activation (more Alpha) in the left hemisphere associated with improved athletic performance and task mastery. This decrease suggests less attention to stimuli and suppression of irrelevant information, and may also suggest either use of an internal automatic pilot to guide performance or an intention to act.

2. Progressive quieting of motor cortex (increased SMR) as an athlete becomes ready to perform. This may be similar to the quiet eye findings reported by Adolphe, Vickers, and Laplante (1997), which showed eye-movement fixation prior to good performance.

3. Task-specific reduction in cerebral activation (more globalized low-frequency Alpha EEG) is believed to be the result of more efficient and task-specific use of brain resources. Highly skilled athletes can perform the same tasks but more efficiently and with less effort. Two early studies have noted that athletes may show these lower activation levels at rest

4. Novices have reduced occipital and left temporal/frontal alpha power and have concomitant heightened Beta and Gamma activity during movement compared to more skilled athletes. During target aiming, the assessment period of shooting, skilled shooters show increased Beta in the left hemisphere. They then shift gears to increase Alpha EEG, more of a quiet mind, for the actual performance. This increased Alpha accompanied improved fine motor control in skilled athletes.

5. Increases in Alpha power at T3 during tasks were shown and believed the result of specific sport training.

6. Less coherence between Fz and T3 was found for Alpha EEG during better shooting performance, and these changes were seen within hours and weeks. This decrease in coherence may

be interpreted as signifying an increase in cerebral differentiation; whereby, the athlete reduces activation in the area of the mind associated with talking through the movement (the verbal area, T3) while keeping active the area of the cortex associated with performing the physical aspects of the task (motor strip, Fz).

7. Training to increase Alpha in the left hemisphere resulted in an increase in shooting performance.
8. Different sports and different positions or moments within a sport have different attentional patterns as reflected in the EEG. An example is the biathlon when athletes must have high arousal during the skiing stages but must shut down active processing and reduce their aroused physiology for the shooting stages.
9. Enhancing SMR (12–15Hz) while decreasing Theta results in more calmness and focused attention. Enhancing 15–18Hz Beta (training) also improves some aspects of attention.
10. Slower Alpha content (7–10Hz) is associated with imagery.

EEG and QEEG (quantitative EEG) have become accepted methods for assessing concussion (Tebano et al., 1988; Thatcher et al., 1989, 2001; Thompson et al., 2005, 2007). These methods assess the amplitude, coherence, and phase of the brainwave patterns. Generally, there is a decrease in the amplitude of higher frequencies (Alpha and Beta) and an increase in the amplitude of lower frequencies (Delta and Theta) in individuals with concussions. There are also disruptions in coherence with either a hyper- or hypo-coherence occurring in any one of a number of frequency bands. This change in coherence, regardless of the direction, represents a disruption of connectivity within the cortex.

Hammond (2007) has also reviewed some of the specific research in this area and has pointed to the potential for the use of neurofeedback in optimal performance in various sports while also pointing out some of the limitations of certain approaches that do not account for individual differences and the different demands of various sports. The majority of studies to date are based on the assumption and existing research evidence that neurofeedback can be used as a method to train and condition various brain states for improving cognitive functions such as attention, concentration, and focus and to help improve regulation of emotional control and negative self talk that is necessary to achieve peak states in sports performance. Further research is necessary to determine the true degree of efficacy of these studies (are they worth the time, effort, and money?)

Neurofeedback appears to be a logical means through which to rehabilitate concussions. Symptoms such as impaired concentration and attention, reduced information processing capacity, depression, and anxiety (symptoms all present in varying degrees in post-concussion syndrome) have all shown symptom reduction following neurofeedback training (Thompson, 2003, 2007; Baehr, E. et. al.,1999). A reduction in these symptoms following the use of EEG treatment for concussion has been shown in work by Duff (2004) and Walker et al. (2003).

EEG Biofeedback or Neurofeedback (NFB) in Performance Enhancement

Even though numerous case studies and clinical suggestions for how to provide neurofeedback for enhancing sport performance have been reported, only one controlled EEG study in sport was found in refereed journals. Landers et al. (1991) used EEG biofeedback to determine if athletes could learn hemisphere differentiation and whether this would then affect sport performance. Pre-elite but experienced archers were given correct slow potential EEG feedback, incorrect feedback, or relaxation with no feedback. In pre- and post-test archery performance scores, there were no differences for the control group, the incorrect feedback group had poorer post-treatment scores, and the correct feedback group significantly improved their post-treatment archery scores. This study illustrated that not only can EEG be changed in athletes by training but that the EEG changes were associated with enhanced archery performance. Interestingly, there were no differences in EEG readings, which may have been a result of too few training sessions or the nature of the feedback.

Performance and enhancement with EEG training has also been reported by Egner and Gruzelier (2003) while working with non-athlete performers. These performers experience years of intense training and competition, and it is required of them to be able to control the mind and body for elite performance when called upon to do so. In this study, elite music students were assigned to four groups: a traditional mental skills training group, a group receiving Alpha and Theta brainwave neurofeedback from Pz, a group receiving SMR and Beta NFB at Cz, and a no-treatment control group. The students' videos of performance were assessed by experts before and after training on standard music grading measures. After eight training sessions, the students in the Alpha/Theta feedback group improved their musical artistry performance by up to two grade points, and none of the other groups significantly improved. While the Alpha/Theta protocol is believed to enhance relaxation, there were no changes in state anxiety levels, and thus, the reason why the treatment worked is unknown.

In a second study using dancers (Raymond et al., 2005), one group received Alpha/Theta for eight NFB training sessions, one group received heart rate variability (HRV) biofeedback, and one group received no feedback. Judges rated the pre-post dance performance on several aspects of dance performance. Both the Alpha/Theta neurofeedback and HRV biofeedback improved their overall execution of dance performance with no changes in the control group. The Alpha/Theta group also improved in their timing while the HRV group improved in technique. Unlike the previous study with musicians, there was no relationship between the Alpha/Theta indices and the performance change. Again, no explanation for group differences could be attributed to underlying changes in EEG functioning. However, long-term EEG changes do not always occur in NFB especially with fewer than 30 sessions.

One needs to stay mindful of the fact that different sports and even different tasks within the same sports are likely to require a totally different pattern of activation in the brain and the autonomic nervous system. Another important concept to keep in mind is that, in assessment and training for peak performance, practitioners need to pay attention to the fact that various EEG frequencies can have a functional significance that is individually very different. Most importantly, considering the implication of the lateralized Alpha activity in optimal response preparation, Klimesch (1999) defined the individual Alpha peak frequency (IAF) as the frequency showing maximum power density peak within a large frequency range from 4 to 14Hz and therefore the Alpha band may or may not fall within the 8–13Hz range as described in some of the EEG and neurofeedback literature. Considering this important factor, the assessment and training of Alpha may require a totally different frequency range which is again personalized and unique to that individual.

Summary

There is significant evidence of changes in EEG during good and poor performance and even different EEG patterns depending upon the nature of the sport. The use of EEG for recovery from post-concussion syndrome is beginning to be utilized. A few controlled studies also support the findings that NFB improves sport performance. As many people report case studies using neurofeedback in sport, a major limitation is the lack of publication of what has been done and how successful it has been.

The following chapters in this section will present more specific applications of EEG biofeedback/neurofeedback for attentional improvement and in specific sport applications (e.g., golf).

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Using EEG for Enhancing Performance: Arousal, Attention, Self Talk, and Imagery
Chapter 8

by

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Abstract

Control of arousal, attention, self talk, and imagery are some of the sport psychology skills that are important for performing at one's best and are appropriate for training using neurofeedback or brain training. This chapter outlines an assessment program used with athletes to determine inattention, ability to focus, imagery ability, and the ability to shut down extraneous self talk. The chapter includes the EEG measures, multiple assessment tasks, and the meaning of the results as used in sport performance. Useful information on how the information is interpreted and presented to the athlete is presented in the last part of the assessment section. Examples of clinical neurofeedback training in sport from two clinics are shown, including instruction in how to design and implement the training. Lastly, for athletes and coaches who do not have access to neurofeedback training, practical exercises that increase an athlete's ability to direct and control attention are included.

Chapter Outline

I. Clinical Use of EEG for Assessment and Training

II. Exercises for Enhancing Attentional States

III. Future Trends for Training

IV. References

"... it was very important to visually see my brain working on a screen because it was there—black and white. No tricking my own mind to this or that...NFB and conversation made me aware of things I did not realize were happening." —Katy, professional athlete

Control of arousal, attention, self talk, and imagery are some of the sport psychology skills that have been identified as important for performing at one's best (Williams, 2006). We believe these four skills are most appropriate for training and amenable to biofeedback and neurofeedback training. This chapter will build on the Introduction to EEG chapter by providing examples of clinical neurofeedback training used in sport, including instruction in how to design and implement the training. The last section provides tips on how a coach, trainer, or sports consultant can provide practical exercises that increase an athlete's ability to direct his attention

Clinical Use of EEG for Assessment and Training

Guidelines and instructions in this section for using neurofeedback (NFB) with athletes are based upon the authors' decades-long work in clinical settings. These impressions are not based on controlled research studies; thus, care should be taken in the interpretation and application of this information. Only appropriately trained biofeedback and neurofeedback therapists and sports consultants should use these techniques.

EEG Assessment

The EEG assessment is one aspect of a total assessment when athletes seek assistance in enhancing performance. Personality profiles, interviews, documentation of performance strengths and weaknesses, and when possible, coach/parent assessments are obtained. A standard protocol, The Optimizing Performance and Health Suite (Wilson, 2007), has been developed by to obtain an assessment profile that determines the psychophysiological system(s) that should be trained and in what order.

Special preparation for the EEG assessment of athletes includes determining pre-session physical exercise information as it significantly affects the EEG data. It is our experience that athletes typically show more

Theta EEG than a non-athlete in a resting situation because they tend to deactivate more quickly. This may be because of relaxation and resting that follows the hours spent in physical activity. Additionally, the time of day effects noted in other clients may be different for various athletes as they often have heavy physical training in the early morning and, thus, are not comparable to typical non-sport results.

Generally, electrodes are placed upon different locations on the scalp depending on the purpose of the assessment. Figure 8.1 shows an athlete (with the active electrode on FCz, the ground electrode on the forehead, and the reference electrodes linked to both ears) practicing the ready state in the sport position for receiving a serve in tennis. The pre-movement state can be cleanly recorded and assists in determining if the athlete is focused and calm before receiving the serve.

Figure 8.1: Athlete in ready position for tennis with active EEG electrode at FCz, ground on the forehead, and referenced to linked ears. Athlete gets into ready state of focused and calm, and then does a return of service. In-office training was extensive while the athlete was injured. The pre-movement state can be cleanly recorded and assists in determining if the athlete is focused and calm before receiving the serve.

In the assessment shown in Figure 8.2 (page 206), with the exception of the traditional Theta/Beta power ratio from attention deficit disorder research (Monastra, Lubar, & Linden, 1999, 2001), all indicators are considered experimental. The measures are derived from underlying physiological functions and research from the non-athlete populations (Thompson & Thompson, 2006). Our attentional profile includes several frequency bands that have been associated with improved performance. However, this has only been observed in clinical work with athletes, not in controlled studies. We use the profile as a guide in asking questions about the athlete's performance as indicated by the behavioral correlations linked to the EEG recordings (see Table 8.1). A full QEEG map may be recommended if a diagnosis of ADHD, learning disabilities, or other psychiatric conditions possibly exist.

EEG Ratios and Interpretations

Please refer to the Introduction to EEG chapter in this book for more explanations of EEG locations, frequencies, bandpasses, etc.

Table 8.1: EEG ratios and interpretations. The experimental ratios are what athletes report is their thinking pattern. For example, athletes who have high busy brain ratios (23–34Hz/13–15Hz) report tendencies to over-evaluate, judge, or ruminate.

Attentional abilities ratio: Theta power/Beta power or $(4\text{–}8\text{Hz})^2/(13\text{–}21\text{Hz})^2$

Lubar's Theta power–Beta ADD power ratio is used to establish the attentional ability of the athlete relative to a normative database. The ratio reflects the capacity of the brain's ability to pay attention when needed. High ratios suggest an inability to attend (more Theta: higher daydreaming and distraction). If there are serious deviations greater than two standard deviations from the age norms (Monastra, Lubar & Linden, 1999), the athlete is retested, and if the same reading is confirmed, the athlete is referred for assessment of attention deficit disorder from clinicians trained in that field. In athletes, our experience suggests there is a much higher rate of ADD than in the general population. Many athletes who do not report experiencing any attentional deficits are given Theta/Beta training for enhancing attention as we believe they can further enhance their ability to attend more specifically and for longer periods, and elite performance of most sports depend upon these abilities.

Problem solving ratio: 6–10/11–12Hz

A second type of slow-wave ratio includes high frequency Theta and low-frequency Alpha, which Lubar called "Thalpha." Data on this ratio are being collected on individuals with attention deficit disorders and elite athletes, but it requires further investigation and publications. Typically, in adults and athletes, the ratio is less than two unless the individual is tuning out mentally. Seldom do athletes score above two in this area as they have learned and practiced tuning in for years. We hypothesize that low ratios suggest the ability to solve problems in an efficient manner

Intensity/trying too hard ratio: 19–22Hz/11–12Hz

This ratio reflects important aspects of the mental state of athletes or executives who report having a high intensity or sometimes a try too hard response when performing. The clinician should ascertain whether anxiety is a possibility when the athlete ratio score is above 1.0.

Busy brain ratio: 23–34Hz/13–15Hz

This ratio may prove to be as important as the traditional Theta/Beta ratio used for assessing the most common subtypes of attention deficit disorders in adults as it may indicate the individual is processing too much or experiencing a nonproductive busy brain. Clinically, adults who are high in this ratio report a large number of ideas both positive and negative. It indicates the brain is active when it should be calm and highly focused on the single task at hand (Thompson, 2006). Calm athletes typically score between 1 and 1.25 in the busy brain ratio. Additionally, athletes who report doing a lot of self-evaluation, judgment, rumination, or over thinking in their sports, especially under the stress of competition, have a ratio above 1.5.

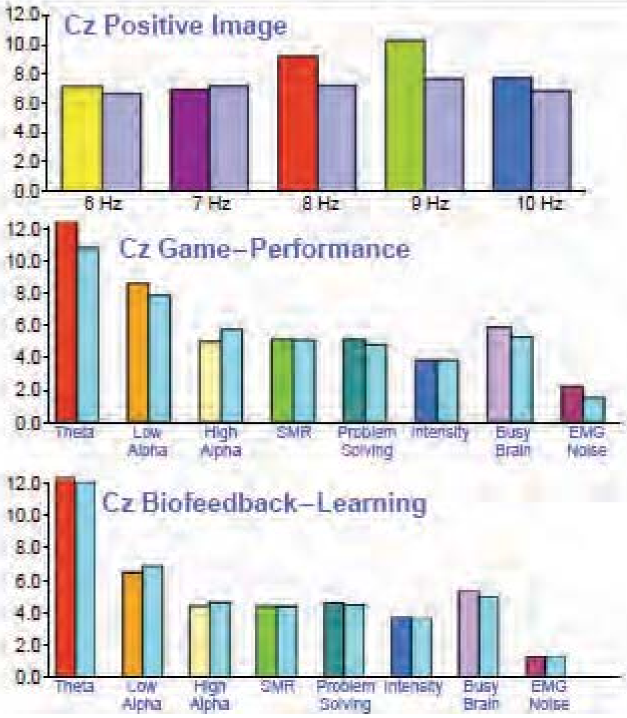
When the intensity and busy brain ratios are high, they are indicative of an athlete who is trying too hard and/or talking himself through the action phase of the performance. Both of these cognitive processes interfere with the flow of the performance, which should be automatic in high performers.

Imagery: 7, 8, or 9Hz

The ability to do imagery is assessed by comparing whether the athlete's sport image has higher slow-frequency amplitude than a baseline. Imagery is performed with the eyes closed and then compared with a baseline of eyes open. Using an eyes-open baseline would not be appropriate as EEG frequencies change amplitude when a person closes the eyes. The peak frequency of an athlete reporting doing sport imagery may be 7, 8, or 9Hz. Clinically athletes who report exceptional vividness and ability to manipulate images typically have much higher amplitudes during the imagery than baseline. The athlete's amplitude (i.e., height of the bar on a display screen) typically decreases when the athlete reports losing the image or becoming tired.

Figure 8.2: Sample report of an EEG assessment of an athlete. The data recorded from Cz (the vertex or most center point on the scalp) are compared with either normative data or with the athlete's own sport group and then across time, with his or her own past data. Following the figure is a capsule explanation used in reviewing the ratios.

Cz	Events Baseline (Eyes Open)	Math (Working Memory)	Game (Performance)	Biofeedback (Learning)
t/beta Ratio	2.506	2.991	2.712	2.561
Problem Solving	1.091	0.991	0.998	1.049
Intensity	0.695	1.069	0.763	0.860
Busy Brain	1.268	1.431	1.154	1.213



Performance and Learning

The use of the brain while performing is assessed while the athlete attends to a reaction type task, (e.g., React Trak, Thought Technology), and is compared with eyes-open baseline. In this game (see figure 8.3), the athlete has to remain very attentive as a ball randomly moves from side to side while the athlete has to use the mouse key to keep the ball from falling off the screen. The athlete often reports a more competition like attitude and response when playing the game.

Figure 8.3: React Trak requires the athlete to use the mouse key on the computer and move the ball right or left to keep it within the side bars and keep the ball from moving beyond the goal lines. The task requires a very narrow focus of attention and good reaction time skills. Athletes find it a challenge not to lose attention momentarily.

While a psychophysiological profile is reviewed in the context of the total information collected from the athlete's interview and paper-and-pencil evaluation, the following description is a simplified interpretation of the athlete illustrated in Fig 8.2. In this assessment, the athlete is showing the most activity in the Theta range (which is normal for a young athlete), followed by the majority of activity in the busy-brain range. The scores are not extreme in this quiet office setting but suggest questions should be asked about whether she has problems “thinking too much and self-evaluation” during competition. Both the coach and athlete confirm this is the situation but only during high-level competition or critical situations. Thus, some of the NFB training focuses on her imagining past situations in which she has overanalyzed or had rapid “stinkin’ thinking” to help shift her brain activity into a calm (enhanced SMR) and focused (lower Theta) state without evaluation and judgment.

While the athlete is learning how to control her breathing at about six breaths per minute while also maintaining low muscle tension in the shoulders the brain is monitored. The clinician is looking to see if the EEG profile is different when learning new tasks as compared to when performing an already-learned task. The purpose of including EEG during learning is that some athletes only show atypical responses in the office when they are required to learn a new task. In this example, the athlete has a tendency to over-evaluate but does not show extreme attentional disorders in this learning setting.

The athlete’s comments and body responses to each of the tasks throughout the assessment are noted by the clinician. This feedback allows the clinician opportunities to determine what the athlete was thinking and how she was feeling and then post-hoc compare that information with the EEG recordings. Parents who often observe the assessment are amazed and exclaim, “You have pegged my child perfectly” when the EEG information is interpreted in light of the behavior and comments of the athlete during the assessment.

In summary, a psychophysiological assessment, including the EEG assessment or QEEG map analyzes the athlete’s reactions to different types of tasks, different degrees of mind and body responses, and while under differing levels of stress. The athlete (and often the parent or coach) is consulted as to whether these responses are representative of the thoughts and behaviors of the athlete during practice and competition. Once concurrence is received, the profile is checked for atypical and significant differences, and if any exist, it may be appropriate to refer the athlete for further assessment. Typically, the athlete, parent, and coach agree that the assessment captures the athlete's performance process, leading to an appropriate design of biofeedback, neurofeedback, mental skill exercises, and changes in practice and competition routines.

EEG Training or Neurofeedback

There are many commercial companies that provide equipment and programs that can be used to train athletes; however, not all EEG equipment has equal capabilities nor do all clinicians have equal knowledge and skill. Check with professional associations (AAPB, ISNR, BFE, BCIA[1]) or universities as to what equipment has been used for your specific purposes and what professionals have the necessary qualifications and experience to perform neurofeedback. For additional information, refer to chapter 13 of this book.

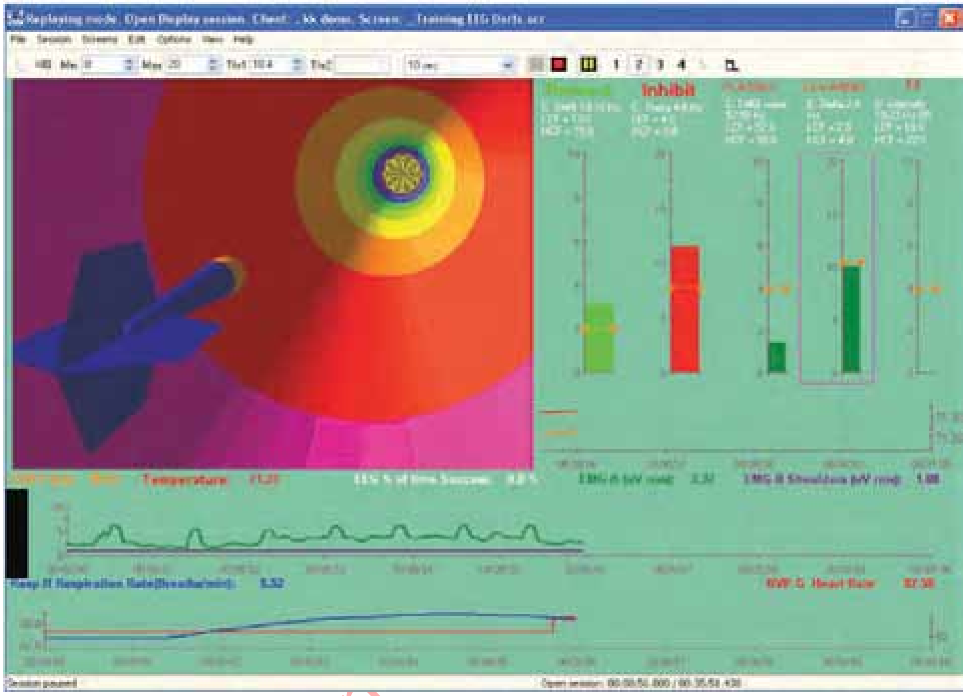
Following the findings from the psychophysiological assessment, including the EEG, the training focuses upon the factor that is most relevant for enhancing the sport performance. For example, if muscle tension in the shoulders is high, and muscle tension interferes with performance, the athlete practices muscle biofeedback in the office, at home with a portable surface muscle recording machine (sEMG), and sometimes, live during the sport setting with sEMG telemetry. Often, the athlete's ability to control muscle tension is demonstrated in the first session and then merely needs constant reinforcement in the sport setting to maintain the appropriate level of relaxation. This is practiced in their performance preparation plan (P3), which is a routine practiced in training and competition until it becomes rote (see LSR in chapter 5 for more details). Other systems, such as blood flow and effortless breathing, often require biofeedback and longer periods of practice before changes are noticed. In our experience, it is valuable to present system physiology biofeedback (such as muscles or respiration) first before EEG biofeedback/neurofeedback as the changes in these systems are easiest to

[1]AAPB: Association for Applied Psychophysiology and Biofeedback, www.aapb.org.
BFE: Biofeedback Foundation of Europe, www.bfe.org.
BCIA: Biofeedback Certification Institute of America, www.bcia.org.
ISNR: International Society for Neurofeedback and Research, www.isnr.org.

understand, and changes can be demonstrated very quickly. Generally, biofeedback is used to demonstrate the following emotion/body effects: skin conductance or sweat response, muscle relaxation or tension (sEMG), increased blood flow (temperature), breath training (respiration, RSA), physical recovery following injury (sEMG, temperature), and reducing performing efforts (sEMG, respiration). Please refer to other chapters in this book for a more detailed discussion of these modalities. Neurofeedback is introduced first if attention is the only component the athlete deems necessary to train. Other biofeedback modalities are still monitored even if EEG is the primary system of interest.

Typically, in the first NFB attention training session, the athlete is requested to calm his mind and focus his attention on a display screen, for example, a dart moving toward a target (see Figure 8.4) while using FCz as the training site. The dart screen mimics the skill of following or visually tracking a target that is required in sports such as tennis and badminton or in sports that use a goalie. This allows training over the motor strip and may pick up frontal 3–10Hz activity when it is too high. At this site, it is also possible to influence anterior cingulate activity, which is important for improving attention and for working with anxiety when it is present. Additionally, the athlete's respiration and shoulder muscle tension are tracked to ensure there is no unnecessary holding of the breath or tightening of the muscles while practicing EEG NFB. The artifact filter settings for controlling eye movement and sleep waves assure the clinician the athlete is only being rewarded for the calm and focused state. The inclusion of the other physiological measures, such as breathing and muscle tension, requires the athlete to maintain healthy body responses while training the mind.

Figure 8.4: With the dart training screen, the athlete moves the dart to the target by remaining focused and calm. The athlete's heart rate, respiration, muscle tension, temperature, and sweat response also indicate the state of the athlete's body responses during the task. Typically the training electrode is on FCz or the left side of the head.



The next NFB training screen (see Figure 8.5) is a favorite of athletes and is used after the dart screen. The athlete must again maintain a calm focus (SMR enhancement) for the top mouse to walk forward and maintain less distraction (Theta reduction) for the bottom mouse to walk forward. Muscle tension will stop both mice from walking. Thresholds (a value that determines whether the person is succeeding and the mice walk forward) are set based on the pre-assessments for each person with success set for about 66 percent with shaping down to 50 percent after three or four sessions. The benefits of this screen are the complexity of information that can distract an athlete, which is similar to competition, and the requirement of the athlete to maintain a single focus. Additionally, when the mouse approaches the end of the screen, athletes will try to push the mouse, which is very similar to what they report doing in a critical moment of competition when they try too hard. Therefore, this screen has the additional benefit of training the athlete to learn to let go.

Figure 8.5: The mouse screen is typically used after the dart screen, as the athlete is required to be aware of more than one event. The task is to make both mice walk across the screen. The top mouse walks if the athlete remains calm, and the bottom mouse walks if the athlete stays focused.

In this screen, if the athlete does not remain calm, the top mouse walks backward, and the bottom mouse walks backward, if the athlete loses focus. Typically athletes tend to try too hard when the mouse approaches the end of the screen, and one or both of the mice walk backward.

The length of training trials depends on the sport requirements. For example, if a tennis point lasts an average of 20 seconds, the training trial is structured to last for 30 seconds, so there is a 25-second break to simulate a match. The number of practice trials is increased in an effort to get the athlete to be able to increase the training/mental recovery to as long a period as possible. Typically 20- to 30-minute training trial lengths are achieved. Other training display screens can be used in which the desired EEG feedback signal is represented by bowling or sailboat racing;

however, in each training program, training lengths are similar to those of the sport performance. If the EEG assessment demonstrates high-amplitude, high-frequency (20–35Hz) Beta, this may correlate with the athlete over-thinking (busy brain). In these cases, suppressing this high-frequency Beta is added to the training screens at the site or scalp location where it dominates. An additional electrode may be added on the left side of the head, typically at T3, to monitor areas associated with verbal processing activity such as self-talk.

After the athlete shows some control over his ability to stay calm and focused, then the athlete is challenged by a very competitive computer game: the React Trak. Before the athlete is allowed to play the competitive computer game, he has to obtain the calm and focused state (Theta and Beta below previously set levels) with the muscles relaxed and the breathing slow and deep. These measures are shown on the screen with the React Trak. The objective is for the athlete to practice his pre-performance state prior to actually performing. This state can be reinforced by the coach requesting the athlete to obtain the pre-performance state in the practice setting.

After the biofeedback trial is over, the athlete again practices his readiness plan (P3) with the psychophysiological measures returning to the performance-state levels, and then the game begins again. This also should be performed within a specified timeframe that is relevant for each sport. For example, in tennis, the rest periods are 25 seconds. In swimming, the rest periods are irrelevant, so discussion of the past trial is undertaken. However, the length of time the athlete is asked to attend in succeeding trials increases until attention can be maintained for the entire length of the event or the athlete shows the ability to refocus immediately if attention is lost.

A limitation of EEG biofeedback with athletes is that almost all the research data has been recorded from people sitting or standing quietly, and what athletes actually do during game performance may not be the same. An ideal training environment would include wireless feedback that could provide immediate sound or pressure information while the athlete is practicing or competing. Psychophysiological information can be monitored in real-time via telemetry or downloaded later to a computer for review and assessment. We have just begun to use telemetry for monitoring when an athlete is practicing, and we provide the verbal cues as to his current muscle-tension level, respiration, heart rate, and sweat response. Unless the athlete has a stop position in the sport setting, such as archery, golf, or shooting, we have been unable to obtain reliable EEG measures because of movement artifacts that corrupt the recorded data. However, equipment manufacturers are currently working on methods to decrease EEG artifact during sport movements.

Another neurofeedback approach for sport performance is to determine what is needed for each section of the sport skill and then to practice the ideal state for each part of the skill in the clinic. Below is an example of a training program for a professional golfer. In the initial assessment, it is important to focus on the EEG and psychophysiological findings at each stage of the specific athletic performance.

The professional golfer's initial resting EEG was higher than expected in the EEG bands of 5–9Hz (Theta), 19–22Hz (high Beta), and 23–35Hz (EMG). Her bursts of high-frequency Beta were accompanied by low high Alpha (11–12Hz) and low SMR (13–15Hz). When psychophysiological variables were assessed during stress, her breathing rate became irregular, shallow, and rapid; her skin temperature decreased; and her shoulders (trapezius muscles) increased in tension. When demonstrating putting, she approached the ball and, through her backswing, her EEG showed increased 23–35Hz activity with a large peak at 26Hz. Her high Alpha and SMR decreased, and her 23–35Hz/13–15Hz ratio was 1.9 or greater. As she felt stressed (her description), her breathing became shallow and irregular while her trapezius and forearm musculature became very tense.

She confirmed that during her approach to the ball and in the backswing she recognized she was ruminating and worrying about the outcome of the shot, and she was anxious about how people in the audience were evaluating her. NFB plus BFB training allowed her to gain control over her mental state. After practice, she was asked to perform a demonstration that consisted of a series of steps. It became apparent that, for any stroke, her EEG record had to be reviewed and analyzed over the total time period. She, like other athletes, is appropriately mentally flexible and, therefore, a sequence of EEG patterns would correspond to different mental states as she went through the various steps associated with a successful putt. To successfully putt from 12 feet, she would need to perform the following sequential steps (if she missed any steps her performance decreased):

1. Stand three feet away from the ball relaxing her face, shoulders, and arms—respiration decreases to six brpm, trapezius and forearm EMG to as low as 0.8 µV, 20–35Hz falls virtually to the baseline. (Refer to the LSR chapter for further explanation of these measures).

2. Beta at 17Hz increases as one judges the distance, grass conditions, wind, slope, and surface angles.

3. Step up to the ball, bend to the correct position to putt with eyes vertically over the ball, arms hanging totally relaxed—EMG remains low (around 0.9 to 1.1 µV) as SMR rises.

4. When mentally relaxed but focused, visualize the putt: 7–9Hz will rise briefly.

5. See only the hole and the course the ball will take. Enter a completely mentally relaxed state, a state of being mentally open yet maintaining focused awareness. See the whole picture of the ball, grass line to the hole, and the hole. In this state, 11–12Hz will rise. All other thoughts or awareness of noise and people around are gone. (20–32Hz will drop markedly, and 11–15Hz will rise). At this point, exhale (diaphragmatic breathing is maintained at six brpm) and putt.

6. At the completion of the putt, remain in the calm mental state for two to four seconds while mentally following through and sensing the ball going into the hole. At this point 9Hz may rise.

There are several lessons to be gleaned from this example. First, she said the real key to her performance was decreasing the high-amplitude, high-frequency Beta EEG activity between 20 and 35Hz. She came up with an appropriate phrase when she said, “I must empty my mind.” She noted that when she did this she could relax and her breathing slowed and became regular and diaphragmatic, her muscle tension dropped dramatically, and her hands felt warm. Second, it could easily be seen when everything was recorded that, prior to her stepping up to the ball and continuing until the ball completed its run, there were EEG changes that corresponded to different mental tasks during the shot. For example, 11–12Hz desynchronized, or become less consistent, when she was in a mental state of problem solving and producing 15–18Hz Beta. It became clear that the average EEG amplitudes, though helpful, do not tell the whole story and can even be misleading. For example, a raised 7–8Hz at the wrong time could mean she was internally distracted. Produced at the correct time in the sequence, it was good evidence of visualizing the shot. Every sport and every activity will have its own unique sequence. However, all sports have in common a need for self-regulation and control of both the brainwave patterns and other psychophysiological variables (Thompson & Thompson, 2003).

Wes Sime (Sime & Silverman, 2008) provides the following description of how he adapts the EEG training for golfers. The duration of attention needed to complete a golf swing while in the zone is not long (one to two seconds). But if golfers do not guard against it, they can lapse into doubt about club selection, the effect of the wind on the shot at hand, the looming water hazard guarding the green, or their ability to pull off the shot in the last second or two before completing the swing. Doubt is the death of any golf swing.

One highly acclaimed legend of golf, Tommy Bolt, had an ideal description for his vulnerability during the critical milliseconds during his swing. The consultant was trying to explain to Bolt how EEG biofeedback could identify the fragile nature of attention with an example of a figurative mirror on the mind.

While explaining how the mind can be hijacked from its original intent into a distracting thought or emotion, resulting in a deviant swing change out of desperation or panic, Bolt interrupted the conversation. He extended his hand and said, “Sonny, I know exactly what you are talking about. I’ll bet that in my career as a professional golfer, I have changed my mind in mid-swing at least 10,000 times.”

To counter the vulnerability to mind hijacking, Sime discussed the use of a tracking exercise; wherein, the computer's mouse is the controller battling against the randomly generated shifting movement of a golf ball on the screen (see React Track). This video exercise requires exceptional eye-hand coordination for successfully controlling the shifting of the golf ball. Instantaneously, EEG feedback and a score in performance tells the client how well he is able to remain focused on the task at hand and how long he maintained an efficient level of attention. Typically an athlete will show high Theta if they lose focus.

Exercises for Enhancing Attentional States

Most athletes do not have access to neurofeedback, but they can still improve their attentional abilities by practicing sport-relevant skills.

Why is this skill called attention? Simply stated, attention is the athlete's capacity to focus and concentrate on relevant information/patterns/signals the person has selected. This can equally include attending internally (what is occurring in the athlete's mind and body) or externally (what is occurring outside the athlete's mind/body) in order to complete a thought or task. The athlete may be aware of other information that is not relevant, but being able to pay attention means he can either ignore or, at least, not be distracted by irrelevant signals and, therefore, attend to what task needs to be completed immediately. Attention is an integral part of preparation for performance as well as being critical to the action within the actual performance. Attention has also been found to relate to the quality of one's performance. For example, expert athletes have been found to be able to attend better than novices are, and how one attends is different between good performance and poorer performance. Thus, not only is paying attention important, but how one attends is important, too. Attention ranges from narrow focus to open focus awareness (non-thinking, reactive state). What is termed a broad, open focus in sport is similar to what is called non directive in meditation. The objective is to allow information from the senses to come in but to neither react nor judge them. This is probably correlated to the increase in Alpha that is seen in the speech areas of the brain (left side, frontal-temporal). Classes in meditation, cognitive relaxation, or attentional balancing exercises (Wilson & Cummings, 2002) can improve one's ability to let go and let it happen. Whether the skill is open-focus or focused attention, it can be enhanced. We prefer to call attention a skill rather than ability because it is trainable. Through appropriate practices, people can enhance this skill.

Unfortunately, when coaches exhort an athlete to pay attention, they usually have no idea of the complexity of the skill they are requesting. The processing of attention to action typically involves the entire brain with the processing typically involving cross-talk occurring between the front of the brain (where executive decisions about when, where, and how to attend are made) and the back of the brain (the visual processing area). Humphreys & Riddoch (2005) suggest there are two interrelated but separate systems; a lower-level system that works on input or the perceptual selection of what one attends to and a higher-level system that performs selections from memory/motor systems for actions related to that perception. The perception and action systems are interrelated, which further complicates the process of paying attention. Finally, if the athlete has not fully learned this attentional skill and he tries to guide or control the action or is making irrelevant self-conversation, there is additional brain processing between the prefrontal and the pre-motor cortex, which typically slows the response or causes interference. No wonder attention is cited first by coaches as the area in sport psychology in which the most assistance is needed.

The ability to attend is partly a hereditary or predisposing trait as well as a skill, which can be modified and improved with practice. The brain processing involved in attention has been shown to be significantly affected by, but not limited to, personality, sleep, stress, drugs, hormones, sex, age, and other factors. Understanding that there are individual differences in attentional style is critical in that no one athlete has the same attentional abilities or styles or sees and attends in the same way. Thus, drills or training protocols will not necessarily work the same way for everyone, nor can one expect the same results from using the same protocol on every athlete. Each protocol should be individually adapted for the individual athlete and the specific sport.

Attention Skill Training

This section will provide examples of how attention can be practiced in various sport settings. It specifically explores in detail 1) where to attend, 2) when to attend, 3) how to attend, and 4) structured routines. Further examples and drills can be found in the chapter entitled “Training Concentration in Athletes” in the book called Applied Sport Psychology (Wilson, Peper, & Schmid, 2006).

1. Where to Attend

While the ideal attention for elite performance may be being (not thinking) and just being in flow (Singer, Lidor, & Cauraugh, 1993), it seldom occurs. Thus, a backup plan for what to attend to, how to attend, and when to attend is needed. Coaches and athletes need to know not only where and what they need to attend to within different sport situations but also devise drills/games to allow the athlete opportunities to practice the sport’s situation-specific attentional skills. Once the skills have been learned in a relatively stress-free environment, the coach should add additional challenges in order for the athlete to practice them in an overload situation. An example of how important it is to know what to focus on is demonstrated by the following priming practice example.

Exercise:
For one minute, scan the room or court and find everything that is green...Now, close your eyes and describe how many things in the room are blue. You may not remember any blue items as you were primed to look for something else (green). The same effect occurs in sport. If you are primed, you are more likely to see it, see it in more detail, and see it more quickly.

Exercise: Priming Practice

Motor learning research (Beilock et al., 2002; Perkins-Ceccato et al., 2003; Wulf & Prinz, 2001) suggests that after a skill is learned, athletes perform better when they focus on external cues (such as the desired effect) rather than focusing on the step-by-step process of how to perform. For example, a golfer would see the ball go into the cup. A tennis player would focus on seeing/telling the ball to land on the inside corner of the service box. If focusing on the ball going into the cup (golf) or landing in the corner (tennis) creates anxiety in the athlete, he may prefer to focus (saying, seeing, or doing) on a cue or activity that enhances the performance at that moment (such as using a cue word for relaxation, e.g., "loose shoulders," or humming for rhythm). Athletes often have to experiment to find what cue works best for them, as the increased arousal during competition may change their mechanics or their cognitive processing speed.

Not only do athletes need to know where and how to look when learning new sport situations, coaches need to tell athletes what to look for in each situation. They need to create drills that allow the athlete to practice different attentional strategies. For example, in sports that require guarding an opponent (such as basketball), the athlete typically focuses on the opponent's midsection rather than the head or ball. After drills in which the opponent fakes as many ways as possible, the defensive player then is given drills that require watching the opponent while, at the same time, being aware of the location of everyone else on the court. Coaches can ask the player to verbally yell out cue words or point one arm to the opponent and one arm to the location of the ball. Research in volleyball (Adolphe, Vickers, & Laplante, 1997) and basketball (Harle & Vickers, 2001) suggests incorporating attention drills in the practice setting improves sport performance. What is critical is that the drills are sport-relevant.

In sports where the spin of the ball is important information to attend to, an athlete can enhance the speed of detecting the spin by practicing with balls that are colored only on one side. The half-colored balls highlight the spin on the ball as it leaves an opponent's racquet or hand. In gun- or whistle-start sports, such as swimming and track, different levels of sound can be used to sensitize the athlete. The gun sound is muffled or made louder than normal during practice in addition to using normal sound. The training is made even more challenging by increases in additional stressors such as noise, movement distractions, or coaches comments that focus on the importance of doing well (reward or punishment). In practicing attention drills, the athlete is trained to just pay attention when the gun/whistle goes off. Coaches need to remind athletes to remain in the optimal performance zone as they practice attention in the overload or simulation situations. Under increased stress, athletes need to inhibit the tendency to tighten their muscles and hold their breath, which are attentional bracing patterns that tend to interfere with the speed of the start reaction.

Exercise: Freeze Drill

For closed-skill sports (where routines are presented and the sequence is totally under control by the athlete), such as skating or gymnastics, it is often helpful to have athletes walk, talk, and see the routine in each segment of the event. Have them repeat the sequence at least twice, as the first time they typically report only what the coach has told them. The second or third time, the clinician walks through it with them, and they begin to come up with better insights as to what they are really thinking or doing. Sometimes the words, feelings, or attention that occurs when the skill was successful can be compared with what occurred when the skill was not successful. For example, a tennis player who used the word "explode" while serving in an attempt to obtain an ace in a critical moment during matches was less successful than other times. He probably tightened his shoulder muscles, which reduced flexibility and, thus, speed and mechanics of the shoulders, so the ball went into the net. Possibly, the word explode may not be the right choice, or he needs to be able to create the mechanics with the word that allows for successful serves. The coach and athlete are reminded that the arsenal of skills, along with the appropriate mind/body zones (P3), need to be practiced and then maintained in the critical moments before competition. This is not the time to try new attentional strategies; it is time to evoke well-established, conditioned routines.

Exercise:
A similar concept can be applied to team sport practices to train field positional awareness and attention. For example, a coach can yell, "freeze" and the players have to immediately stop and close their eyes. The coach then asks the players or a selected player where everyone is on the floor and the location of the ball or puck.

2. When to attend

It is impossible to attend all the time; hence training athletes to attend at the appropriate time and in the appropriate sequence enhances optimum performance and allows for regeneration. Like all body processes, attention needs periods of inattention for regeneration.

Adolphe, Vickers, and Laplante (1997) found that experts in volleyball attended to the flight of the ball during the moment of the quiet eye, before they began their movements. Less skilled players moved and also attended to the ball. It was as if the experts waited to see where to move before beginning the move. The quiet eye is a brief moment of eye fixation that has been noted just before good performance. Sterman, Mann, Kaiser, and Suyenobu (1994) noted in EEG research with cats during the 1970s and 1980s that sensorimotor EEG rhythm (SMR) is seen exclusively during alert quiescence and is suppressed by voluntary or imposed movements. Thus, it is reasonable to propose that the quiet eye is a downstream product of SMR, and training athletes to enhance SMR should result in the behavioral patterns noted in elite athletes or noted after training athletes to enhance the quiet eye.

Athletes and coaches may also wish to improve reaction time in sports for which reaction time is critical (such as in 100-meter runs). In general, we found most athletes improved their reaction time by increasing the athlete's heart rate (but maintaining muscle relaxation) and then, just before the firing of the start gun, holding their breath during the quiet eye moment. By using this strategy, they are able to explode more quickly out of the blocks (Wilson, 2001).

3. How to attend

Equally as important as where to attend and when to attend is the final component: how to attend. Two major how-to-attend techniques are intention and focusing on what you want. How to attend begins with the athlete's intention, which is the preparation of the brain to tell the athlete where to pay attention. Intention affects not only attention but also effort, and thus, it affects all the mind/body responses. Research (Latash & Jaric, 1998; Theodorakis, Laparidis, & Kioumourtzoglou, 1998; Thill, Bryche, Pourmarat, & Rigoulet, 1997) has shown that the intent of an individual affects performance even when the individual is trying to maintain maximum effort. The following concept and exercise illustrates the effect of intention.

Exercise: Denting the Wall (Intention)

The intentions should be specified before the skill is performed. You can repeat the above game using different feelings (happy, sad, or angry) or qualities (smooth, rhythmical, or accurate) or outcomes (high inside or low outside) depending on the nature of your sport skill. A caution is in order: Whatever words or pictures or sounds you choose, they should be concurrent with the actual movement to make sure they match the performance that is needed.

For example, an athlete coming out of the starting blocks used the word “explode” to facilitate fast arm action at the sound of the gun. When checking his reaction time, it was faster with the cue words. However, he also altered his body position to an incorrect posture of standing up too soon. After experimenting with words, he decided on the cue “snap,” which allowed him to acquire both the faster arm action necessary for a quick start and to be in the proper body position coming out of the blocks.

> Exercise:
> Toss a ball against the wall two or three times. Judge or time how fast the ball traveled. Now toss the ball again trying as hard as you can and judge the speed of the ball. Finally, before you toss the ball, see the ball create a dent in the wall or go through the wall and add a sound or word that makes the ball even more forceful. Toss the ball and judge the speed. For most athletes the ball will go faster in the last setting.

A second method of how to attend is not to focus on what you do not want but to focus on what you do want. Try this concept exercise:

> Exercise:
> Do not focus on a lemon. Do not notice the color of the yellow lemon, nor pay attention to its bumpy surface. You can’t smell its tangy smell, and you can’t taste how bitter it is as you put a juicy slice into your mouth. You probably saw, smelled, and tasted the lemon. The negative words don’t, no, etc. are not retained as well as the sensory words, yellow, lemon, bitter, etc. Similarly, most people have heard about the coach who went to the pitcher’s mound and told the player, “whatever you do, do not throw the ball high and outside” and promptly left the mound. The pitcher threw it high and outside. The coach probably would have had more success if he clearly stated what he wanted: “Throw the ball low and inside.”

Exercise: Lemon

Similarly, if you are telling yourself not to be nervous, your brain will first have to evoke the memory and somatic experience of nervousness thereby capturing and creating actual nervousness. Instead, you should focus on what you want, such as slowing your breathing, relaxing your shoulders, or looking for the ball, etc. This concept is easily experienced in the following concept exercise (adapted from Peper, Gibney, & Holt, 2002) in which thinking/remembering helpless, hopeless, and powerless memories reduces strength and competence while thinking/remembering positive and empowering memories enhances strength.

Exercise: Positive-Negative Thinking

Note: This exercise is done in pairs. Begin by standing facing each other. Identify who is the subject and who is the experimenter.

Exercise:

- Begin by testing the strength of the subject's arms. The subject extends his left arm straight out to the side and holds it in a horizontal position. The experimenter places his right hand on top of the subject's left wrist and gently applies downward pressure while the subject resists. The experimenter slowly increases the pressure until he senses when the subject can no longer hold the arm in a horizontal position. Relax and repeat the test with subject's right arm.
- Identify which arm appears stronger and more able to resist the downward pressure.
- Now, with both arms hanging at his side, the subject is to mentally evoke a past memory or experience in which he felt either hopeless, helpless, and powerless or empowered, positive, and successful. (If the subject is unable to quickly remember an experience, he can just make one up.)
- Do not reveal to the experimenter which memory is chosen.
- After choosing one of the above, think about the memory and make it as real as possible—feel it, hear it, and so forth. The goal is to quickly have a felt-sense of that memory. Then, when the experience is felt, extend the stronger arm straight out to the side. The experimenter, once again, tests the strength of the arm by pressing down on the wrist.

- After being tested, without saying anything or describing the experience to each other, the subject lets go of the memory and drops his arm to his side. He then evokes the opposite memory, making it as real as possible. When the subject feels the experience, he raises his strong arm again, and the experimenter tests the strength of the arm by pressing down on the wrist.
- When done, reverse roles and repeat the same exercise.
- Now the athletes compare their experiences.
- Observation: In almost all cases, when people thought of the hopeless, helpless, and powerless memory, they had significantly less strength than when they thought of the empowering, positive, and successful memory. With the hopeless, helpless, and powerless memory, the arm is much easier to press down, the subject experienced a lack of oomph and a sense of not being able to resist—as if the whole body just collapsed and let go. With the empowering, positive, and successful memory, the experimenter needed to apply more pressure to the subject's arm, and the subject experienced a sense of energy and ability to resist the pressure.

The importance of intention and what to focus on is critical for performance. What and how we think impacts our performance. To repeat: What we focus on is what is most likely to occur; therefore, focus on what you want, not what you do not want.

Sime (Sime & Silverman, 2008) provides this example of how to attend in a playful manner and the importance of practicing. If you recall, several years ago there was a TV commercial featuring highly acclaimed golfer Tiger Woods. With one hand, he wiggled the front edge of his wedge under a golf ball and then flicked the ball straight up into the air. He then proceeded to keep the ball airborne between multiple hits on the face of the club. Today, that particular mind/body exercise is quite common out on the PGA Tour and with some amateur golfers. It is possible to bounce the ball on the face of the club much like the inverse of dribbling a basketball. However, what Woods did to increase the difficulty of the exercise was to move around while bouncing the ball, and then he maneuvered the club through his legs from behind alternating between bounces. This is an unbelievably difficult task because of the interruption of eye contact (tracking the ball) with the ball and the club face as the club moved beneath Woods' leg. We heard the television crew had to take many shots of the exercise before Woods got it just right. In the final scene of the commercial, Woods flicked the ball straight up to shoulder height, made a half body turn, and hit the ball in midair with a full swing.

That was an awesome exercise in attention and focus—even if it was completed with multiple retakes for the cameras. Regardless, the feat Woods accomplished with this drill is, no doubt, related in some way to the remarkable focus he exhibits for days at a time while out on tour. However, please understand this high level of personal achievement and mental discipline is quite elusive, even for Woods. From the coverage he receives, you will notice that from time to time even Woods' level of mind/body control is not sufficient either to make the cut or to score high up on the field. Woods may have stumbled onto training and mental discipline activities which shine on most occasions, but we know it is possible to further hone and shape those attention skills even further, systematically, to achieve even greater consistency in performance using attention skills and neurofeedback training.

4. Structure routines

Pre-performance and maintenance routines are important for consistent sport performance (Singer, 2002). Athletes need to remember to use their plan or performance preparation plan (see P3 in LSR chapter). The athlete needs to practice the plan under different conditions in order to become aware of the small changes during stress and how to readjust the mind and body to maintain performance. Athletes are typically not aware that their arousal level is often too high during competition, and thus, the sport mechanics are slightly different. By over-learning how to maintain a routine during all situations, it is expected that performance will remain high. Athletes and coaches should also be cautioned that the most important part of a performance is the actual performance and not the pre-performance routine. We have found athletes who have become experts in routines and then fail to perform consistently well in the competition. Some experienced athletes can forego routines and perform consistently well in competition. Experiment with each athlete and see what works best for the competition outcomes.

Future Trends for Training

Success in sport does not depend solely on the execution of a physical skill but rather on the proper execution of an appropriate plan. This means that prior to the physical execution of a skill there must be a planning process and readiness for action. As well, following execution, there must be an evaluation period to assess the effectiveness of the execution in order to refine or reinforce for the future. Successful practice then, requires a four-step loop: active planning, readiness for action, execution, and evaluation. This four step process is shown in Figure 8.6.

Figure 8.6: The four stages of practice

This four-stage practice process is the foundation of enhanced sport performance, which in the future will include dynamic and simultaneous physical monitoring to identify brain and body processes that may interfere with optimal performance. Training athletes in a virtual environment that allows for psychophysiological monitoring during all phases of practice allows for the greatest rate of return for training sessions. In the virtual reality (VR) environment, mind and body measures are constantly monitored and recorded using small, stick-on, wireless devices on the athlete that will not interfere with movements. As the athlete views the unfolding scenario on the simulator, tactile and sound feedback regarding the athlete's psychophysiological state can be immediately fed back to the athlete, so he can make appropriate adjustments. It can be set up such that the scenario will only run when the athlete is meeting the set thresholds of EEG and physiological measures.

The room has walls in front and on either side of the athlete. Projected on the walls is a 3D virtual-reality simulation of the sporting environment and the athlete is required to analyze (active planning), prepare (readiness for action), react and perform (execution), and then evaluate sport movements and outcomes appropriate to the simulations. Within this environment, the coach and athlete are given the opportunity not only to practice a physical skill, but also to monitor the neurological and somatic processes that leads to the execution of that skill.

Stage 1: Active Planning

The first stage in the practice process is the active planning stage. This stage requires attention, focus, and active cognitive processing in order to develop a performance strategy. In this phase, the athlete needs to engage the mind in active problem solving. This is measured as an increase in the production of EEG Beta activity and a reduction in Alpha and Theta activity in the cognitive processing areas of the brain. This period of active cognitive processing is coupled with the beginnings of a relaxed physiology (low muscle tension and sweat response, peripheral warmth, and slower breathing and heart rate).

Stage 2: Readiness for Action

Following the active planning stage, the athlete must become mentally and physically set for the readiness for action stage. This stage requires both a mental and physical letting go of process thoughts and inappropriate physiological tension (see Figure 8.7). The future of practice involves qualitative measures of both these processes in order to guide the athlete through the transition from the stage one, active planning process, to the stage two, readiness phases, where letting go of the active processing must occur. EEG measures monitor the cognitive planning and the mental letting go and reduction in self-talk during this transition (reduction in Beta, increases in Alpha/Theta). Physiological measures of muscle tension (sEMG), heart rate (HR), respiration, skin temperature, and electrodermal responses will measure physical readiness prior to movement initiation. Each athlete will have his own optimum performance profile. The physiological monitoring and reinforcing of optimal performance state improves the athlete's recognition of this state and improves the chances of reaching this state more quickly and easily. Taken together, stages one and two constitute the preparation phase.

Figure 8.7: Archer is training in the natural environment with active EEG electrode on FCz, ground on ear, and reference on the other ear. When the athlete began to think too much, he had a poorer shot. During the poor shots, his Beta waves increased. Practice continued with feedback to the archer to abort the shot if the Beta waves increased.

Stage 3: Execution

Once the athlete has quantitatively shown the proper mental and physical readiness through the preparation phase (stages one and two), the VR simulation is incorporated and will allow the athlete to perform the action. This third stage of the practice model is the execution stage. The running of the simulation will be made contingent upon the athlete meeting set thresholds of EEG activity frequency bands as well as physiological thresholds such as heart rate, respiration rate, and appropriate EMG levels. The movements of the athlete are measured by accelerometers and video devices as is information regarding the angles and speed of the ball, arrow, bullet, etc. As with traditional practice, the athlete and coach can interact either during or following the physical performance or both. In the virtual environment, the athlete can execute the skill while the simulator responds using probability algorithms and information from the performance, thus giving realistic results of that performance. For example, a hockey player could make a pass from the point to a teammate. If the pass is accurate and hard enough, the teammate may take a shot and score. If the pass is sent to a teammate who is covered by an opponent or if the pass is too soft (a deficiency in the active planning, readiness for action, or execution stage), then the pass would be intercepted.

Stage 4: Evaluation (Knowledge of Results)

The fourth stage of practice is the evaluation stage. In this stage, the resulting simulation played out in the virtual environment combined with psychophysiological data recorded in stages one through three are assessed to determine where improvements can be made in the performance. Did the athlete properly scan the environment using active cognitive processing? Did the athlete use too much self-talk throughout the execution, thereby, not allowing for free movement? Was there lingering muscle tension in the trapezius or lumbar regions that inhibited range of motion? The evaluation phase uses the simulated results paired with the information from stages one, two, and three to refine the overall process. This refinement is then used to improve the next practice segment.

The benefits of this approach are many. The environment is safe and controlled, thus allowing the athlete to feel comfortable and work on the appropriate skills. The simulation can be set to isolate performance skills that need to be improved or it can mimic the sporting environment with sounds (e.g., noisy crowd, yelling teammates), sensory input (visual distractions), wind, temperature, or other distracting factors. Also, it allows athletes in team sports to practice on their own or while recovering from injury.

The skills learned and technology used to measure the athlete's processes can then be taken to practices or even competition, depending on the rules of the governing body. This allows a transfer of skills and logical progression from the initial, safe VR learning environment to the practice field and on to the competitive environment. While monitoring and altering key physiological processes, the more the practice environment resembles the competitive environment, the better the athlete's planning, readiness for action, execution, and analysis will transfer to the competitive environment. In this way, the consultant is also helping the athlete become aware of his psychophysiological processes and to help him self-coach when the coach is not available. This, too, leads to improvements in the transfer of skills from the practice environment to the competitive environment.

In the future, functional and reliable EEG somatic recordings that provide quality neuron and somatic feedback (and eliminate recording artifacts) could be worn in the actual setting or used with wireless equipment (i.e., in a hockey helmet). Or feedback could be integrated with many of the sport simulators that are coming onto the market.

In summary, the promise of developing and delivering scientifically based training of the mind and body is now possible through the use of neurofeedback. In the ensuing years, technological advances should make it easier to more precisely delineate what needs to be trained with NFB and the means to efficiently and effectively deliver the services to athletes.

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BCIA. Biofeedback Certification Institute of America. www.BCIA.org

BFE. Biofeedback Foundation of Europe. www.bfe.org

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Tuning Your Mind with Neurofeedback for High Performance Golf
Chapter 9

by

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Abstract

Optimal performance in any sport involves the learning and integration of many different skills, the mastery of a number of different attentional states, and the flexibility to shift from one to another. It involves both the training/developmental process as well as optimal performance in the moment. This chapter identifies and describes these various conditions along with the presentation of exercises and neurofeedback protocols to enhance each of them. These include optimal mental focus and ability to block out distractions while maintaining calm muscles; optimal resting state; a highly activated state to enhance learning; a deeply inward state for reframing, reprogramming, to facilitate memory consolidation, and trauma healing; brain synchrony to minimize left-brain dominance during shot preparation; enhanced flexibility; and training to perform optimally under pressure. In addition, basic motivational and training considerations are presented.

Chapter Outline

I. Introduction

II. Performing in the Moment

III. Training the Ongoing and Long-Term Improvement of Skills, including how to be in the zone: Right training

IV. Mental and Emotional Tools to Enhance Performance and the Training Process

- a.) Focus
- b.) Appropriate levels of calmness
- c.) Calm under pressure
- d.) Emotional focus
- e.) Cognitive focus
- f.) Decision making
- g.) Energy management
- h.) Confidence building through right thinking
- i.) Sourcing: Inner versus outer
- j.) Maximizing capacity: A resilience model for performance and health

V. Mental and Emotional Conditioning for Optimal Training and Performance Using Neurofeedback

- a. Basic neurofeedback training considerations
- b. Neurofeedback training protocols
- c. Training to perform optimally while under pressure

Introduction

Jack Nicklaus was rumored to have said golf is 90 percent mental. We all admire the professional who—like Nicklaus—under the most pressurized situations, is able to sink a long putt on the 18th hole to win a tournament. When watching a match approach the key moments of win or lose, the spectator can feel the heightened intensity as the announcer might say the tension is so heavy "you could cut it with a knife." Some golfers, such as Greg Norman, have become legendary for choking, or tensing, in the final stretch of a tournament. And a professional's legacy is sealed—one way or another—by their peak tournament moments.

Of course, the most pressurized of competitive situations only heightens the impact of mental and emotional processes that are an ongoing presence with golfers. Coaches and sport psychologists have long attempted to find ways of helping the golfer remain calm, stay focused, and hit the green while maintaining high levels of energy and, in general, maximize all aspects of his ability. Optimally performing under pressure is just a part of what is involved in the mental aspect of golf.

There are many ways mental and emotional factors positively or negatively impact performance. Furthermore, this impact can be on immediate performance, or it can be on the ongoing training process. Immediate performance has to do with whether you can optimize or fully manifest your skills and abilities in the moment. Training, however, involves a developmental process that unfolds over time. It involves modifying and establishing new neural pathways that improve skills and capacities. What many in sports are not aware of is that it is this very process of learning that can be engaged to enhance confidence and self-efficacy itself by fully owning one's experience during the training process and training right thinking, which will be described below.

This chapter is designed to cover the many ways mental training, and more specifically, neurofeedback training, can improve golf performance. Each golfer, as well as the coach, can identify which of these areas are most needed for his performance enhancement. Factors to consider in such decisions are presented as each aspect of training is discussed.

Performing in the Moment

Optimal immediate performance is typically referred to as being in the zone or the flow. This is a state when the mind and body are working together in harmony. This state is epitomized by a sense of timelessness; of letting it all go; of allowing, rather than trying, to make it happen or controlling the performance. Sometimes players in this state are referred to as being unconscious because they are not thinking at all about their performance—it just happens. This state is taking the brakes off (no unnecessary tension) and being totally confident of the results; there is no worry or fear about making a mistake—you are going for it and expecting you will give your best performance. At the highest levels, the athlete is expecting to make the shot.

This process begins with a combination of trust and going for it. Trust means, "I know what I am doing. I know what the best shot is, or at least, I am confident I can hit my best shot." In the moment is not the time to question your abilities or your mechanics. Those are tasks for the training venue. One must leave all doubt behind when going for best performance. Going for it is about boldness. Goethe once said when one acts with boldness, heaven and earth conspire to make it happen.

Boldness must then be combined with the appropriate focus and somatosensory state. Somatosensory means sensing your body. Many golfers get stuck in this awareness process when they become too preoccupied with the sensing of a particular part of their body, such as their left shoulder or their grip, the placement of their hips or whatever the last thing they addressed in training was, as they prepare for a shot. Optimal somatosensory awareness involves the balanced sensing of one's body in all its aspects: equally feeling your entire body as you prepare for the shot.

Case Example

A professional golfer I worked with had difficulty on his backswing. His focus would frequently go to an awareness of his shoulders at the top of his backswing. It was not a question of right or wrong, but simply what he was paying attention to was an interruption of flow. In addressing this issue, I asked the athlete to bring his focus to the space between his shoulders. While thinking this was odd at first, he quickly realized guiding his focus in this way created a more diffuse sense of his body and—in an unstressed manner—shifted it away from his preoccupation with his shoulders, which was creating both a tension in that area and a mental concern. I used similar phrases to help this player notice the space between other parts of his body. This technique, referred to as "open focus" (Fehmi, 2007), brings into play the right hemisphere of the brain. This makes it easier to move away from linear, analytical thinking, which is a left-brain function.

Training the Ongoing and Long-Term Improvement of Skills: How to Be in the Zone: Right Training

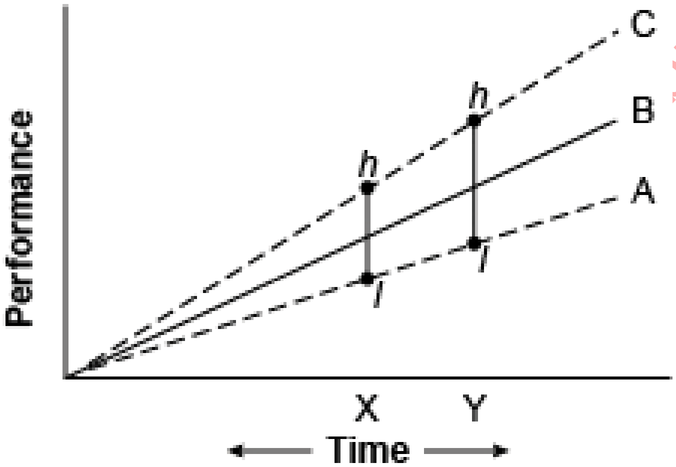
Training is the process whereby skills are learned and continually improved upon. An athlete who has potential is perceived to have some natural ability. It is then the job of athlete and trainer or coach to develop that potential into well-honed skills along with the appropriate application of those skills. We recognize the variance in ability of coaches to get the most out of their athletes and the variance in athletes to get the most out of their natural abilities. How to perform optimally in the moment is also a skill in and of itself that needs to be trained as is how to use attention during training for optimal improvement.

Right training is an approach to maximizing an athlete's abilities and the learning of performance skills. Learning appears to involve the morphogenesis of new nerve cells and their integration with existing cell assemblies along with the creation of new neuronal pathways (Rossi, 2002). Right training maximizes this developmental process and includes the athlete /golfer's awareness that they are engaged in this process.

Figure 9.1 presents two ways performance can be enhanced. The three lines A, B, and C show three hypothetical paths of improvement over time. The different slopes and endpoints of these three lines demonstrate the impact of training programs with differing levels of effectiveness. As you will note, the training program that is represented by line C is the most successful.

Figure 9.1: Performance Enhancement.

Two ways to enhance performance: a) training over time and b) performing in the moment. Lines A, B, and C show improvement over time with training approaches of differing effectiveness. The two vertical lines indicate the potential range of performance for specific events noted by X and Y.



At the same time, we can look at points in time along a training curve, such as points X and Y for line B. These might represent two different sporting events. The vertical lines indicate the potential variation in performance during these two events. Here, the athlete's performance is impacted by his or her mental and emotional state, immediate conditions and the responses to them. Within this range, the best performance he or she is capable of executing is indicated by the top of the line noted as "h." This is where the athlete is in the zone, optimally focused and getting the most out of his or her abilities.

At the bottom of the range, noted as "l," is the lowest or worst an athlete is likely to perform given his or her current level of abilities. Here, performance may begin with some muscle tension when under pressure, worry about the outcome, or too much emphasis on one's mechanics. This could lead to a poor shot. If the golfer reacts to this mistake with additional tension or by becoming upset, then the performance would deteriorate further.

Peak performance training adds another dimension to peak performance. It adds the dimension of time, practice, and training. Therefore, in addition to obtaining optimal performance, we are talking about optimal training to maximize one's potential performance. And like interest in a bank account, it can be compounded differently. The more it is compounded through right training, the greater the improvement.

During right training, the objective is to train with the maximum amount of intensity and focus. During this training, the athlete must take greater risks. It is the athletes who fully test their limits during training, who push the envelope of their skills, who make the greatest improvement. In a sense, we can say it is this process that enhances neuronal growth and, ultimately, one's physical and mental capacity.

This was reflected in a golfer who was afraid to use his driver. He found he had less control when he used it, which made the outcome of his shots less predictable. As he tried to improve his swing, his unconscious expectation of making a mistake resulted in him attempting to control the swing, which was creating inappropriate tension. My right training had this golfer focus on letting himself go during his practice. This approach involves holding an image of the optimal swing while taking a full swing. The key is that once you hold an image of the optimal outcome, unconsciously, the body will attempt to approximate this image. After the swing, a comparison is made between the actual and the imagined swing. By doing this, you are creating a feedback mechanism in which the body attempts to get closer to the imagined optimal swing. This is a process of noticing without controlling, and the result is less inappropriate muscle tension.

A key component to right training is training how to perform when under pressure. To address this, a segment of the training, called "dress rehearsal," is presented to the athlete. As with actors preparing for a play, this segment is designed to have the athlete simulate, as much as possible, the pressure conditions of an actual game or an actual tournament. This will be accomplished using visualization in the office as well as actual onsite training with a portable biofeedback system. The more closely you can give an athlete the sense of actual conditions, the greater will be the transfer of training to the real situation. Refer to chapter 12 for additional information on transfer of training.

Case Example

One golfer became intimidated on the very first shot of a tournament. All of his excessive tension and self-doubt was focused on this one shot. If he got past this with a desirable outcome, he would typically be fine for the rest of the round. A few sessions were held on the golf course where I played an audio sample that was recorded during an actual tournament. The announcer was setting up the start of the fourth round of the event, and the golfer who was about to begin was four shots behind the leader. As the announcer noted the added pressure on the golfer, the trainee went into his pre-shot ritual, which included experiencing this information as energy to be taken into his body. Then, as he took a deep breath, he was instructed to feel this energy being distributed throughout his body. He was then instructed to wait until he felt this energy in the tips of his fingers and toes—and then to take his shot. This awareness was facilitated by monitoring his EEG. When he held a brain state of calm focus for one half second, he received a tone, which was his signal to swing.

Mental and Emotional Tools to Enhance Performance and the Training Process

Let us first identify the mental and emotional tools, the skills, that golf performance depends upon.

Focus

The most obvious skill is the ability to be focused, even under stressful and pressurized situations. Focus has to do with where, how, and with what control you place your awareness and your attention. Focus has to do with the quality of the focus and how much detail is taken into consideration (Nideffer, 1992).

Focus can also be wide or narrow. A wide focus means you are taking in a large part of the environment. A wide focus is necessary when lining up a shot. For example, on a tee shot, at some point in your preparation you will want to take in as much of the fairway as possible. If you are hitting a putt, a wide focus allows for taking in the entire trajectory of the potential shot.

A narrow focus is when you place this awareness on a single point. The narrowest type of focus can be referred to as pinpoint focus. An important aspect of focus is the control and the intensity of placing your visual contact, which should be unwavering.

Let us take a moment to experiment with your ability to focus. First, look at the period at the end of this sentence: "." Next, broaden your focus to see the entire page. Now, let us further broaden your focus to see as much detail in your peripheral vision as possible. See how close you can get to 180 degrees. Now, try shifting back and forth from the period to your broadest range of focus. As you broaden your focus, try to identify a specific object at the periphery of your visual field. Then note any details of that object, such as its shape or an edge of the object. This is a good exercise to sharpen your ability to focus and most importantly to enhance your ability to control your focus.

Exercise

Try this exercise when you are on the golf course. Shift your focus from the ball to the space between the ball and the hole. Notice as you practice this procedure that you are less likely to be thinking about other things in your life. In other words, strengthening your focus is also enhancing your ability to reduce distractions. Later we will be identifying neurofeedback training that facilitates this ability.

Appropriate Levels of Calmness

One of the biggest breakthroughs in the history of Olympic runners was when they began training the ability to relax certain leg muscles (Pepper, 2008). With too much tension, muscles lose both flexibility and control. It also reduces stamina. In golf, this excess muscle tension results in reduced accuracy as well as fatigue over time. Thus both awareness of muscular tension and the ability to control it and keep it at a low level become important ingredients in peak performance.

There is no shortcut to achieving muscle control and the ability to relax muscles. The almost constant daily initiation of our stress response, with its concomitant constriction of muscles as we prepare for fight or flight, slowly and progressively increases our baseline muscle tension. Because this often occurs over long periods of time, we gradually adapt to higher levels of tension and, thus, it feels normal. Because our muscles have built-in memory, they are always returning to their most familiar, typically tense levels, even after practicing a relaxation exercise.

In addition to musculoskeletal calmness with the appropriate level of muscle activation, there is also autonomic calmness. This refers to a quiet nervous system. Most athletes are familiar with the symptoms of an over-activated nervous system, including the adrenalin rush, butterflies in the stomach, or sweaty hands. For some, this is manifested in the experience of a pounding heart. Any of these sensations can distract a golfer. More importantly, they may interfere with the athlete's rhythm, thus affecting successful execution of the shot.

Later in this chapter, we will address neurofeedback protocols to facilitate a state of greater calmness and reduced tension. In the box below is an exercise that will help to enhance a balanced awareness of your body. Your body has a natural ability for restoring balance and calmness if you give it a chance. Through this process of noncritical awareness, of simply noticing, you will give your body an opportunity to engage in its natural process of self-regulation.

Exercise: Using Noncritical Awareness for Self-Regulation

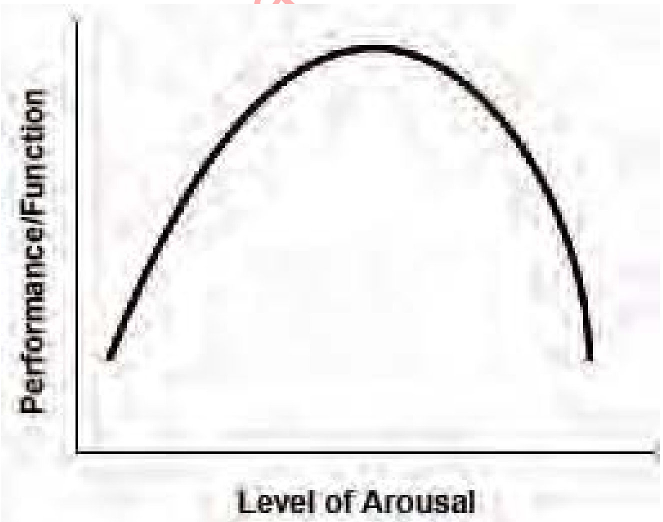
Think of your body as a container. Now, imagine that you transform your mental awareness into mental liquid. Start at the top of your head and slowly begin pouring this awareness. Feel it touching the top of your head. Feel the liquid move evenly over and through your body. At the same time, check your breathing. Simply make sure it is consistent from one breath to the next. As you follow your awareness, notice the different feelings at different points in your body. Notice the different levels of tightness or holding. Do not engage in making any intentional adjustment; simply move your awareness. As you repeat this a few times, notice any changes. You may notice a sense of increased calmness.

Calm under Pressure

Many athletes are able to experience calmness when practicing their golf game or during noncompetitive situations. However, as pressure from competition begins to build, tension goes up, and performance becomes impaired. Each golfer must find his optimal level of body activation. This is the level that allows for the best performance. The goal is to be able to maintain this level as the demands of the situation escalate.

Figure 9.2 shows the relationship between performance and arousal, which takes the form of an inverted U-shaped curve. In other words, at low levels of activation or stress, performance is poor. This is because a certain level of arousal is needed to enhance motivation and to mobilize the body for action. As arousal increases, performance, therefore, improves. At some point in this continuum, the athlete reaches his or her optimal level of arousal/activation, the point at which the athlete experiences peak performance. As stress and tension increase beyond this point, performance begins to deteriorate. While there are some exceptions to this function, the key to your best performance is your ability to reach but not go beyond this optimal level of arousal/tension. Later, we will discuss how one can extend this window of peak performance.

Figure 9.2: Performance curve. The relationship between arousal levels and performance in which performance improves as arousal increases. At the high end of arousal, tension and other factors contribute to a decrement in performance.



Emotional Focus

Emotional focus involves the optimal level of passion and intensity channeled through the body with minimal emotional distress or anxiety. It is the ability to let go of a reaction to a poor shot and, at the same time, not react or worry about the performance of a competitor. In addition, it is managing the excitement following a great shot.

In the previous section, calmness under pressure was presented. In addition to the pressure created by tournament situations, pressure can also be internally triggered by the thought process and perceptions of the golfer. This was the case with one golfer who had a six handicap. Whenever he had a strong first nine holes with the potential to break his best game, he would become nervous and would blow it on the back nine. When questioned, it became obvious he had placed a ceiling on himself, a belief that he was a six handicapper. He had preset his psychological boundary. As it appeared as if he might break through that barrier, he became tense and missed shots he otherwise would have made.

This highlights the impact of limiting developmental messages. For example, unpleasant performance experiences in our past can leave us feeling insecure in our abilities and even lead to self-sabotage. Not only are we reactive to these limiting mental and emotional factors, but our bodies are also etched by the bracing and other physical reactions they produce. Therefore, optimal golf performance depends upon removing sources of emotional reactivity as well as learning how to focus, how to be intense, and how to feel confident at the moment of performing.

Cognitive Focus

Cognitive or mental focus is attending to the most important stimuli to optimize your shot and your game. It involves blocking out distractions. It is the ability to censor unwanted thoughts, such as “Don’t hit it into the bunker.” It is knowing where to place attention and intention. Much of the problem with golfers is their tendency to engage in analytical thinking, which interferes with getting into the appropriate mindset for the task at hand. When this happens there is typically an over-activation of the left hemisphere of the brain. This can be addressed by training greater balance between right and left hemisphere brain activation.

Mental distractions of all kinds can be a particular trap for the golfer. The most common is a focus on what we do not want to happen or what we are afraid might happen. We may be concerned about a tendency to hook the ball or some other consistent difficulty we have been experiencing. On the other hand, our mental attention may be hijacked by a hazard on the golf course, such as a sand trap or a body of water. We may even know it is not a good idea, but our mind is still occupied by the thought, “Don’t hit it into the water.”

In the 2006 World Series, pitchers from the losing Detroit Tigers made a record five errors. When interviewed, one pitcher said as he fielded a ground ball and was about to throw to third base ahead of the runner, he thought, “Don’t throw it away,” which is exactly what happened. The physical tension caused by his fear interfered with his ability to throw the ball accurately; he over-controlled his throw. In golf, the ratio of downtime to actual play, taking a shot, is so great it is easy for inappropriate thinking to slip into the golfer’s mind and interfere with performance.

Decision Making

There are many forms of assessment and multiple decisions that need to be made during a golf match. The golfer must plan how to play a hole and how to adjust this plan after each shot. Each lie of the ball and the route and trajectory of the next shot must be accurately determined. All of this involves optimal decision-making abilities. This is a function of the frontal cortex of the brain, what is known as the executive brain. When this area is under-activated, the player is subject to either poor decisions or inadequate concentration leading to mental mistakes (Killgore et al., 2006). In addition, when stress is not properly managed, the frontal cortex tends to shut down, further affecting performance (Bondi et al., 2008).

Energy Management

The length of time it takes to play a complete round of golf can also lead to fatigue, both physical and mental, which can greatly affect performance. Research appears to indicate there is a shift to slower frequencies (related to reduced attention and increased distractibility) of the EEG with fatigue (Boksem et al., 2005). Therefore, mental stamina, the ability to maintain focus, in addition to physical stamina becomes important.

As mentioned above, there is considerable downtime during a match. Energy management becomes an important aspect of optimal performance, particularly during the final stages of a game. A player needs to be able to perform at the same level on the 18th hole as he did on the first hole. This requires the ability to shift gears quickly and frequently from the intensity of an important putt to a more relaxed mental and physical condition between shots and between holes, which minimizes fatigue and allows for periods of recovery. This should be an added intention for the golfer throughout the game.

Confidence Building through Right Thinking

Confidence is one of the keys to performing well under pressure. Confidence, and trusting oneself, is what allows an athlete to maintain his or her center, that deep, inner place where the best performances originate. Two neurofeedback approaches to enhance confidence are used: a healing remediation component and a training component.

Healing or remediation has to do with addressing internal negative messages, emotional trauma, self-criticism, fear of judgments, and thoughts such as "I don't deserve." When these issues have not been addressed, there is a greater tendency for self-sabotage. These factors can contribute to a golfer focusing more on things that are outside of him rather than within, on what others want or expect, and their judgments. This leads to tension and distraction. As will be discussed in a later section, this process is addressed within an Alpha/Theta brainwave protocol. Here right thinking is holding the belief "I deserve."

The training component of confidence building involves a cognitive aspect in which the athlete begins to identify right thinking patterns performed in conjunction with certain neurofeedback protocols. Right thinking in this context is the directing of one's mental focus to the appropriate golf-related stimuli. It is a focus on what you want and expect to happen, not what you want to avoid. Right thinking is the discrimination between relevant and irrelevant representational states:

focus should be on the thought “I am capable of hitting my best shot at any moment” as opposed to focusing on “what should I hit.”

Right thinking also involves the identification and reinforcement of a feeling state associated with successful shots. Once noticed, this state should be fully felt and appreciated. This process of noting the positive state reinforces and enhances neural circuitry along with the player’s ability in recreating this optimal state.

Golfers and other athletes frequently say, “After that shot, I lost my confidence.” Training involves making a mental shift away from the notion that confidence is all or nothing and can be totally lost with one bad shot. Training also involves how to reframe one’s performance, so confidence can be quickly regained following a mistake.

One of the most common problems golfers have is their negative emotional reaction after hitting a poor shot and then carrying this feeling to the next shot or the next hole. Some of the time, this reaction facilitates anger toward oneself. At other times, it is a sense of dejection and even defeat. Frequently, golfers say, “I lost my confidence.” So, it becomes very important to let go of a mistake as quickly as possible, and to not let it negatively affect confidence. This may be facilitated through the use of visualization and neurofeedback by visualizing the way the shot was supposed to go immediately after the mistake was made. Here is a rapid step-by-step approach to this process of letting go of a poor shot:

Step 1: Notice your feelings—let the feelings be okay, for example, if you are angry—but give yourself 30 seconds to feel and express this anger. Because most of the time the athlete is in competition with others, this process can be performed silently.

Step 2: Remind yourself that to perform at your best it is important to let go of the negative feeling and to forgive yourself. Emotional overexcitement, even when positive, will detract from performance.

Step 3: Identify what the mistake was, such as lifting your head too quickly during the shot.

Step 4: Focus on the correct way of doing it. Visualize performing the correct swing and having the shot go just as you had wanted it to.

Step 5: Take slow deep breaths, focusing on a sense of calmness and letting go as you allow yourself to sit with this image.

Step 6: Remind yourself that you are capable of making this shot.

Sourcing: Inner versus Outer

This is a subtle difference but an important one. One component of right thinking and staying centered is keeping the focus on the relevant stimuli. Pressure typically affects us when we buy into the source of the pressure, when we are more concerned with what others think than what we think of ourselves. A primary consideration in addressing pressure (as well as our "shoulds," which throw us off our own course), is addressing how we feel and what we think.

Confidence is the focus on your belief in yourself and your abilities. As soon as there is a shift toward what is expected or hoped for by others or your own critic, you have lost your connection to the source of your confidence and to your center. When you focus on what others expect, you are also left with an unclear goal. This vagueness then leads down a slippery slope of negative thoughts such as “I can’t make that shot” or “I’m not going to be able to do it.”

So the goal for each shot is to make your best shot. This is something you can believe in and thus reduce your fear and tension.

Maximizing Capacity: A Resilience Model for Performance and Health

Michelangelo, in referring to how he sculpted David, said the figure of David was already in the marble and his work was simply to uncover it. In right training, what is important is removing limitations and ways the golfer gets in the way of his best performance. This is a very ineffective process that occurs when an athlete pushes too hard to do better. This results in tension and constriction.

Case Example

An example of this was a golfer who had great difficulty in tournaments and particularly in the latter stages of the competition when everything is on the line. This is when his lack of trust in himself was exposed. In a simulated competition, his muscle tension was monitored and compared to readings taken during regular practice. As expected, muscle tension during the simulated competition was almost twice as high. In a sense, he was trying to compensate for his performance concerns.

To address this automatic tendency, in addition to training muscle relaxation, we worked on self-acceptance. This does not mean a willingness to stand pat; to accept his current level as being his limit; but to be okay with where he is now. By accepting that any outcome is adequate, he was able to release this tension. It was this notion of self-acceptance, "what is inside is okay," that brought out his best performance.

Right training cultivates the belief that your best game is inside, and the goal is simply to allow it to come out. This is facilitated by maximizing one's capacity. Here we can make an analogy to the capacity of a car engine. The greater its capacity, the faster it is capable of going. But more importantly, it will be able to maintain power under greater levels of stress, such as climbing a hill. In Figure 9.2, the relationship between performance and arousal, or stress, is presented. It demonstrates there is an optimal level of arousal for each athlete's best performance. Figure 9.3 incorporates the concept of capacity. As you increase capacity, you extend the range of optimal performance to higher levels of arousal and stress, shown by the curve labeled B. This results in both higher levels of performance and the ability to maintain peak performance at higher levels of stress or pressure.

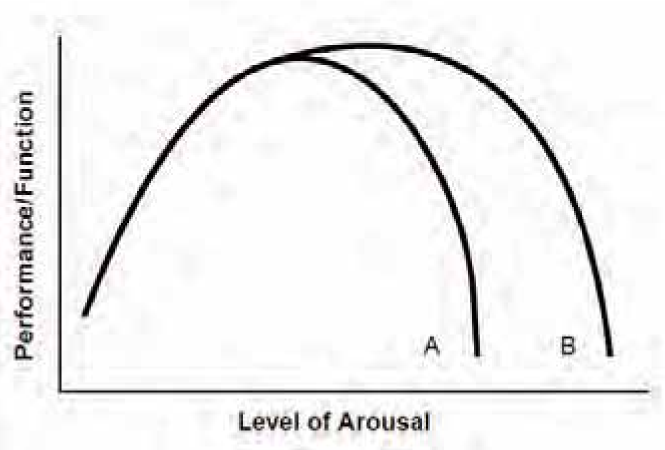


Figure 9.3: Capacity and Performance. The curve labeled B shows how increasing one's capacity improves performance at higher levels of arousal or stress. It also shows how increasing capacity helps maintain peak performance as stress and arousal are increased.

Capacity can be determined and best measured by a model: The nine components of resilience (Sideroff, 2004). These nine areas cover many of the key aspects of optimal functioning and performance. It is the maximization of these nine aspects of personal living that enhances capacity and confidence, which in turn, is believed to positively impact performance under pressure.

The nine components fall into three categories: 1) relational, 2) organismic balance and mastery, and 3) process.

Relational

In this model, the areas of relationship include 1) relationship with yourself, 2) with others, and 3) with something greater. Relationship with yourself is the degree to which you love and accept yourself. It is the belief that you deserve to be successful. With this as the basis, it is never okay to put yourself down. If you make a mistake, it is reasonable to be angry, but there is a boundary to its intensity and duration, and it certainly does not continue to a level that affects performance.

The next component in this model is your relationship with others. Do you establish and maintain caring, positive, and supportive relationships with others? These contribute to your positive sense of self as well as to serve as a support.

The last component of relationship is relationship with something greater. This might be your spiritual beliefs or having a sense of purpose in your life. It is anything that broadens your perspective so temporary failures or hassles are held in perspective and do not make you feel overwhelmed. It also enhances the motivation to persist.

Organismic Balance and Mastery

The three components involved in balance and mastery include 4) physical, 5) emotional, and 6) mental or cognitive. Physical or physiological balance and mastery has to do with how well your body mobilizes and responds to a demand and how quickly and fully you recover when the demand is over. It is the intuitive management of your energy to maximize stamina throughout a performance. The energy output should be sufficient for the task, but any over-activation will result in either premature fatigue or unnecessary tension during the task.

Balance and mastery is also the ability to fully and deeply relax, to maximally recover after an event, to sleep more deeply, and to be better prepared for an upcoming event. Finally, it is the ability to let go of a source of stress that creates unnecessary tension. This component directly relates to maintaining a calm focus, stamina, controlling tension, preventing injury, and performing under stress.

The expression “someone pushed my buttons” is used to explain a reaction that is bigger or more intense than what appears to be necessary, and demonstrates a heightened emotional sensitivity. At the heart of emotional balance and mastery is the ability to appropriately deal with emotions, so you are not carrying excess baggage.

Unfinished business from past emotional experiences leads to a propensity for overreaction, and unfinished business that is not addressed leads to more buttons that can be pushed. The result of this process is emotional pain, wasted energy, and destructive behaviors. It affects performance and training to the extent that one feels less self-trust and less worthy of success. This creates an artificial ceiling on one’s performance. It also makes an athlete more susceptible to emotional reactions that can be magnified in competitive situations.

According to my model of resilience (Sideroff, 2004) cognitive mastery and balance refers to the ability to direct one’s thinking and maintain focus in a positive and constructive direction. This has been addressed already under focus but also includes positive expectations, the knowing that you can hit your best shot.

Process

The last three components (Sideroff, 2004) have to do with your process or how you live your life. Component 7 is presence. This is your ability to not get distracted from your sensory contact and awareness with the environment. Staying in contact with the target is particularly important for a golfer, and the quality of this contact appears to be significant in determining accuracy (Vickers, 1996). It is how tuned in you are, how confident you are, and your sense of solidness.

The next component (8) is your ability to be flexible. Here we can use the analogy of a willow tree that is able to bend with the wind, so it does not break. But flexibility isn't only a physical condition. Are you able to take what life gives you and make the most out of it? You know the story of the princess and the pea? The princess was so sensitive that even when she slept on 20 mattresses, she could still feel a pea underneath the bottom one. To what degree do you get thrown off balance when conditions are changed or are not the way you want them? Flexibility is being able to adjust your requirements and appreciate a situation as is. And finally, power, the ninth component, refers to the ability to get things done. This is a very important component of training because it relates to persistence, courage, and not getting discouraged by obstacles or setbacks.

Appendix A presents a 40-item, self-scoring resilience questionnaire. Appendix B is the corresponding self-scoring profile. You can plot your scores on the nine components to see which areas are your strengths and which areas need further development. You may make copies, so you can get your resilience score multiple times during your training to note ongoing improvement in your capacity.

Mental and Emotional Conditioning for Optimal Training and Performance Using Neurofeedback

Basic Neurofeedback Training Considerations

Neurofeedback is the monitoring of brainwaves or an electroencephalogram (EEG) and feeding back information about specific components of the EEG, so the athlete can learn to make adjustments that improve brain functioning.

Neurofeedback training has shown some promise with golfers. Chartier (2001) showed the training of Alpha rhythm improved performance, and Arns et al. (2008), in preliminary studies, showed they could identify EEG patterns associated with successful putts. They then trained golfers to replicate these patterns, which yielded improvement in putting accuracy. In addition, Crews and Landers (1993) used EEG recordings to discriminate between accurate and inaccurate putts. In their study, the EEG of successful putts showed a more balanced activation of left and right hemispheres, and the EEGs just prior to an inaccurate shot showed a greater activation of the left hemisphere.

There are a number of specific brain states and conditions that can enhance the development of golf skills and golf performance as noted above. Training therefore employs a number of protocols that are used sequentially, or during separate sessions, to correspond to the different attentional, emotional, and cognitive processes required. In addition, the use of different protocols impacts overall capacity, which translates into greater confidence.

As discussed in other chapters of this book, with peripheral biofeedback, one of the most effective training procedures is to train in both directions: the desired direction, such as lowering skin conductance, and raising this same measure. Self-regulation is also referred to as self-control. By training in both directions the result is greater control. For this reason, the more varied the training, the more you gain flexibility and the ability to respond under progressively more difficult situations. In addition, peak performance in golf is achieved by doing many different things right. For these reasons, it is important to utilize many different neurofeedback protocols

It is important to note that, in my experience, neurofeedback for peak performance training in golf does not necessarily produce changes in normal or healthy baseline EEG. Training appears to do four things: 1) If there are abnormalities or deficits in the EEG, it can normalize these and thus change baseline; 2) it can enhance the brain's ability to shift into a particular pattern that is being reinforced; 3) it can enhance the brain's ability to stay in that pattern longer, and we can call this mental stamina; and 4) it produces an overall enhancement in the brain's flexibility, its ability to shift from one pattern to another without getting stuck. This allows the brain to function better in general. In addition, neurofeedback during peak performance training is probably stimulating the development or enhancement of specific neural pathways associated with the learned skills as well as capacity.

One question to consider is whether the athlete needs a quantitative EEG (QEEG) before training in order to determine where and how to train. A QEEG assesses multiple brain locations under different conditions to determine where there might be abnormalities or imbalances (i.e., assessing brain locations where there is either under- or over-activation of the EEG).

Typically, we do not initially employ a QEEG but rather incorporate a QEEG assessment only when there is a lack of progress in training. With golfers, this turns out to be very infrequent (estimated to be less than five percent of the time).

Aside from the specific neurofeedback training protocols, there are a few general learning approaches that I have been utilizing. These have to do with the client/consultant relationship and how to present information about brain function to the client. The benefit of working with elite athletes, and athletes in general, is they show up to do the work. They are eager to do and learn whatever it takes to improve their performance. It typically means the clinician does not have to be thinking of keeping them interested with animations and games. Instead, you can focus on the optimal way of presenting information.

There are four basic overall considerations in neurofeedback training that I use with athletes. The first two here relate specifically to the trainer-athlete process and are directed toward the consultant or practitioner. Neurofeedback and biofeedback are not procedures that are simply done to the athlete. It is a learning process, and the training must be conducive for learning to take place. The initial considerations therefore, have to do with setting up the ideal learning conditions.

The first consideration is the relationship between trainer and athlete. A neurofeedback trainer must establish a good, trusting relationship with the athlete. The trainer must convey a sense of confidence in the program and have full knowledge of the procedures to be used. This is best achieved when the trainer completes his own training successfully. In my personal preparation for training peak performance, specifically in golf, I found I needed to do my own neurofeedback work as well as my own golf training.

A good client/trainer connection is the key to establishing the optimal relationship for training. The trainer must be genuinely interested in the athlete and in his success. When meeting the athlete, it is very important that the trainer is not distracted by external thoughts, events, or stresses. In other words, he must be fully present and focused. Trainers must also be effective in dealing with their own stress, so they model the demeanor of the ideal athlete.

The second consideration is incorporating an educational component. Some trainers will simply tell their trainees to "turn on the sound" referring to the auditory signal or reward that occurs when the trainee achieves certain criteria or threshold with their brainwaves. In an effort to improve the conditions for learning, we have found it is helpful to fully engage the trainee. A degree of explanation about brainwaves and brain activation gives a map that trainees find helpful when traversing the terrain of neurofeedback.

The third consideration is the optimal presentation of information about the EEG. Figure 9.4 presents a typical display for neurofeedback training, using the Thought Technology Infiniti system. This display is also referred to as a protocol screen, showing how EEG information is presented to the athlete. First, notice the EEG or electroencephalogram in the bottom half of the screen. This is a representation of brain activity directly below the scalp, where the electrode is placed, in real time (i.e., as it is actually being produced). Note the EEG is comprised of waves of different frequencies, from the slowest at about one cycle per second, or Hz, to the fastest of approximately 40Hz. In the accompanying histogram, just below it, the same information is presented in one- Hz bins; in other words, the amount in amplitude each single frequency is displayed. In this way, one can see the relative amounts of each frequency component.

Figure 9.4: Neurofeedback Training Screen: A typical protocol screen in which one EEG frequency range is being reinforced at three progressive amplitude levels. This is being displayed in three separate bar graphs. In addition, two other frequency bands are being down-trained also using bar graphs. Each graph will become green when the bar is in successful position (either above or below the threshold line) and red when not successful.

By using appropriate filters, the protocol can separately display the specific components of the EEG of interest in either enhancing (rewarding) or inhibiting (down-training). It can display other aspects of the EEG, for example, the ratio between the Theta or lower frequencies (daydreaming/distracted) compared to the Beta or higher frequencies (attention/focus). In this protocol, there are five bar graphs displaying the amplitude of specific components of this subject's EEG. On the right are two bar graphs representing frequency components that are being down-trained. On the left, all three bar graphs represent the same brainwave component that is being rewarded; in other words, the goal is to enhance this frequency band.

You will note that within each bar graph is a threshold, the horizontal line within each bar graph that can be adjusted based on performance, that can turn on or off both auditory and visual reinforcement. In addition, the bar will turn green with success and red when criteria are not achieved. At the same time, there is the continuous analogue information of the moment-by-moment changes of the bar itself. This additional level of information has been found in some studies to improve results (Hardt & Kamiya, 1976).

In the example presented, the goal is to train both focus and calmness. On the right, one bar graph is displaying Theta frequencies of 4–8Hz. The bar graph next to it displays high Beta frequencies in the 24 to 38Hz range. The bars of both graphs will turn green (indicating success) when they are below the level of the horizontal threshold lines. In other words, these frequencies are trained down. By down-training Theta frequencies, the athlete can reduce those frequencies that contribute to the under-activation of the brain. The ability to focus is thus enhanced by reducing slower brainwave activity. A reduction of the higher Beta frequencies is encouraged because this is an indication of over-activation, which occurs with worry, tension, and obsessive thinking.

All three bar graphs on the left side represent the same frequency component, in this case, sensorimotor rhythm: 12–15Hz. Here, the bars will turn green (success) when they rise above the horizontal threshold line. The three thresholds are set at different levels with separate sounds being turned on as the level goes above each threshold. When the third or highest threshold is achieved, the athlete will hear a three-note chord.

In general, the frustration tolerance between athletes varies during training. Thus, if the reward threshold is made too difficult, some athletes will become discouraged. At the same time, if success is too easy, some athletes may become bored or disinterested. By using three different threshold levels for reward frequencies, one can combine easy and difficult goals. The multiple target goals satisfy a broader range of subject sensitivities. Thus, the first threshold will be set to reward approximately 75 to 80 percent of the time. The second threshold will reward approximately 50 percent of the time, and the third will reward approximately 20 percent of the time.

In training regimens, a series of three-minute trials are used except when using the Alpha/Theta protocols. There are a few considerations in dividing a session in this way. It allows time for memory consolidation, it approximates actual performance demands, and the inter-trial interval allows for rest and recovery. This approach also fits with my clinical experience. Ultimately, however, this is an empirical question that requires more data.

The fourth basic overall consideration is the transfer of training to the golf course and the golf tournament situation. There are a few principles that should be considered to achieve this. First is the use of multiple protocols and training goals. This has been found to be beneficial with athletic cross-training to address different aspects of fitness. We theorize that by combining different neurofeedback training and goals, we are broadening the brain's proficiencies.

As training progresses, the reward criteria will be changed, for example increasing the length of time the goal EEG pattern is required in order to receive reinforcement, e.g., going from one quarter second to one half second. Stress and pressure are presented to better simulate the demands of competition. This is accomplished through the introduction of distractions or increasing the psychological demand. For example, an audio of various voices and sounds will be played, or discussions of how other exceptional golfers were able to perform on the same task are held.

Another aspect of transfer of learning is the use of visualization in conjunction with the neurofeedback training to make the associations between training and real-life situations. In addition, I will use a neurofeedback protocol that reinforces production of 7Hz. brain frequencies, which facilitate the athlete's ability to visualize.

Next, the golfer stands with the putter, addressing the ball during training in the office and listening for the auditory feedback. Finally, I will take my portable system to the golf course for onsite training. The Thought Technology system is small enough to wear on the athlete's belt. A fiber-optic cable about 10 feet long connects the device to a laptop computer. This and other systems also use telemetry for wireless connection.

A pre-shot ritual is another way to facilitate the transfer of neurofeedback training to the golf course and the actual performance. It is also a procedure necessary to jump start optimal focus just prior to a golfer's swing. Many coaches teach a player to design and then practice a series of behaviors just prior to the swing that help corral his or her attention. The sequence is the final message, "let go of everything but the task at hand. Bring in your focus. Pay attention." It is like the final count down before the performance action begins.

During neurofeedback training, have the golfer perform his pre-shot ritual while he is hooked up to the computer with the golf club in his hands. In this manner, we can develop an association between the ritual and hearing the feedback sounds. The resultant connection between reinforcing sounds and ritual creates a bridge to the actual game. Thus, during a game, whenever the golfer begins his ritual, he is making another association with the neurofeedback training situation.

Neurofeedback Training Protocols

Many of the skills that are important for optimal golf performance have already been presented. From this, a number of brain states and training methods can be identified for the improvement of these skills. The fact that a number of optimal patterns and training programs are implicated is significant.

There have been other approaches using neurofeedback in golf that appear promising. Most reported experiences using neurofeedback to improve golf performance have been case studies or anecdotal reports. Chartier (2001) reported using a protocol originally reported by Patton (1996) that was effective with athletes in a variety of sports. Here, sequential reinforcement of three different frequency components, 4Hz, 7Hz, and 13Hz, was integrated with golf-related visualizations. Chartier found significant improvement in stroke reduction as well as in mood.

Other studies (Crews & Landers, 1993) have focused on the relationship between left and right hemispheres. This study addressed the question: Is there a disruptive effect of too much left-hemisphere activation? The theory here is that you want to turn off any analytical thinking that can cause tension or the interruption of flow just prior to taking a shot. Analytical, linear thinking is a function of the left hemisphere of the brain. Furthermore, the right hemisphere is where spatial awareness resides. Crews and Landers (1993), for example, found significant increases in right-hemisphere activity in both motor and temporal cortices of golfers. In addition, they found increased right hemisphere Alpha activity just prior to the putt predicted greater accuracy.

Finally, another potentially fruitful approach is based on the notion that each athlete is different and will have his own optimal brain pattern just prior to shot initiation. Based on this model, the trainer will monitor EEG patterns from a single channel over a series of shots. By identifying a consistent difference between successful shots as compared to poor shots, an optimal EEG template can be created. The golfer can then be trained to specifically enhance this pattern, identify that he is in that brain state, and learn to take his shot right at that moment. In a preliminary study, Arns et al. (2005) found reinforcing these individual patterns enhanced golf performance.

The following approach is one that was found to be most effective in work with golfers and other athletes. It has been used successfully with members of the UCLA golf team and other professional and elite golfers. It is based on the concept of enhancing the athlete's ability to go into specific but multiple brain states to respond to specific yet varied conditions of the game and of training.

What follows are the training protocols, related brain states, and goals that I use. The arrangement and use of each of the following protocols will depend on the specific needs of each golfer as described below. Most athletes will ultimately receive training in all or most of the protocols. Sometimes the entire session will be spent on one type of training, and at other times, different protocols are combined within the same session.

Many neurofeedback clinicians use the results of a QEEG map as the basis of their protocol selection and order; however, the use of these QEEG mapping techniques with athletes is currently in its early development.

Optimal Mental Focus with Calm Muscle Tone

One way of describing mental focus is it is the way in which the athlete makes contact with the environment. As mentioned above, focus can be broad or narrow. For the golfer, a broad focus is used to determine distance as well as the optimal trajectory of a shot. When putting, a broad focus is used to aim while seeing the ball and the hole at the same time. A narrow focus is used, for example, in the process of aligning the head of the club with the ball.

Optimal focus is when the athlete engages in a task or a performance with full and single attention and intention. Single focus means the athlete is able to totally block out all distractions and does not react to irrelevant stimuli. The athlete is able to block out sounds and other aspects of the environment that are not absolutely necessary for the immediate performance.

We typically think of focus as an auditory-visual process with the external environment; however, there is also an optimal kinesthetic focus that needs to be addressed. As noted above, a golfer may have an inappropriate kinesthetic focus on a shoulder, arm, grip, or other place in the body that is counterproductive. Tension can easily be a source of distraction.

The neurofeedback protocol that is optimal for a calm focus combines the enhancement of sensorimotor rhythm, or SMR, along with the down-training of slow Theta frequencies and high Beta frequencies, such as between 24 and 32Hz. The sensorimotor rhythm is located above the motor cortex and is present when there is a decrease in activity in sensory and motor brain pathways, which typically translates into less muscle tension.

The inhibition of Theta (4–8Hz brainwave activity) is designed to help increase the activation of the brain, allowing for greater presence and focus. Theta waves are the relatively slower brainwaves. When too much Theta activity is present, the brain will be under-activated. This leaves the athlete more prone to distraction and with greater difficulty focusing. The inhibition of the higher Beta frequencies contributes to the control of obsessive thinking patterns and mental tension, which can also cause distractions. Thus, a protocol screen can be designed that requires simultaneous achievement of these three requirements for success. This screen is presented in Figure 9.4.

Electrode placement is determined based on a standardized system referred to as the 10–20 electrode placement system (Jasper, 1958). Training can be achieved at monopolar scalp locations (e.g., Cz or central), or it can be a bipolar (two-electrode montage) scalp placement. With a monopolar arrangement, the active electrode on the scalp is compared or referenced to a second electrode placed where there is no brain activity, such as an earlobe. With this configuration, the resultant EEG is representing activity solely under the active electrode site. With bipolar placements, there are two electrodes placed above particular areas of the brain. In this case, the EEG will address activity from the two brain locations.

Thus, the consultant might choose to use a bipolar arrangement with one electrode at Cz and the second electrode at FP1 (above the prefrontal cortex), which would provide training of the frontal cortex. This protocol would be used to enhance executive functions such as improved decision making and reaction time. Variations in location, such as moving lateral to either C3 or C4 can be considered. A C3 location might be used if there is a greater need for focus or alertness (a left-brain function) over calmness and C4 if there is a greater need for calmness (a right-brain function) over focus.

An alternative protocol could be to train the ratio of Theta to low Beta (either 13–15Hz or 15–18Hz) frequencies. With this protocol, the athlete can train the relative proportion of these two brain components. The training goal would be to lower this ratio; in other words, to reduce the relative proportion of Theta to Beta (distraction to focus).

Case Example

This monopolar approach was used with a female collegiate golfer. This young woman had difficulty coping with the pressure of a tournament along with the expectations placed on her. Because of an earlier success, she was expected to play an important role on her team. As soon as she found herself in difficult competitive situations, she became nervous—worried about not meeting expectations. The resultant physical nervousness occupied her attention and distracted her from her focus. In addition, the nervousness itself affected her swing.

She reluctantly decided to accept her role as a second-tier player. But her nervousness continued. She was a good candidate to use the SMR protocol that included Theta and high Beta inhibits. She trained twice a week for 10 weeks. During some sessions, a monopolar Cz placement was used; on other occasions, a bipolar placement of Fz/C4 or Pz/C4 was used, bringing in more of the right hemisphere to enhance a sense of calmness. A bipolar placement, again, means you are picking up brain EEG activity below two active electrode sites instead of just one. During some sessions an Alpha training protocol at Cz was used together with an Alpha/Theta protocol using a scripted visualization (described below).

The golfer experienced a noticeable enhancement in her ability to be and stay calm. This awareness furthermore was reassuring to her, as she said, "I feel more confident knowing I have a tool, a skill I can employ when under pressure." This resulted in her being less fearful and more confident. The result was less nervousness when she competed. Within three months, she had dropped five strokes from her tournament performance.

Optimal Resting State and Calm, Quiet Nervous System

This protocol is used to minimize fatigue, increase stamina, reduce emotional reactivity, and facilitate the feeling of being centered. Alpha training is used here to train the ability to quiet the nervous system and let go. The Alpha rhythm represents the brain's resting state. At the same time, sports research has demonstrated improved performance with increases in 8–13Hz power (Collins et al., 1990). Alpha training appears to enhance an overall feeling of well being, which facilitates a greater sense of confidence and increased capacity.

Two different protocols can be used for Alpha training. The first protocol is the 8–12Hz frequency range most commonly used for clinical populations. However, I have used a second protocol, a 10–13Hz protocol, almost exclusively for athletic performance. This has followed the evidence that a higher dominant Alpha frequency leads to better performance (Sterman, 1993)

This 10–13Hz protocol addresses autonomic and emotional reactivity. A typical example is Sandy, a very good elite player. Her greatest psychological challenge was when she fell behind the opponent she was paired with. If she fell behind by a couple of strokes, she became worried and focused on the need to make up shots to catch up to her opponent. This self-applied pressure usually led to extra tension that then interfered with her best performance.

The training I used at UCLA emphasized playing against the course and not against the opponent. The idea is that you cannot make yourself play better when you are playing behind your opponent. As soon as you begin pressing, you create tension that further interferes with your best performance. To help Sandy, the high Alpha 10–13Hz training was used. To facilitate achievement of this mental state, she was trained on the optimal breathing pattern (presented below) in which she followed the rhythm of her breath and visualized a motion that felt like her breathing pattern. Incorporating this visualization gave her a mechanism she could take on to the golf course and incorporate when she was in competition.

Optimal Breathing Pattern

Your breathing pattern is very sensitive to the stress and competitive pressures of golf. When breathing is disrupted, it can alter other physiological and mental functioning that then has a cascading effect and will impact performance. Conversely, well-practiced optimal breathing can help insure calmness and serve as an anchor that can help maintain one's center during difficult moments.

There are three places where breathing can occur: the abdomen, the chest, and the shoulders. A stressful breathing pattern will be more shallow and rapid. It will also be higher with over-involvement of the shoulders. A more optimal pattern will start with expansion of the abdomen followed by the chest while keeping the shoulders as relaxed as possible. The keys to optimal breathing include the following:

- Fully exhaling before each breath intake. By letting go of all the air in your lungs, you are more capable of a good, relaxed next breath and the optimal exchange of gases—oxygen for carbon dioxide.

- Emphasizing the exhale. Four seconds on the inhale and six seconds on the exhale are encouraged. The athlete is encouraged to inhale through the nose and exhale through the mouth with lips pursed.
- Experiencing a sense of letting go on the exhale. This can be facilitated by visualizing heaviness or the sinking or melting into the chair. Enjoy this feeling of letting go.
- An intention to keep each breathing pattern identical to the last.

When the athlete is inappropriately focused on the performance of his opponent or any other habitual mental pattern, it is not possible to tell him to stop doing the behavior and expect it to occur as if turning on a switch. As with any ongoing habit that has been repeatedly reinforced, change involves the creation of an ongoing retraining process. This is part of right training and right thinking. The establishment of a new behavior requires the creation of an ongoing retraining approach.

The approach is simple, but must be consistently reinforced and cued; otherwise it will be forgotten. We can identify a four-step process:

Right Thinking to Correct Negative Habit Pattern

Step 1: Notice the inappropriate cognitive distraction (e.g., attending to the opponent and the opponent's score).

Step 2: Engage in a rational thought process to help shift away from the distraction, such as "paying attention to my opponent cannot make my game better. It is only a distraction and will hurt my performance."

Step 3: Refocus, engage in a centering process, such as focusing on the optimal breathing pattern learned during training.

Step 4: If you are about to hit the ball, reinitiate your pre-shot ritual and restore your focus.

Sandy began using this retraining approach along with Alpha training. While at first she reported she was still getting caught up in the inappropriate thinking, by her fourth tournament, she noticed her pattern had changed. In that tournament, while she found herself four strokes behind the player she was paired with, she maintained her center and focus and gained two strokes over the final few holes.

Highly activated and intense state to enhance learning, passion, and boldness and to increase the athlete’s ability to stay at a peak level of functioning:

During golf training, the desire to improve is important. The depth of motivation an athlete has is one raw ingredient that can provide the emotional fuel to reach deeply inside to produce a good result. It is this energy that links the body’s ability to the specific goals of a golf game. This enhances the learning process. Related to this is boldness and assertiveness in one’s golf related behavior.

Within limits, the greater the physical and mental activation of the athlete, the greater is the learning potential. Two different protocols can be used to mentally activate the athlete. The first focuses on the Beta frequencies that are higher than are typically used (18–22Hz) and typically when using this protocol for short periods, roughly five minutes, it enhances the impact of training. It also appears to create a shift in athletes who have difficulty getting fully motivated for the rigors of training sessions. Caution should be used with this protocol as it sometimes can be too activating. Therefore, it is important to check with the athlete to make sure there are no after-effects such as excessive tension or difficulty falling sleep at night. For this reason, some neurofeedback experience is completed before utilizing this protocol.

Another approach that appears to facilitate training is the enhancement of the Scheer rhythm of 40Hz (38–42Hz). Synchronous bursts at this frequency have been found during problem solving (Demos, 2005). When there is 40Hz activity, it seems to link different parts of the brain together to facilitate learning (Sheer, 1989). Clinically, athletes report experiencing greater clarity with this protocol, particularly when implemented just prior to a golf lesson.

These approaches were used in working with Jake, a young professional golfer who had difficulty staying focused, particularly during training. He would quickly become bored as he practiced a particular shot or the use of an iron.

A sequenced program that combined first 18–22Hz reinforcement (with the Theta and high Beta inhibits) for five minutes at Cz was performed. This was followed by a second protocol using SMR at Cz. This protocol would be combined with a discussion about right training. This has to do with the type of attitude that an athlete brings to training and competitive performance.

Jake was a typical example of young golfers who have natural talent and are able to motivate themselves during a competition but have great difficulty becoming fully activated during practice. Some go through their practices on automatic or, more frequently, experience it as a necessary chore. These athletes typically have great promise, but after some initial success, reach a plateau and no longer progress. Attitude was important in right training Jake. We adopted the philosophy that if he was going to spend the time practicing, he might as well find a way to be enthusiastic and engaged. It is this full engagement and intensity that has the greatest impact on the modification of brain neural pathways, encouraging new and more optimal brain templates of performance.

Besides this, engaging in the right attitude during training is one of the keys to handling pressure during a competition. Excitement and passion practiced during training translates into the ability to appropriately contain the energy and stay centered and focused during highly stressful competitive situations. In other words, the use of high Beta training (18–22Hz) trains a golfer to manage larger amounts of energy experienced during pressure situations.

Deeply inward state to reframe and develop new cognitive and emotional scripts that influence confidence and reduce reactivity to the demands and expectations of others:

This protocol can facilitate a sense of power, self-confidence, and self-trust or an “I can do it” mindset. This is the unseen and often-overlooked aspect of the will to win: the ability to prevent self-sabotage and avoid the ways we place artificial ceilings on our performance. This includes unconscious negative messages, even those we think we have already overcome. This is not only talking about “you are not good enough” but also “you can only do so well and no better”; a much more subtle limitation experienced by many golfers.

Alpha/Theta training involves the reinforcement of both Alpha and Theta frequencies, using a different sound to distinguish the two, with Alpha reward being of a higher auditory pitch. In addition, a separate sound is employed to note when crossover occurs. This is when amplitude of the lower Theta frequencies is higher than the Alpha and signifies a deeper mental state.

A typical location for Alpha/Theta training is Pz. Training is performed with eyes closed in a darkened room to facilitate the lowering of arousal and ultimately going into a deep state of calm. An Alpha/Theta session will be 30 minutes in duration.

There are many reasons for utilizing an Alpha/Theta protocol for this consideration. Alpha/Theta enhancement creates a mental state in which an athlete can become more receptive and open to new ideas. In many cases, the boundaries of performance are established during our childhood. We all carry a story about our life and about ourselves. Our stories are very detailed and include beliefs about how good or how bad we are as a person with infinite shades of gray in between. Our stories even include whether we are the type of person who chokes at important moments or who might be second string on a collegiate team but not a first stringer, the number three player but not number one. And we unconsciously adhere to this story despite its limitations.

In previous research, my colleagues and I have noted the effectiveness of Alpha/Theta training in the process of releasing maladaptive training and messages from our past (Scott et al., 2005). Alpha/Theta, when combined with the presentation of constructive and positively motivated ideas and images can begin to reframe old stories. This process can reshape aspects of our story to open up new possibilities. When properly approached, this process can address the consequences of our stories, such as physical tensing, anxiety, holding back, and poor course decision making.

When sports psychologists and athletes talk about being in the flow or in the zone they are referring to a physical/mental state in which there is an effortless merging of action and awareness, and heightened energy. (Young and Pain, 1999). This is typically accompanied by an absence of thinking or just doing without thinking. There is no excess physical holding of the jaw or the stomach or any other part of the body. This allows for the fluidity of movement that is the hallmark of most exceptional and successful golfers. The Alpha/Theta protocols facilitate the letting go of old scripts that can get in the way of this flow.

Typically, this training is preceded with reading a predetermined script that presents a golf scenario designed to address a feeling of success. The scenario will also incorporate the specific training needs uncovered in a prior discussion with the athlete. This may include the message of “I deserve” or “I am fully capable”; messages designed to replace existing negative self-images. Sometimes a separate sound is incorporated when 7Hz rises above a certain threshold. This specific emphasis is to enhance visualization.

Case Example

Karen was a professional golfer who always seemed to come up just short at tournament time. She worked hard to improve but had hit a wall in her development, despite tremendous promise. Initial neurofeedback using the SMR protocols were helpful in reducing her anxiety, which translated into better performances, but she was erratic and unreliable in pressure situations.

Karen’s story had to do with having three brothers who were all athletic and received more attention and encouragement from her family. She felt a lot of pride as she became successful and even a bit competitive with her brothers. What we discovered, however, was that her story included the messages that she was not as good as her brothers, and it was not okay for her to outshine them.

The first of these messages created doubt in how good she could actually be. The second resulted in emotional conflicts whenever she was playing at the top of her game. This conflict created anxiety and tension that impacted her performance, thus reinforcing the first message. It was a vicious cycle that, up to that point, kept her stuck.

A script was designed that mirrored her belief that she had the right to become as good as her talents and abilities would allow while at the same time making sure her love and care for her brothers and family was honored. The script included imagining she was moving up in the professional rankings, allowing her to feel comfortable and excited about being competitive and aggressive. The script also included visualizing winning a tournament and fully embracing the success and joy.

This script was tape recorded in Karen's own voice, so it could be played for her just prior to the Alpha/Theta neurofeedback. Later, we found alternating with a second tape that used the sports psychologist's voice enhanced the process. Karen reported feeling a shift in her confidence and a greater sense of entitlement. Finally, she recognized she no longer felt conflicted when she was at the top of her game. Instead, for the first time, she felt the support of her family as she approached difficult tournament situations. This resulted in winning her first professional tournament.

A left-right brain synchrony to enhance full brain integration and to minimize inappropriate cognitive analysis:

A common trap most golfers encounter is focusing on the mechanics of a swing or some other nonproductive thinking, for example, what not to do, just before or during a swing. This behavior correlates with left-hemisphere brain activity. One way of approaching this issue is to train greater activation of the right hemisphere of the brain. We prefer the training of interhemisphere synchronization and the balancing of activation of the two hemispheres.

Peak performance involves the optimal utilization of both hemispheres of the brain, the two sides of the brain, as well as their communication and integration. This maximizes accessibility to their various functions. Different types of mind-mirror protocols that present simultaneous and identical left-right hemisphere information are used. With a mind-mirror screen, the activity of two channels of data is displayed, one from the left hemisphere and the other from the right hemisphere. The electrodes will be placed at symmetrical locations such as C3 (left) and C4 (right).

Mind mirror refers to a particular display in which the EEG frequencies (they can be in one-Hz bin width or in 4Hz bin widths that correspond with the approximate bandwidths of Delta, Theta, and Alpha as well as the subcomponents of Beta) are displayed as if they were mirror images of each other. The screens will also incorporate reward and inhibits. A typical protocol would reward 15–18Hz on the left side (C3) while rewarding SMR at 12–15Hz on the right side (C4). Standard inhibits of Theta and high Beta frequencies described above are also used. Figure 9.5 presents a version of this protocol screen, which helps the golfer synchronize the activity of the two sides of the brain.

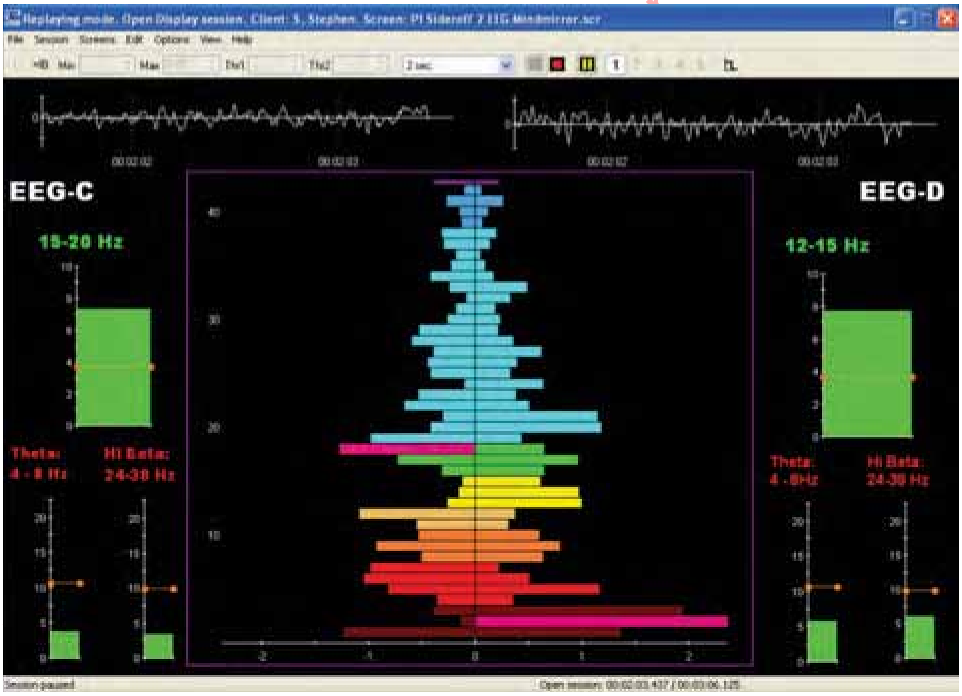


Figure 9.5: Mind-Mirror EEG Presentation. This protocol display allows for the simultaneous presentation of EEGs from both sides of the brain, presented as mirror images of each other. This presentation fosters the synchronization of the two hemispheres. This screen also presents one reinforcing and two inhibit frequency bands for each electrode location.

The protocol screen in Figure 9.5 was used with Don, a professional golfer who was very diligent in following everything his coach taught him. He recognized his tendency to obsess over a particular aspect of his swing mechanics after it was presented to him. Despite training using SMR and Alpha protocols this tendency persisted. The mind-mirror protocol proved very effective in helping Don get more into the feel of the swing and the feel of his entire body, not just one part, as he prepared to swing. This was also supplemented with training of the Sheer rhythm mentioned previously. This protocol appears to facilitate the integration of different areas of the brain.

Enhanced mental flexibility for quick recovery (the letting go of a poor shot) and to facilitate a seamless flow from one need to another:

This training involves the selection of multiple protocols within a single session that address a series of different actual play scenarios. As each scenario, with a new set of mental requirements, is presented, the golfer is guided into a particular visualization vignette that corresponds to this new scenario. The session might start with the first visualization of preparing for a tournament. Here an Alpha protocol of either 8–12Hz or 10–13Hz for two three-minute trials is employed.

The next visualization will have the golfer imagine he is addressing the ball in preparation for a swing. Here, the protocol would be the calm focused protocol (i.e., SMR with Theta and high Beta inhibits) followed by the mind mirror. Alternately, the mind mirror might combine specific reinforcement of a 10–15Hz band, which overlaps the Alpha and the SMR EEG bands with the pre-shot ritual. To help transfer the achievement of this state onto the golf course, the athlete is instructed to stand and hold his golf club and address the golf ball, which is placed on the floor of the office. The golfer will then hear the reward sounds each time his brain shifts into the desired brain state.

After perhaps nine minutes of three three-minute trials, a new situation and protocol would be introduced. This would be the follow-up to a shot and may be reinforcing 7Hz or the full Alpha range of 8–12Hz in which the golfer holds the image of the perfect shot just hit. The golfer is instructed to visualize his best shot under all post-shot conditions. If he actually hit his best shot, he would be mentally reinforcing it and his ability to do it. If his shot was not optimum, this process helps to let go of the poor shot and again allow the brain to remember the optimal. This component of the session would last approximately 5 to 10 minutes.

In the next section, the athlete is instructed to imagine moving to his next shot or the next hole. He is instructed to totally let go mentally and achieve a calm state between shots, regardless of whether the shot was good or bad. Over-exuberant celebration following a great shot or getting a birdie can disrupt focus on the subsequent hole just as much as hitting a poor shot. In this case, the golfer should set a boundary on his excitement. Once he starts walking to his next shot, it is time to let go.

The instructions for the above process include having the golfer visualize the golf course's green expanse, trees, and other relevant aspects of the golf experience. This becomes his time for recuperation. By incorporating this visualization, it helps anchor the training to the actual golf environment. Conversely, when the golfer is on the course, he should mentally recall the training environment, including the training screens and reinforcing sounds.

Training to Perform Optimally while under Pressure

This is essentially a composite of the approaches presented to this point. This includes ways of accessing the various mental states and training skills learned during neurofeedback when in competition. It is also fully incorporating the feeling of success from a winning shot or winning a match. The use of anchors, learned mental and physical patterns and images, could be called on during competition to trigger the desired state. These include the optimal breathing pattern and the pre shot ritual. During competition, the golfer can also call on the reinforcing neurofeedback training sounds to access the attentional state that was trained to that sound.

Using a golf club and addressing the golf ball while doing neurofeedback, either in the office or on the golf course, brings in components of actual play. This further facilitates the transfer of training. Creating specific tournament situations that the athlete can visualize while doing neurofeedback will further enhance the training process. These are all aspects of dress rehearsal that were described previously, which will help desensitize the athlete to the stress of the competitive situation.

Case Example

A typical training designed to handle pressure was used with Bill, a professional golfer who performed poorly in the closing phases of a golf round. This ongoing difficulty had left him feeling discouraged and with little confidence. In addition to the cognitive coaching that has already been described, the following series of protocols were implemented.

Initial training integrated primarily high Alpha, 10–13Hz, along with Theta and high Beta inhibits. During this training, he was instructed to practice the optimal breathing pattern described above. Assigned homework included daily practice of a relaxation exercise that was recorded for home use. This was followed, after eight sessions, by a series of Alpha/Theta sessions. We worked together to develop a script that he listened to prior to each Alpha/Theta session. The script presented a scenario that described his successful completion of the last three holes of a tournament.

Additional sessions integrated a protocol that started with 18–22Hz feedback followed by Alpha training. Here, he was given practice in managing a more highly activated state. By following five minutes of this protocol with Alpha training, his ability to shift his level of activation was being trained as he would need to do during a tournament.

Finally, he was guided through a specific desensitization process. After 15 minutes of alpha training (8–12Hz), he was asked to notice and then confirm when he had achieved a relaxed state. Then he was asked to visualize playing the 18th hole in as much detail as possible. Sometimes he would visualize being at the tee, and at other times, he would see himself standing on the green getting ready to putt. In both cases, there would be a large crowd watching. In addition, he would be paired with a player who made him particularly nervous as a result of his previous critical comments.

After approximately 15 seconds of visualization, he was asked to clear the image, in other words, clear his mind of the scene, and return to the relaxation process. By limiting the visualization to 15 seconds, there would be little time to fully lose the relaxed state he had achieved. He then completed two minutes of Alpha training to regain the relaxed state. Once again, he engaged in the same visualization while noticing how relaxed he was. In a similar manner, he would shift between the Alpha relaxation and stress imagery four times. As this training progressed, he was able to hold the relaxed state for increasingly longer periods until he could sit for an entire minute visualizing the stressful scene. Bill reported that this process was effective in reducing his nervousness during late-match situations.

Conclusion

This chapter presented a systematic program for improving golf performance. General optimal performance approaches were discussed in combination with specific neurofeedback (EEG biofeedback) protocols that can maximize both training and performance. The concept of neurofeedback itself can serve as a model for approaching optimal performance in golf. Neurofeedback is the process of learning self-regulation. This is based on the knowledge that the body, left to its own mechanisms, is designed to work at its best: to achieve homeostasis, or balance.

A key factor in neurofeedback training is to help the athlete overcome the tendency to try to make it happen. Trying can be equated to an outside motivation. The key to optimal performance is finding the source of the motivation that is deep inside at one's center. The learning process is balancing the internal calm with the internal drive. But both drive and calm must be found within. The most commonly used invocation to the trainee during training is to allow it to happen. This facilitates the shift into a more focus state.

Going within is the antidote to much of the elite golfer's challenges and mistakes. Whether it is getting distracted by an obstacle or by the performance of an opponent, by the distress in hitting a poor shot or worrying about your coach or parent's judgments, the problem often boils down to having too much of an external focus.

In other words, the goal is to gain a sense of trust in your performance. As mentioned previously, when approaching the tee box, or anyplace else on the golf course, you are going for your best shot. Having trust is believing you will always be able to hit your best shot. It may not be the game winner, it may not be the shot that your opponent hit, but it is what you know you can do. This is the path to optimal performance and optimal improvement during training

RESILIENCE

By Stephen Sideroff, PhD

Name: ______________________ **Date:** ____________

Please answer each question by circling the number that best describes your current views and life situation. Add your total score for each component and transfer this number to your Resilience Profile. Please answer to the best of your ability and as honestly as possible. This is for your own awareness. There are no right or wrong answers.

		Not at all True			Very True
1.	I feel good about myself. I like who I am	0	1	2	3
2.	I take care of myself—I exercise and eat right	0	1	2	3
3.	I have a hard time taking in compliments	3	2	1	0

4. I am more apt to pick out what I did wrong rather than what I did right	3	2	1	0
TOTAL SCORE: RELATIONSHIP WITH SELF				______
5. I let people take advantage of me	3	2	1	0
6. I have a good network of people in my life who want me to succeed	0	1	2	3
7. It is hard for me to ask for help	3	2	1	0
8. I have difficulty making friends	3	2	1	0
TOTAL SCORE: RELATIONSHIP WITH OTHERS				______
9. I find purpose in my life	0	1	2	3
10. I am committed to giving service to a cause	0	1	2	3
11. I believe in something greater than myself	0	1	2	3
12. I have a basic enjoyment and love of life	0	1	2	3
TOTAL SCORE: RELATIONSHIP WITH SOMETHING GREATER				______
13. I am able to easily relax	0	1	2	3
14. When stressed I recover quickly	0	1	2	3
15. I have difficulty unwinding	3	2	1	0
16. When I go to bed, it takes me awhile to fall asleep, or I may toss and turn and not feel rested in the morning	3	2	1	0
TOTAL SCORE: PHYSIOLOGICAL BALANCE				______
17. I am aware of my feelings	0	1	2	3
18. I am able to express my feelings	0	1	2	3
19. I get impatient when others make mistakes, are slow, or don't understand things	3	2	1	0
20. I overreact in certain situations	3	2	1	0
21. I am able to let go of difficult feelings	0	1	2	3
TOTAL SCORE: EMOTIONAL BALANCE				______
22. I have positive expectations going into situations	0	1	2	3
23. I don't dwell on my mistakes	0	1	2	3
24. When I wake up in the morning I worry about what might happen during the day	3	2	1	0
25. I am usually on the lookout for what can go wrong	3	2	1	0
TOTAL SCORE: COGNITIVE BALANCE				______

26. I don't notice details in my environment	3	2	1	0
27. I am able to stay in the present	0	1	2	3
28. I have confidence in myself	0	1	2	3
29. I anticipate and take action instead of reacting to events	0	1	2	3
30. I get distracted easily	3	2	1	0

TOTAL SCORE: PRESENCE ______

31. I am able to see the perspective of others	0	1	2	3
32. I look for new experiences to learn from	0	1	2	3
33. I have difficulty being flexible	3	2	1	0
34. If my path is thwarted, I have difficulty improvising and adjusting to a more attainable goal	3	2	1	0

TOTAL SCORE: FLEXIBILITY ______

35. I do not let my fears stop me from taking action	0	1	2	3
36. I have difficulty making important decisions	3	2	1	0
37. I procrastinate before taking action	3	2	1	0
38. I am able to be assertive to overcome an obstacle	0	1	2	3
39. I have a strong will	0	1	2	3
40. I have difficulty finishing what I start	3	2	1	0

TOTAL SCORE: POWER ______

Resilience Profile

	Relational			Organismic			Process		
	With Self	With Other	Something Greater	Physiological	Emotional	Cognitive	Presence	Flexibility	Power
Optimal Functioning	12 11 10	12 11 10	12 11 10	12 11 10	15 14 13 12	12 11 10	15 14 13 12	12 11 10	18 17 16 15 14
Average Functioning	9 8 7	9 8 7	9 8 7	9 8 7	11 10 9 8	9 8 7	11 10 9 8	9 8 7	13 12 11 10
Borderline	6 5	6 5	6 5	6 5	7 6	6 5	7 6	6 5	9 8 7
Problem Area	4 3 2 1	4 3 2 1	4 3 2 1	4 3 2 1	5 4 3 2 1	4 3 2 1	5 4 3 2 1	4 3 2 1	6 5 4 3 2 1

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Peak Performance Using Personalized and Task-Specific Event-Locked EEG: A Wireless, Personalized Medicine Approach to Sports Performance Enhancement
Chapter 10

by

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Abstract

This chapter describes a personalized assessment and training model for sports performance enhancement in golf that utilizes task-specific, event-locked EEG recording and training during telemetry EEG monitoring and neurofeedback. This model of training emphasizes capturing the personalized real-time (temporal dimension) and real-life (specific personal, task- and environment-related variables) brain dynamics as the brain is engaged in sport-related, task-specific challenges. Using wireless and telemetry EEG monitoring and neurofeedback training, the model allows for assessment and training in sport-specific settings rather than a laboratory environment and takes into account individual differences in brain dynamics. Efficiency of the model and the result of individual and group data from pilot studies are discussed. Future research and relevance to clinical settings is explored.

Chapter Outline

I. Training the Brain Based on Personalized Performance and Brain States:
Operant, classical, & contextual conditioning

II. Use of Wireless Technology for Monitoring and Training of Brain States

III. Group Study: Assessment and Training

IV. Case Study: Assessment and Training of an Elite Performer

V. Conclusions and Future Research

VI. References

Although the majority, if not all, of research studies exploring the utility of neurofeedback in sports performance are non-controlled group studies or case studies, there is convincing evidence that conditioning and training various brain states as measured by EEG is a promising method for peak performance training (see Hammond, 2007 and Hatfield et al., 2006 for summary). Most studies to date are based on the research evidence that neurofeedback can be used as a method to train and condition various brain states for improving cognitive functions such as attention, concentration, and focus and to help improve regulation of emotional control and to minimize the negative self-talk that is necessary to achieve peak states in sports performance (Williams, 2006; Egner & Gruzelier, 2003; Haufler et al., 2000; Konttinen et al., 2000; Chartier et al., 1997; Landers et al., 1994; Crews & Landers, 1993; Salazar et al., 1990; Landers et al., 1991; Salazar et al., 1990; Hatfield et al.,1984).

A number of these studies suggest the deactivation of the left hemisphere as measured by increased Alpha power or synchrony can lead to improved performance in specific tasks in certain sports that require quieting and freeing the mind from irrelevant stimuli, focusing on the task at hand, and getting rid of mental chatter and verbal-analytic processes (for details see the chapter on history of EEG biofeedback).

Other studies have observed that a generalized reduction in cerebral activity, as evidenced by a lower activation level across all bands, is characteristic for peak states in sports and other types of performances, also called the “all inhibit” or “squash” protocol. The earliest account of the use of multi-band or all-band suppression protocols we have found is the work of Dr. Gastaul Pourier, a Canadian neurologist, in the early 1970s who identified uncommon peaks in the Fourier transform and suppressed them by using broadband inhibits. His work was presented and was mentioned in the first *Journal of Biofeedback* in 1973. He used this method with epilepsy among other clinical categories. Many clinicians in the field ended up using this type of protocol for a variety of psychological disorders in their clinical practice based on such reports or just based on their own clinical observation of excessive activity in more than one traditional band in various disorders. For instance, white-matter damage as a result of various etiologies, including trauma, solvents, heavy metals, metabolic issues, and lack of myelination, may result in excessive slow activity that may encompass excess activity within the Theta band. In some cases, slow Alpha may also be present with increased amplitude in addition to the slower activity. Similar patterns may appear in some forms of depression where a wide band of slow activity appears anteriorly. From a clinical point of view, inhibition of multiple bands became a common practice among neurofeedback practitioners. Eventually, these findings ended up being used in various settings, including peak performance and sports enhancement.

For peak performance and sports enhancement purposes, the lower activation level across all bands has been interpreted as less activation and less demand on the brain during the performance. Because slower activity (within Delta and Theta range) is often associated with decreased cortical functions and being unfocused and less alert, it can also be argued that because the magnitude of the slower frequency bands (such as Delta and Theta) contribute to most of the amplitude or power within the frequency spectrum in comparison to the faster activity (Beta), a wide-band reduction in amplitude is likely to have larger reduction on the slow activity, which is hypothesized to be responsible for these training effects. The reduction of amplitude within slow activity range Theta and low Alpha range, for instance, has been linked to suppression of unwanted and/or distracting thoughts. Therefore, wide-band inhibit filters are likely to provide such training effect. There are also other possible mechanisms that can explain the learning effects observed in such protocols. For instance, in a pilot study in our Brainclinics lab, six healthy volunteers were randomly assigned to one of the two protocols, broadband inhibit/squash protocol or SMR/Theta training. Twenty sessions of three times, 10 minutes, were held three times each week during seven weeks. In the SMR/Theta group, an increase of absolute SMR activity was found, whereas, in the squash group, a decrease of absolute Theta activity was found (Breteler, Litjens, & Arns, 2004). However, closer inspection of these data revealed that for the squash protocol the effects were even stronger for a reduction in Delta, suggesting this effect to be mainly a result of fixating the eyes and hence reducing the slow EEG content from EOG activity. No clear pre- and post-QEEG and neuropsychological differences were found in the squash protocol. These findings indicate people could gain control over the inhibit band very quickly. However, these effects seemed to mostly depend on the decrease of EOG activity, hence an indirect non-cerebral effect.

The reported concluded that focused attention by some people may be explained by fixating the eyes, thereby reducing the power in the low frequency bands. This would correspond with the previously noted research on the quiet eye during good performance and perhaps enhanced SMR (see intro to EEG and/or attention chapters).

Training the Brain Based on Personalized Performance and Brain States

An important concept in peak performance is that various EEG frequencies can have a functional significance that is individually very different. Most importantly, considering the implication of the lateralized Alpha activity in optimal response preparation, Klimesch (1999) defined the individual Alpha peak (IAF) as the frequency showing the maximum power-density peak within a large frequency range from 4 to 14Hz, and therefore the Alpha band may or may not fall within the 8–12Hz range as described in some of the EEG and neurofeedback literature. Considering this important factor, the assessment and training of Alpha may require a totally different frequency range that is unique to that individual.

Finally, we recommend using a personalized time-locked and real-time contextual conditioning method of neurofeedback training (Arns et al., 2008) as opposed to the more commonly used operant method in sports. The benefits of this approach include the following:

1. The ability to do real-time telemetry recording to capture personal brain dynamics for successful versus unsuccessful moments.
2. Brain responses are event-locked; therefore, the same methodology can be used for various skills and may lead to different training protocols.
3. Response-reward association is more efficient; therefore, training time is relatively shorter and skill can be improved within a few sessions.

4. Training is personalized and reinforces brain states and skills that are within the scope of the trainee’s own brain dynamics.

5. Training can be done either in the lab or on the field.

The disadvantages are these:

1. Although this protocol is likely to reduce the length of training and maximize learning effects, the initial assessment and procedures are more complex in comparison to other methods.

2. Customization of assessment and treatment requires specialized hardware and software installation.

3. A difference in EEGs between successful and unsuccessful events is required in order to be able to offer any training.

4. Analysis is time-consuming unless automated.

Operant, Classical, & Contextual Conditioning

The mechanism behind neurofeedback is generally known to be operant conditioning. Operant conditioning is the principle that describes how one learns to develop a new behavior through reinforcement (desirable consequences that promote the reoccurrence of that behavior). In traditional neurofeedback, a change in behavior (desirable changes in brain activity in this case) elicits reinforcement (an intuitively desirable outcome such as winning in a game or an agreed-upon signal for positive outcome such as a green light or a pleasant tone). Classical conditioning, on the other hand, usually involves an involuntary, or automatic, response to a stimulus.

Using the conditioning model, instead of reinforcing a particular brain state to generalize (e.g., increase Alpha in the left posterior hemisphere), we promote the identification and association of a particular brain state for a specific task. In this model, a brain state is associated and paired with the presence or absence of a stimulus that is also associated with the cues from the internal states and the environment (the gestalt experience). This model suggests, for example, that the ideal condition for training a golfer is to get as close as possible to the gestalt experience that is associated with the mental state of successful performance, which would include training on the golf course. Therefore, while training in the laboratory may trigger many other associated elements that elicit the required association and approximate the desired brain state, training directly on the golf course would be superior to training in the laboratory. This is because the contextual conditioning model would train the athlete with the appropriate responses or brain state in the golf environment, and there is no need for generalization from the laboratory environment to the golf course. However, that does not mean training in the laboratory using this model will not be beneficial.

For instance, in our work, the involuntary response (changes in heart rate or EEG) is identified and reinforced by the paired stimuli condition. Once the association is made, it is assumed that learning has occurred. It is through multiple exposures to the same condition pairing these two conditions that pairing takes place. To translate this into our actual experience in sports enhancement, a golfer, for instance, learns the desirable brain state is paired with certain contextual cues, such as seeing the hole in close proximity, holding the putter, and standing in a typical putting posture as would be normal during a real game of golf. Ultimately, the desired state of mind is achieved with minimum effort because contextual cues (position for putting) trigger the desired brain state that has been paired and generalized.

Regardless of the conditioning paradigm being used when doing peak performance training for sports, our view is that it is essential to keep the personalized brain profile in mind, as well as specific demands of the sport and other real-time variables that tend to change cognitive and emotional reactions that are all reflected by brain dynamics. These variables may include, but are not limited to, factors such as time of day, environmental conditions, audience effect, level of competition or peer pressure, etc.

Overall, the authors of this chapter agree with the sentiments and conclusions made by Hammond (2007) that echo these concerns and assert that different brains demand different approaches and simplistic one-size-fits-all approaches to neurofeedback in sports are likely to be ineffective when applying it to training across various sports. Furthermore, we believe individual differences in brain dynamics, phenotypes, temperaments, personality, and genetics are likely to demand a more personalized approach to EEG assessment and training in sports performance enhancement. Later in this chapter, we provide an example of how we assess and train considering these variables.

Use of Wireless Technology for Monitoring and Training of Brain States

To most people who have been attached to EEG and other physiological monitoring and feedback equipment, it is very clear that the combination of being in a real-life sports performance situation and being attached to sensors and related equipment presents a challenge in terms of comfort, mobility, and practicality. Wearing sensors and all the wires attached to the computer device while trying to play a game of tennis or even a more stationary activity such as putting in golf does not promote a natural and pleasant experience for the athlete.

Being mindful of this problem for research and training and with the goal of having access to equipment for real-life, outside-the-lab assessment and training, we set out to develop wireless technology for this purpose several years ago. After a few years of research and development, this fantasy became a reality. Since that time, this technology has been available for research and clinical use, and more development has been promoted in this area. In addition, the availability and flexibility of such tools have motivated us to think about new and innovative ways of conducting research and training (for more information visit www.brainresourcecenter.com and www.brainquiry.com).

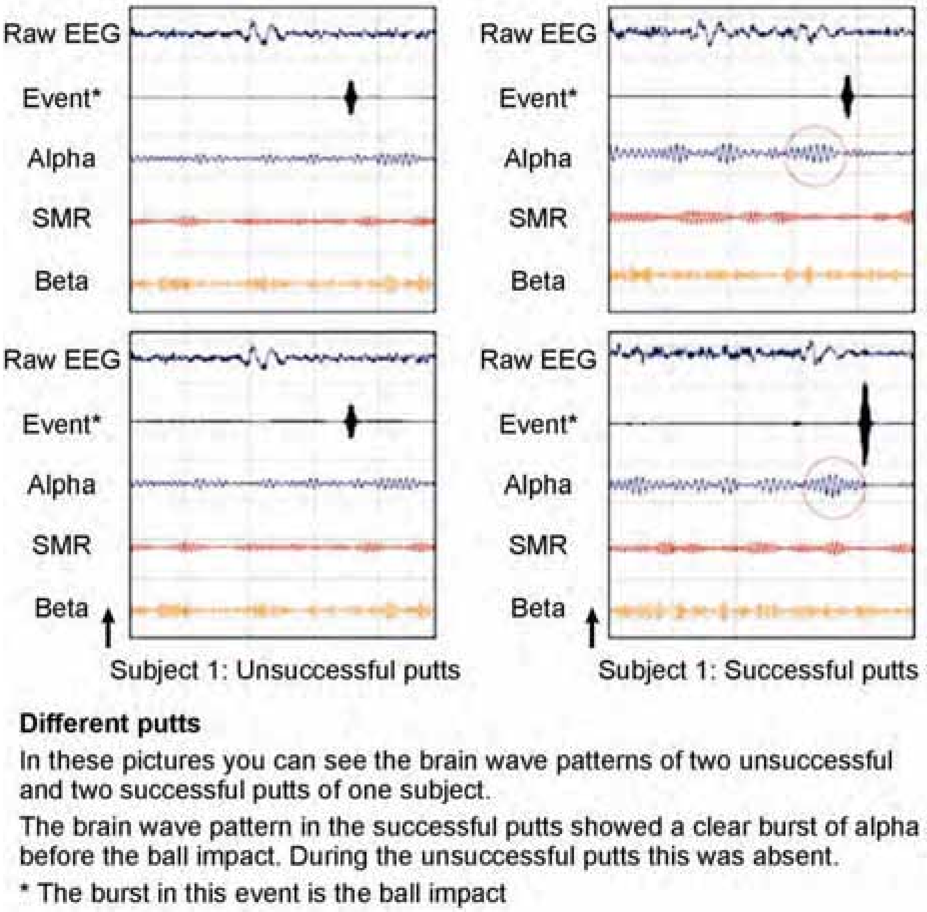
Often QEEGs are recommended to guide neurofeedback training. This chapter's authors believe, however, that while having the QEEG data is always helpful, for the purpose of optimal performance, QEEGs may not be as necessary because they are more difficult to use, not readily available, can be expensive, and most sports people tend to have healthier brains as compared to the clinical population for which the QEEG assessment is usually provided. More importantly, QEEGs may not be as suitable for peak-performance training as they are in clinical settings because, in peak performance, the intention is probably to train someone into a direction of peak performance rather than a regression to the mean as is often done in clinical disorders. The authors of this chapter, therefore, do not recommend Z-score training or QEEG-based normalization procedures for peak performance unless an obvious cognitive (e.g., ADD) or emotional (e.g., depression, bipolar) barrier is preventing an athlete from performing at his peak. We developed a within-subject assessment, to assess the difference between good and bad performance, making use of the within-subject optimal state, and training this intra-individual peak-performance state specifically relevant to that person. Research on good versus bad performance supports this direction (see Hatfield et al., 2006 for an overview). In our centers, while we do routine QEEG evaluations for all clinical cases, for the purpose of sports enhancement, the assessment and training is often completed with wireless, two-channel portable EEG equipment that can be used in the sports field.

Group Study: Assessment and Training

In an initial pilot study, EEG was assessed for one advanced golfer (zero handicap) in a real-life situation on the golf course. The subject's EEG was recorded using a two-channel Brainquiry PET 2 (Personal Efficiency Trainer by Brainquiry) wireless EEG device. His time-locked brain electrical activity was measured and recorded at Fpz. For each putt, the exact moment of ball impact was registered using a carefully designed sensor mounted on the putter face. This method was used to standardize and record a time-locked event response at the exact moment of impact. We overlaid the brain activity with the exact moment of the impact and analyzed the preparatory brain response. The EEG data suggest the ability to discriminate successful from unsuccessful putts by seeing real-time and time-locked pre-stimulus (moment of ball impact) changes in the EEG, which for this golfer was the presence or absence of an Alpha burst one second before the putt. To see a short movie clip that shows, in slow motion, the brain activity of the golfer performing a putt go to www.brainclinics.com/sport or www.brainresourcecenter.com/sports.html.

Based on this case study, a group study was conducted (Arns et al., 2008) that tested the hypothesis that event-related changes between successful versus unsuccessful performance in the putting game of golf were measurable and could be used to give neurofeedback training to improve performance. Six participants were recruited from a local golf club, average handicap 12.3 (SD = 5.6), and assessed using a real-time and time-locked pre-stimulus model. In the assessment period, a personal, event-locked EEG profile at Fpz was determined for each subject for successful versus unsuccessful putts. Active electrodes were used; hence, impedance issues and movement artifacts were minimized. Active electrodes use a circuitry in the housing where sensors connect to the scalp locations and help improve common physiology recording system issues such as high impedances and movement artifacts. For more information, see www.brainquiry.com. Furthermore, a linked-ears (A1+A2/2) montage was used, minimizing the effects of lateral eye movements. Target frequency bands and amplitudes marking the optimal prefrontal brain state were clinically derived from the profile by two independent raters. An example of one golfer's successful from unsuccessful putts is shown in Figure 10.1.

Figure 10.1. Brain patterns of successful versus unsuccessful putts:



The golfers then received three real-life neurofeedback training sessions based on their personal profile obtained from the assessment procedure. The training was done over three different days, and during each day, a full A-B-A-B log was recorded.

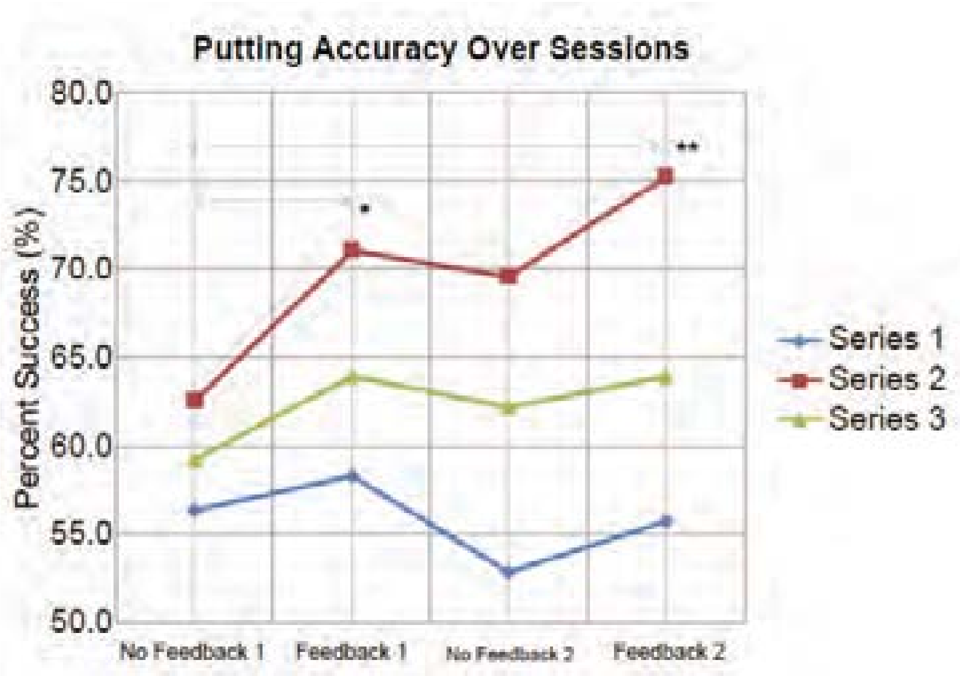
For the second part of the study, it was predicted that by real-life, wireless EEG training during actual performance on the golf course subjects could learn to enhance their putting performance based on their personal brain dynamics for successful attempts. The training was conducted over a three-day period. The training sessions consisted of four series of 20 putts per series, resulting in 80 putts (per day) in an A-B-A-B design. The training protocol was based on subjects' individualized profiles that enhanced or suppressed certain frequency bands. For example, a golfer could be trained to keep Theta (4–8Hz) and Alpha 1 (8–10Hz) below 15 µV and have SMR and Beta 1 (15–18Hz) above 10 µV before he could putt the ball. The inter-rater reliability of target frequency bands was calculated at 91 percent (for details also see Arns et al., 2008).

The feedback in the second and fourth series was administered in the form of a continuous no-go tone (golfer was standing ready to putt but was only allowed to putt when the background no-go tone ceased, indicating that he showed the right brain activity); whereas, in the first and third series, no feedback was provided. In these series, participants were instructed to perform the putt only after the no-go tone had ceased (we used a cessation of the tone because introducing a tone might take the golfer out of the zone). This tone was terminated only when the participants' EEG met their personal profile of brain state associated with successful putts based on their assessment-defined criteria.

The number of successful putts was averaged over subjects and across conditions and statistically analyzed. For details of statistical analysis, see Arns et al. (2008). The results indicated the overall percentage of successful putts was significantly larger in the second and fourth series (feedback condition) of training compared to the first and third series (no feedback condition). Furthermore, subjects improved their performance in the feedback conditions by an average of 25 percent.

Figure 10.2 demonstrates the results of feedback based on the personalized protocol. In all sessions, a highly specific performance increase is seen in the second and fourth (feedback) series compared to the first and third series, in which no feedback was provided. The participants improved their performance in the first EEG feedback trial by 12.5 percent on average (see session two, taking into account that they all started at 50 percent this represents a 25 percent improvement).

Figure 10.2. Putting accuracy averaged over subjects: (**) indicates a significant effect. Effect of feedback shows a clear increase in putting accuracy. Highly significant effects are shown on session two. Every series was a separate session.



When looking at session three, one should notice the flat line, indicating the feedback sessions did not add significantly to the improvement in performance. Whether the golfers in session three were regressing towards the mean or session two was abnormally high because of an "ah-ha" or novelty effect is unknown and needs further testing.

This study demonstrates that the zone or the optimal mental state for golf putting shows clear recognizable personalized patterns. The learning effects suggest this real-life approach to neurofeedback improves learning speed. In addition, this study showed that, as predicted, there were clear discernable differences between the pre-putting, event-locked EEG profiles associated with each individual's successful and unsuccessful putts. This means that after careful assessment of the individual's EEG during a specific task performance (golf putting in this case), we were able to predict if they were likely to succeed or fail based on their EEG dynamic in real-time.

Furthermore, this study suggests different people under similar task conditions (putting a golf ball) show individualized EEG patterns prior to successfully putting a golf ball. Some subjects showed increased Alpha before ball impact as the optimal mental state, as previous literature suggests (Landers et al., 1991; Salazar et al., 1990). However, most other subjects showed a totally different pattern such as increase in SMR-low Beta or a clear phase shift (i.e., expected event-locked EEG changes prior to the golf club hitting the ball peaking too early or too late) in their Alpha and Theta activity. Given these personalized profiles, it is hard to tell exactly why these differences existed. It might be that from an arousal perspective, and keeping the U-shaped arousal-performance curve in mind, some people need to lower their arousal a bit more in order to achieve optimal performance; whereas, other people need to arouse themselves a bit more in order to achieve optimal performance. The fact is that there are clear differences between different subjects and a personalized approach is, perhaps, the key to real peak performance.

Case Study: Assessment and Training of an Elite Performer

Stefan Matel: "I never thought somebody could improve my putting through my brain!"

A case study of a high-level performer is provided to illustrate that not only can moderately skilled golfers benefit from the EEG training, but also that significant performance enhancement can be demonstrated in a highly skilled golfer.

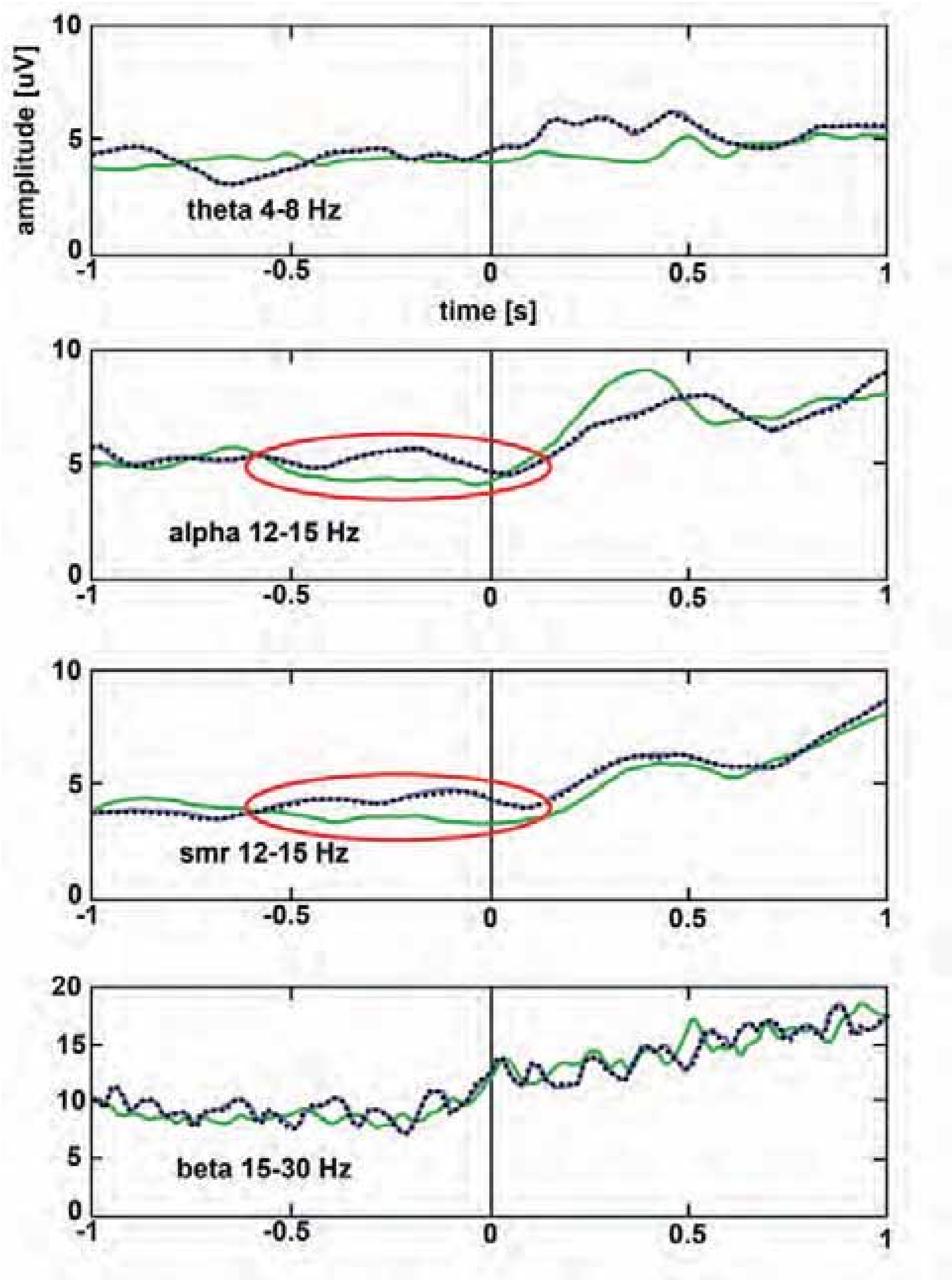
In a real-life, wireless neurofeedback training tract at a putting green with a top-level golfer (zero handicap) playing for the Dutch national selection, an assessment session was completed first on an inside golf court. The assessment consisted of 120 putts from a distance that resulted in approximately 50 percent success. During the assessment, his time-locked brain electrical activity was measured and recorded wirelessly at Fpz by using a two-channel Brainquiry PET 2 (Personal Efficiency

Trainer) wireless EEG device as described earlier in this paper. The specific characteristics of his profile are shown in Figure 10.3.

We emphasize that this profile could have been totally different for successful putting in another player as we have seen from our previous study (Arns et al., 2008):

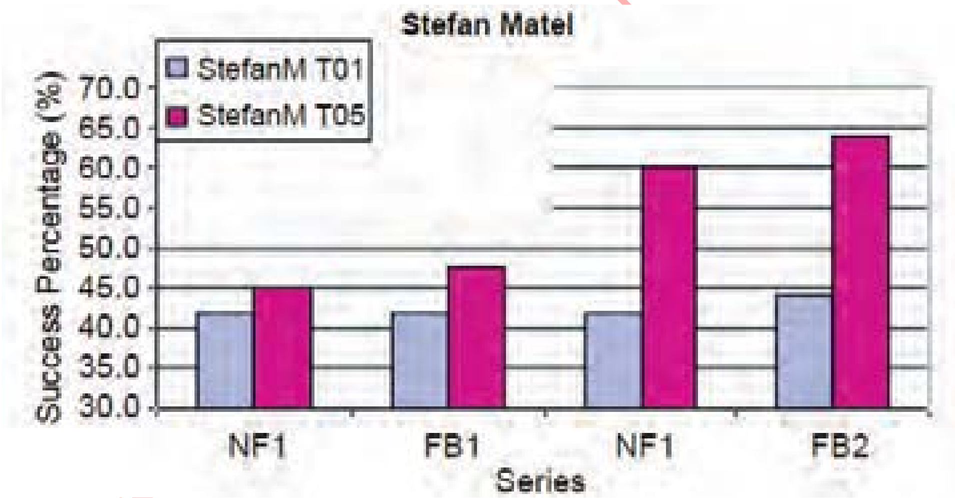
- Quieted EEG activity in the pre-shot interval
- Low 4–8Hz (Theta) activity (nonspecific) in the pre-shot interval
- Increased 8–12Hz (Alpha) activity for successful versus unsuccessful puts at a half-second before the actual putt
- Increased 12–15Hz (low Beta) activity for successful versus unsuccessful putts at less than half a second before impact
- Increased activity one second after the putt (8–30Hz)

Figure 10.3. Averaged event-locked EEG activity for successful (dotted line) versus unsuccessful (solid) putts in the interval from one second before to one second after ball impact (0 seconds).



Subsequently, he was trained according to the wireless, real-life neurofeedback method that uses contextual conditioning as explained earlier in this chapter. In a training session, he hit four series of 50 putts in an A-B-A-B design, alternating no feedback (A/NF) series with feedback (B/FB) series across five days. In the feedback series, putting was prohibited when he had not reached his optimal mindset as determined in the assessment session. The constant, low-pitch tone was shut off when he reached his optimal mental state. He was instructed to putt only when the feedback tone terminated and when he was ready to make the putt. The results are shown in Figure 10.4 below.

Figure 10.4 shows the data from the pro's first (T01) and last (T05) training session on different days approximately one week apart. It indicates an improvement in his putting of 22 percent from the first series in his first training session to his last series in his fifth training session (NF = no feedback, FB = feedback).



The height of the bars (see figure 10.4) during feedback sessions indicates how the percentage of successful putts in feedback series develops over real-life neurofeedback sessions across trials. The results demonstrate a very good learning effect.

Overall, the case study shows real-life neurofeedback can bring performance to a higher level. Confronted with the remarkable improvement, Matel said, "I can advise everyone to give it a try. At first, I thought, 'Is this going to help me?' But if it makes you hole one more putt in a match, that could be the one that makes the difference between losing or winning. I've already played a few tournaments after real-life neurofeedback training, and I can say that my putting has improved a lot. I never thought somebody could improve my putting through my brain."

Conclusions and Future Research

In many other methods using EEG in sports, the assessment and training is not personalized and is not task-specific. In fact, in many cases, there is either no assessment and training is done based on a one-size-fits-all model or the assessment is done in resting conditions in a laboratory setting. These approaches miss the opportunity to capture the brain dynamics in real-life sports settings where the brain is likely to show different dynamic tendencies while engaged in a sport-related, task-specific challenge within a different environment and context. In such cases, the context may include many task and environmental variables such as the physical and social attributes of the context (i.e., recorded while putting).

This chapter proposes a task-related, event-locked assessment and training of EEG using a contextual conditioning model of telemetry neurofeedback training during actual sports performance, probably employing elements of classical conditioning rather than operant conditioning. This is important because this model accounts for various task-related and environmental variables and also helps reduce training time.

From a theoretical point of view and based on our research, the authors suggest that by using a personalized, task-related, and event-locked approach in assessing and training brain states that are sport-specific, one can possibly maximize the identification and regulation of states of attention, focus, arousal, imagery, and self talk.

In addition, it is important to identify brain and arousal dynamics before, during, and after an event, which is the actual sports performance in this case. As stated before, we also believe that although this approach can identify a generalized peak brain state for the individual, by definition, the peak state pattern may be different from sport to sport and in various tasks within the same sport or even within subject (for the same person).

However, there may be similar tasks across sports that may prove to require the same brain state. For instance, the brain state and arousal level in putting in golf may prove to be very similar to the brain state required to perform in archery, shooting, or a game of darts. However, the same person may require a totally different brain state when playing tennis or football.

Finally, the chapter authors emphasize that the real-life neurofeedback approach employed could also be used for clinical cases. We suggest that by utilizing this approach the brain learns to enter the desired state and facilitate the desired response precisely at the desired moment, hence making the training more targeted and efficient.

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Rhythm, Timing, Routine, and Brain Training: Becoming Fully Engaged in Performance
Chapter 11

by

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Abstract

We have refined a number of adjunctive methods in sport psychology to supplement direct (EEG) brain training used for enhancing sport performance. Some of the latest technological advances in biofeedback and applied psychophysiology support these efforts, giving attention to rhythm, timing, tempo, routines, and sensory balance. Our goal is to demonstrate methods of enhancing awareness, attention, perception, memory, imagery, and problem solving as manifestations of mental discipline and stamina. We have featured a 10-year case study, illustrating the use of neurofeedback together with Interactive Metronome training with a professional baseball player. We have also detailed the procedures on how to use the Interactive Metronome as part of systematic routine training among elite golfers in a coaching format. By contrast, we have also provided the comprehensive description of the introduction and session-to-session procedures that are used when working with athletes in the clinical office, which includes getting to know the individual as a performer, guiding him or her to reach realistic and attainable goals, analyzing the words and body language reflecting frustration level and emotional cues indicative of unrealistic demands the athletes put on themselves. Among several other case studies, we have documented a number of practical, non-instrumented exercises that use the athlete's natural skills to refine focus and concentration via simple strategies including quiet eye and eye-hand coordination in golf-ball-to-club-head exercises. In essence, we acknowledge the potent impact of emotional stress and residual tension on athlete performance while striving to minimize choking by various means of relaxation, focused attention, rhythm, and timing components that are commonly associated with getting into the zone and performing automatically while being on autopilot or cruise control.

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Introduction

This chapter presents the variety of experiences we have had in developing methods for enhancing sport performance using traditional sport psychology together with the latest technological advances in biofeedback and applied psychophysiology. A number of case examples to highlight this work document different models wherein a combination of biofeedback, neurofeedback, and/or rhythm/timing training were used with varying degrees of success.

The first of these models features a professional baseball player whom we have worked with across many years but in sporadic time periods ranging from an intense training model of two sessions of neurofeedback (NFB) and Interactive Metronome (IM) daily for two to four days at a time to not seeing the athlete for several months because of the long periods of seasonal competition in professional baseball when players are traveling to different cities every three or four days.

Case Example in Professional Baseball

Almost 10 years ago now, a talented but inexperienced minor league baseball player was traded to another team and was simultaneously promoted to the big leagues. In all the excitement of his first season of spring training in the Big Leagues, his attention was lax (or narrowed) when, accidentally, two players each threw a ball to him at the same time. He caught the first one, and the second one hit him in the face, crushing several bones near his eye. Several weeks later, after surgical repair when his fractured orbital socket was nearly mended, he was expected to return to the game as if nothing traumatic had ever happened. That is the nature of professional baseball; get in there and play, or we will find someone else.

Not surprisingly, this young man had great difficulty in the batters' box facing pitchers throwing the ball 90+ mph without flinching as he responded as if the pain was about to hit him once again. After several weeks of unsuccessful attempts to adjust, he finally made a call to one member of this consultant team. During the first year of training, he adapted well and overcome the fear of standing in the batters' box to duel against talented pitchers throwing blazing fastballs and nasty, off-speed pitches that strike fear. Further, in the first three years, he was eager to learn the rudiments of focus and concentration while neither the player nor the sport psychologist realized he had a brainwave pattern characteristic of attention deficient disorder (daydreaming, high Theta). When his performance waned at the end of that season, we made a home visit consultation wherein the player finally agreed to undergo a brief evaluation as part of a demonstration of EEG biofeedback. After discussing the possibility of ADD or memory problems, the player's wife agreed that he had an underlying ADD issue. She said, "I can answer a question he asks me about our plans for the day, and 10 minutes later, he can't remember that I ever told him."

In the fourth year of consultation, after many ups and downs in performance, when the player was in the off-season (January–February), he agreed to participate in neurofeedback training seriously on a regular basis with a collaborating clinician (whose practice was located close to the player's off-season home) twice weekly for six weeks before his season started. In essence, this case study features an A-B-A design in the first four years of traditional sport psychology counseling as the B intervention.

During the rest of this 10-year case study consultation, the design featured NFB and IM in addition to sport psychology counseling, so the design consisted of A-C-A (where C = IM added to the NFB intervention). Throughout this extended time period, the player's performance (batting average = .140 to 350) fluctuated up and down in direct proportion to the relative immediacy of consultation; that is, he sought out training when his batting average and his confidence were low. Shortly after beginning the intense training each year (sometimes early, sometimes later in the season), his batting average increased linearly. The training effect lasted in direct correlation with whether he made time and resources available to continue the training every month or two. One might ask why he did not keep up the training on a regular basis. Part of the answer is that training intruded on his very limited leisure time and because he had to bear the entire cost of training, as it was not provided by the organization. Furthermore, until the end of 2007, the player did not fully recognize the strong association between periods of training versus no training together with his constantly fluctuating batting average. He has been greatly enlightened as we have reviewed the process and the outcomes of this intervention program with him systematically.

The highlights of this player's baseball career included an appearance on the All-Star team in one season and a World Series performance, wherein he stepped up with a record-setting batting average of over .500, during which time the consultant was with the player during the playoffs providing very intense (two per day) training. Ironically this player had not done any previous training during that season and had a very modest batting average (.220)—some of which is related to injury going into the playoffs. It should be noted, for those who do not understand baseball, that a record-setting batting average (over .500) is nearly unheard of in professional baseball. In the last few years Major League Baseball has been tainted by evidence showing some players have resorted to using steroids and other performance-enhancing drugs. The player in our case study has adamantly opposed and has never used any illegal substances, opting instead for the mental techniques we have provided. More details about the neurofeedback and IM protocols for this client are provided in Appendix I of this chapter.

Tempo and Rhythm of Movement Related to Sport Performance Outcomes

A less frequently reported technology and technique for performance enhancement is related to training the time relationships in performance. Temporal disruption during elite performance can be a result of stress, whether measured by reaction time (Williams & Andersen, 1997), quiet eye duration (Williams, Singer, & Frehlich, 2002), or by other means involving sensory balance (timing, tempo, rhythm, and concentration). Novosel and Garrity (2004) have uncovered a relationship between temporal dimensions, motor performance, and stress. In video analysis of the golf swings of numerous male and female world-class professional golfers during actual competition, it was found that rhythm and tempo interact in the form of a defined ratio with which to swing a golf club (3:1). This ratio was measured from takeaway to the top of the backswing and into the power phase (three units of time), followed by the downward swing to contact with the golf ball (one unit of time). While Novosel and Garrity (2004) assert this ratio to be the ideal and claim it to be associated with optimal brain functioning and lack of stress, there has been little scientific corroboration of this phenomenon. Regardless, the salient value of this 3:1 ratio has been documented among elite baseball and tennis performers by Paul Davis (Davis & Sime, 2006).

When dealing with highly stressful conditions, athletes need to shift resources from the visual to the kinesthetic system and back (while maintaining tempo) as they search for awareness of target and body position. Stress may adversely affect the psychomotor system as well, leading the athlete to consciously process motor movements, while taxing delicate sensory integration functions and disrupting the subtle, finite muscle contractions necessary for optimal rhythmic performance (Hatfield & Hillman, 2001). This is what athletes describe when they say, “I didn't have a feel for the game today.”

Rhythm, Timing, Routines, and Sensory Balance for Concentration in Sport Performance

The athletic brain has the capacity for awareness, attention, organization, execution, and feedback through all of the senses (sight, touch, hearing, proprioception, and balance) and for producing appropriate physical responses. Further, the process of creating and maintaining timing through sensory integration and balance is very complex and multi-staged requiring interpretation, organization, execution, feedback, and recalibration. The mind/body balance is a neuromuscular process of sensory balancing that includes 1) input from the receptors for the senses, 2) the brain’s processing of information, 3) organizing mentally and physically for upcoming movements, 4) the resulting physical execution of movements, and 5) learning from feedback.

The objectives of this section include 1) increase the understanding of how mental-training techniques and advanced-timing training function together, 2) provide examples of how to implement mental-timing and performance training within regular practice sessions, and 3) introduce advanced feedback training in the area of sensory balance. There are eight essential psychophysiological terms that provide us with a conceptual foundation for understanding the relationship between underlying brain functions (invisible to us) and the ultimate sport performance outcome which is observable.

Definition of Terms

Sensory Integration (Balance): Sensory balancing is the core foundation beneath every multi-staged performance process. Lapses in the sport performance, especially under competitive conditions, can be attributable to even slight imbalances (at the millisecond level) within one or more of these stages.

Sensory Balancing and Motor Coordination: The process of receiving and organizing sensory input from the environment and producing appropriate motor responses, e.g., reading the court and making the best play possible under the conditions. Sensory balancing includes awareness, attention, interpretation, response organization, response execution, and feedback processing.

Cognitive Skills: A process of thinking that includes such critical performance capacities as awareness, attention, perception, memory, imagination and creativity, and problem solving—all of which require significantly high levels of mental discipline and stamina.

Neuroplasticity: The ability of the human brain to change and grow throughout life. This is particularly vital following sport injuries or emotional trauma, which makes it difficult to regain pre-injury performance levels.

Proprioception: Proprioceptive sensors are located throughout muscles and joints. Proprioception includes sensations resulting from the movement of body parts through time and space. This system is critical to athletic performance as it relates to the awareness of movement that formulates the motor memories (blueprints) required of preconscious movement.

Timing/Sequencing: The order of movements through a sequence, such as a putt or golf swing; the control of movement through time in order that the body may generate its maximum force at the proper time.

Rhythm: Movement with uniform or patterned recurrence of a beat. The regular recurrence of related elements in a progression or system of motion. Rhythm in movement has been described as the correct proportions, and the balanced relationships, between the factors of space, time, and energy.

Behavioral and Cognitive Routines: Routines are sequential behavioral or cognitive processes that allow athletes to connect physical, technical, tactical, and mental strategies that are directed toward enhancing competitive performance. Routines are a greater function of sequence than of rhythm, though the process may involve the rhythm of the athletic task. Routines occur at the intersection of skills, knowledge, attitudes, and consistent application. For golfers, the routines provide the necessary structure for habituating the skills necessary for them to play at the automatic phase of skill execution, which involves staying with the mental blueprint and remaining in the immediate moment, neither recalling the past nor looking ahead to the outcome.

Rationale for Training with the Interactive Metronome

To execute performance efficiently at the highest levels of sport, athletes must have precise sensory integration and balance as well as an ideal level of emotional and physical intensity. Without sensory balance and ideal levels of performance intensity, we commonly see errors in the execution of sensory integration associated with stress, which interferes with the athlete's level of performance. If an athlete experiences cognitive or emotional interference and improper sensorimotor integration, then timing, tempo, rhythm, and balance through motion can be disrupted, thus making it more difficult to produce efficient movement (Libkuman, Otani, & Steger, 2002). Even millisecond errors in the sensory integration and the sequence of processing information from vestibular, visual, and proprioceptive subsystems results in imbalances that are evidenced by movement errors in practice or competition. Within the sensory balancing process, breakdowns in awareness and attention can occur in the initial stages of the process. This is where the athlete is either not attending to the task or is not certain of the best cues to pay attention to in the environment. Breakdowns also occur when the athlete attends to internal cues (both cognitive and emotional) versus appropriate cues from the environment and the current situation. When the sensory integration process is working at its peak, the athlete attends to the appropriate cues from the environment, interprets them correctly, and organizes appropriately for the current situation. It is during the organization stage of the process where the athlete actually creates the exact blueprint for motor execution. Breakdowns in the early stages of sensory integration, although not seen by observers, can lead to errors in the physical execution of a mental model. Assessing psychomotor movement is necessary because it is critical to timing, tempo, rhythm, and pace in sport.

The Interactive Metronome (IM) is a computerized electronic metronome that helps athletes combine their senses of hearing, sight, touch/kinesthetic, and balance through motion as they react to standard visual and auditory cues. The computerized equipment tracks the athlete's deviation from the reference cues at the millisecond level. In essence, the athlete hears a stimulus sound at about one per second and is required to match the timing as if he was in a marching band. The specific intention of making a definitive sport movement (e.g., jumping, throwing, etc.) is best organized and executed in sequential fashion and at a preconscious level (Singer, 2002). However, sometimes an athlete's muscular effort does not respond according to this blueprint because of systemic disruptions caused by stress. This creates inefficient timing and synchronicity between the motor planning and execution stages, ultimately leading to reductions in task performance (Hatfield & Hillman, 2001). In order to make corrections in these cognitive deficiencies, the athlete must learn to use sensory processing as if on automatic pilot rather than to think too much about the outcome. In order to conceive this kind of automaticity in learning, we must acknowledge the concept of neuroplasticity; whereby, the human brain can change and grow throughout life.

The next section describes an objective method to critically analyze an athlete's ability to organize and execute motor movements at the preconscious level, which minimizes the intrusion of negative self-talk.

How Does the Interactive Metronome (IM) Work?

The athlete performs the various hand and/or foot exercises (e.g., hand clapping or foot stepping) to a rhythmic beat (sound of a cowbell) for a large number of repetitions. All of these tasks have been designed for their simplicity in order to eliminate learning from the motor performance equation. In the simplest form of training, the client claps his hands with a sensor attached to one hand while following a repetitive beeping tone. While the motion simulates clapping, the movements are kept very simple so that no learning has to take place. The motion is much like clanging symbols in a circular motion at one-per-second intervals. The second task is clapping the right hand upon the right hip in a circular fashion. The difference (Delta) between the participant's response and the reference tone is measured in milliseconds and is presented as an average score (variation from the reference) at the end of a defined period of performance. The variance between early and late hits is also presented as a percentage, (e.g., 75 percent early to 25 percent late hits). The number of hits in a row, as registered within +/- one standard deviation from the reference tone is another performance outcome measure. For example, at the end of a one-minute set, the average deviation for perfect timing is given in hundredths of a second. The range of scores may be as low as 10–20 (near perfect) or as high as 100–150 (very far off).

In the other tasks, the client is instructed to use a flat sensory pad on the floor for a toe touch or heel touch under the same format with the hand as with the lower body to assess and train precise sensory balance for smooth, consistent rhythm in movement, simulating the ideal lower body performance in the sport. The systematic clinical training protocol demands a very complex sensory integration process with sophisticated measurements, yet the results are presented in a simple format for clients to understand and track progress on their own if necessary.

The consultants who purchase and use the system are required to undergo training and certification in proper usage (certification by Interactive Metronome Company). An extra benefit of IM training is reducing self-talk. It is nearly impossible to score well on these tasks without being fully engaged mentally and physically; thus self-talk simply cannot coexist during the session. It truly takes the athletes out of the mind and back into the body.

This system was designed initially for rehabilitation and is used primarily by speech, physical, and occupational therapists. The format of 12 different hand and/or foot tasks appears to be irrelevant to sport movements, making it difficult to rationalize this training to the athlete initially. However, the athlete must become convinced that the underlying sensory integration yields a core conditioning of the brain that is important for sport performance. In addition, athletes need to understand that a systematic and comprehensive program (i.e., upper and lower body, left and right sides) is necessary to enhance brain-body functioning.

IM Training for Athletes to Be Mentally Engaged and Physically Poised

In more advanced training or as an initial demonstration, the rhythmic task is made to appear more relevant. For example, a golfer or baseball player can take a warm-up swing back and forth as part of the repetitive motion in rhythm with the reference tone. The athlete then makes contact with the hand sensor as in clapping at the approximate point of ball strike, i.e., in the middle of the warm-up swing. By keeping the beat, the athlete's brain is trained to plan, sequence, process, execute, and learn from the feedback more effectively. The brain learns through repetition of precise activities when accurate feedback is present (Libkuman, Otani, & Steger, 2002). In turn, measurable gains in sensory integration (timing, tempo, rhythm, balance in motion, and concentration) produce well-defined outcome in physical and mental capacity. IM leads to improved awareness, attention, sensory focus, concentration, interpretation, organization, execution, and the ability to process feedback effectively. In addition, IM is particularly relevant in identifying major deficiencies, especially among injured athletes whose proprioceptive processing has not returned to pre-injury, normal levels. With most injuries, the proprioceptive system is the first to be damaged and the last to recover. Following acute injury and during acute or long-term rehabilitation, it is not uncommon to see the scores for that injured area of the body climb into high numbers sometimes exceeding 100 milliseconds in variance.

Typically the IM training requires a minimum commitment of 12–15 one-hour sessions, conducted over a three to five week period. The optimum training frequency is three to five times per week. Training less than twice a week may not produce the desired results.

Natural Temporal Parameters with the Interactive Metronome

In the case study of the baseball player, he struggled and had lost interest in doing only neurofeedback for his training, so we introduced the IM. Because rhythm is such a naturally occurring process in successful hitting, this player adjusted to the IM training regimen very well. Our training currently includes both the neurofeedback and IM, plus any practical counseling that is possible within limited timeframes and as necessary for routine personal and family problems. More specifically, the baseball player in this case study used a combined hand and foot movement that simulated the stride and wrist/hand motion involved in hitting the ball.

For golf clients, a similar adaptation works very well: a warm-up motion that involves a half swing with the hands clasped around the sensor as if around the grip of the club. The purpose is to close the grip on the sensor at the sound of the bell tone close to where ball strike would occur with an actual golf club. Numerous repetitions, allowing an intermediate sound for the backswing, provide the correct timing for each subsequent contact. IM allows for longer or shorter time intervals between reference tones to adjust to various individual or sport-specific needs. In addition, we use an adaptation of the foot strike pad to simulate the stepping motion in the weight shift action during the simulated golf swing. This is a slow on-then-off motion that can be repeated to develop an internal sense of rhythmic timing necessary in golf.

The Golf Consultant Approach to Performance Enhancement: Using the IM and Neurofeedback

Our consultant team has a very broad range of expertise ranging from two clinicians who do most of their work in an office setting to a pair of performance coaches who do most of their work on the sidelines of the playing field or the golf course. The clinical psychologist conducted training in the office for periods of three to eight weeks, featuring both neurofeedback and Interactive Metronome training. The golf coach/academic instructor conducted Interactive Metronome training along with carefully constructed development of performance routines to eliminate self-talk and negative thinking. Lastly the sport psychologist member of the team conducted biofeedback, neurofeedback, and Interactive Metronome training in various venues, including the practice range of the golf course, the clubhouse of the golf course, and in the indoor training facilities of a golf academy. The assessment and training approach with the IM protocol was much the same in all of these settings.

The next case study is based upon research featuring training in golf using the IM. Libkuman et al. (2002) did pre- and post-testing with 20 some golfers for accuracy with multiple shots and three different clubs (wedges) when distance in feet from the target was the outcome measure. The intervention between testing periods consisted of 10 hours of training on the Interactive Metronome. The results showed significant improvement in the accuracy (ranging from 18 percent to 35 percent) measured by the distance from the target of their golf shots based upon training in timing, rhythm, and balance through motion and concentration, a concordant outcome of the training.

Case Study of IM with a Golf Team

The data collected while coaching college golfers was focused on short-game training to get the ball within six to eight feet of the target from a distance of 40–120 yards out from the target. The pre-testing measured the distance from the target among 50 golfers. The training was followed by a series of 10 training sessions weekly on the Interactive Metronome, which lasted from 30 to 40 minutes. In addition, the golfers were instructed in the use of a 10-step peak performance routine. The post-test results showed a range of accuracy improvement from 31 percent to 98 percent (as measured by the distance from the target).

The 10-step peak performance routine (see Appendix II) has been found to be a critical performance element in all phases of the golf game. This particular routine is designed to improve both physical and mental skills during the stages of pre-shot, shot execution, and post-shot feedback. Techniques present within the routine prepare the golfer, so visual information can be gathered systematically while the golfer increases his physical and mental engagement using rhythmic breathing and functional relaxation. In addition, self-talk interferes with the capacity for performance imagery (both visual and kinesthetic) and, thus, with the ability to create and execute blueprints at a preconscious level. Therefore, the process of carrying out the 10-step routine serves to enhance playing in the moment and executing each shot on autopilot.

There is a neurological basis for the relative degree of success that occurs in the midst of such routines as playing in the moment and being on autopilot. Shanoy (2006) found the human brain favors creativity over consistency in the formulation and execution of sport performance. This is the main reason an athlete cannot make exactly the same golf swing every time because of the randomness of individual neuron activity in the pre-motor cortex. Thus, we generally recommend the use of a systematic routine together with the IM training in order to perform and to reinforce the transfer of learning to the competitive field of play.

Clinical Office Methods Using Neurofeedback and Interactive Metronome

Our focus in working with athletes in the clinical office is to get to know them as individuals and to guide/counsel them to reach realistic and attainable goals. The initial consultation typically includes the following:

1. We ask about health issues: unusual illnesses, seizures, concussions, surgeries, or emotional issues that may impact performance. We then want to know their level of proficiency in their sport and their long-term goals. We ask what has helped in the past and what has not worked for them. In one extreme case, an All-American golfer reported his anxiety and depression was so high he could only play well if he drank a six-pack before the round. In training, he showed improvements in just three visits regarding his focus but was still overwhelmed and did not follow through. Lesson learned is that there are some clients in some circumstances that simply cannot be helped through their problems.

2. We listen to their words and body language and look at their frustration level and emotional cues they transmit while talking about what they want to change. We search for unrealistic demands they put on themselves. If they “have to succeed” or “must make it,” we may observe other physical signs of undue tension. We want to gradually teach the athlete to learn how to be in the zone by becoming emotionally, mentally, and physically in sync.

3. We conduct initial assessments of timing and rhythm on the IM to establish baseline criteria of performance and to demonstrate that they do more poorly when they are in their heads with thought and performance fears rather than performing on automatic. We also perform an assessment of the difference in positive thoughts and emotions during neurofeedback and get the person to be able to shift out of a negative brainwave state and recognize this transition. Golf clients are instructed to practice taking their club back in a simulated swing and then review the activity on the screen immediately thereafter to observe the degree to which they had a quiet mind as measured by a 0–40Hz squash protocol.

4. In some cases, it is deemed appropriate to discuss brain mapping (quantitative EEG) particularly if there is reason to believe emotional issues are related to the performance problems. This is particularly true if symptoms of ADD, anxiety, and/or depression are present. If there are excessive or deficient levels of activity in one or more areas separate or together with asymmetries or coherence problems, we can often relate these to specific outcomes in poor performance. For those clients having some emotional issues, we routinely incorporate neurofeedback based on the brain map.

5. Smart brain technology is very useful for younger athlete clients who like video games. It provides excellent tactile/physical feedback when not enough SMR is created (the controller vibrates and turns off reward). This system is very effective in lowering excessive Beta in select clients.

Neurocybernetics is very helpful because you can actually see the waves and voltage and how brainwave activity varies with focusing changes and alterations in positive and negative cognitions.

6. IM is particularly useful with clients who profit from kinesthetic feedback because the large muscle movement of the arms and legs creates a physical expression of outcome for those who really seem to need to be active to create greater focus. When using the IM with athletes to reinforce increased focus and attention to task, it is possible to use either the visual or the auditory feedback and sometimes both. Similarly, eyes open and closed repetitive motion is desirable to create internal generalization of focus and mind quieting.

7. Length of treatment usually depends on the schedule of the client and his/her commitment in terms of time and costs. We typically explain to clients that we prefer to do enough training to not only make a difference but to also maintain these gains in enhanced performance, particularly over time and under pressure. We prefer if they are able to do 20 visits incorporating both modalities, using neurofeedback and IM with everybody such that a typical session includes a half hour of IM and another half-hour for neurofeedback. In the orientation with new clients, we suggest the training can significantly help them quiet their minds, improve performance, improve mental and physical timing, reduce distractibility, and help them with decision making under stress, but only if they are willing to participate regularly and actively in the program described. The methods described above have been used in varying periods of intervention based upon client availability but mostly for periods of three to eight weeks.

Multiple Case Studies in the Clinical Setting

A top collegiate baseball pitcher highly touted to be a first-round draft choice, received IM and neurofeedback. Initially referred for ADD and drinking problems that put his current situation and potential career at risk, he was very receptive to neurofeedback training at the C3 scalp location, raising 15–18Hz and lowering excessive Alpha, 8–10Hz frequency brainwaves. He completed 20 sessions of NFB together with IM training that resulted in a very successful first year on his college team that almost won the NCAA championship. He reported that the training also helped him a great deal academically.

A tennis pro who had great potential, having previously beaten a former U.S. Open winner on the Tour received IM and neurofeedback. Emotional factors, including a hot temper and boredom on the court (from ADD), had prevented him from advancing. He completed six sessions of IM training and neurofeedback (neurocybernetics equipment) at frontal scalp locations, lowering Theta (4–8Hz) and increasing SMR (12–15Hz) brainwave frequencies. On the IM, he worked with both of his hands together and his right and left hands separately for an average of 300 repetitions. He did not have the frustration tolerance to do longer repetitions. Ultimately, he was unable or unwilling to dedicate the time commitment to continue in spite of his marginally improved focus. We attribute this relatively unsuccessful outcome to the fact that the client had ADD and poor attention and organization and was never able to grasp the link between the neurofeedback and his performance by way of mental conditioning. This illustrates the continuing difficult challenge of establishing motivation for training among ADD clients.

In an ongoing consultation, the authors worked with a high school golfer whose brain map showed excessive Beta activity, particularly centrally and in the posterior sites. In addition, he showed diminished Alpha, which helped us understand his erratic performance history. He trained on Smart Brain Games and neurocybernetics to raise Alpha (posterior) and to lower high Beta. As a result of the initial training, this client is now more cognizant of suppressed feelings of an obsession to succeed on somewhat of a joyless, self-defeating mission. He had been competing for the attention of his emotionally distant father and against the vague, immeasurable golfing success of an older brother. Subsequently, he has been doing IM training as well as having completed six sessions using repetitions up to 500 and showing very low millisecond scores of 18. He is becoming more reflective and concentrating better. He is now playing much more consistently.

Eight Gateway Tour golfers received IM and the same neurofeedback programs described above with all clients generally showing improvement with mental attitude and reduced anxiety in regard to their reactions to a bad shot or generally poor play. Typically, they completed 200 to 500 repetitions of hands-only IM. It was important to identify the sources of anxiety and frustration when they did not play well. During the neurofeedback, they were encouraged to talk about their successful and unsuccessful performances and to simultaneously examine their EEG. As they visualized poor playing or a shot they had missed, we analyzed the neurocybernetics EEG feedback to identify increasing amplitude on slow activity when negative thoughts entered their minds. Diaphragmatic breathing was instructed to assist in controlling brainwaves, and the difference was explained between the counter-conditioning of positive thoughts and emotions to negative ones.

One of the authors worked with a former Cy Young Award–winning pitcher and Major League coach who was aware that his own career had been shortened by his inability to focus consistently during intense periods of pitching. He completed neurofeedback, frontal suppression of Theta while simultaneously enhancing Beta. Later, he was trained on the IM. He trained for his own growth as he conveyed a sense of desperation related to his own ADD and focus problems, which continued to affect his coaching performance and social life. He was pleased with the results and became interested in applying these techniques with his team, but progress was slow because of the old guard resistance, which is common in professional baseball. It is not unusual to find a great deal of organizational push back among all professional sports in regard to any kind of new technology which is difficult to relate to on-field performance.

Summary and Conclusions

This chapter has discussed the possibility of integrating biofeedback and neurofeedback together with a relatively new technology (Interactive Metronome) to advance traditional performance enhancement in several applied psychophysiology settings including the baseball field and the golf course. We are encouraging practitioners who have an understanding of sport together with biofeedback and neurofeedback skills to expand their horizons to provide services in a variety of athletic settings (Carlstedt, 2001; Davis & Sime, 2006). Details of a case study featuring a professional baseball player whose ultimate success appears to be directly related to neurofeedback and IM intervention over the course of 10 years was reviewed. We have also presented numerous other case examples featuring our experience with professional golfers, tennis players, and swimmers.

It seems clear from the sport psychology literature that emotional stress and residual tension (nonfunctional tightness) is associated with choking in sport and that some forms of relaxation, focused attention, and various rhythm and timing components are equally well associated with getting into the zone and performing well with automaticity or being on autopilot with cruise control of the body. The authors advocate developing more specific unobtrusive sensing apparatus together with small preamplifiers and, we hope, with wireless remote viewing capabilities. Lastly, we advocate a process of training NFB for a calm yet alert and focused brainwave state that reinforces optimal imagery of the performance together with an on/off quality that is under the athlete's control. A good example of this quality occurring in the freestanding population of elite athletes is a videotaped TV commercial wherein Tiger Woods bounces a golf ball off a wedge (golf club) repeatedly amid several body position changes that interrupt visual contact (would distract anyone else into losing continuity), and then he finishes by hitting the ball out of the air, a feat that requires extreme eye-hand coordination with intense focus.

Appendix I

Protocol for the Baseball Case Study

The neurofeedback training was administered on a neurocybernetics instrument from EEG Spectrum International. The training was initiated with this player during the off season, which was essential at the outset considering the distractions of regular season travel and daily competition. He had 20 sessions of C3 scalp location, enhancing 15–18Hz with a 2–7 inhibit and a 22–30 inhibit. The initial training sessions were designed to establish the training threshold levels and a training zone. Once the settings were determined, the subsequent adjustments were kept to a minimum as the player began to have the feeling of success based on his performance in having control of his brain alertness state. In close approximation, his batting performance improved almost immediately following a two- to three-day sequence of training (during regular season) and usually dissipated in the ensuing six to eight weeks if further reinforcement was not available.

The player worked diligently in neurofeedback training during the next off season, participating in another 10 sessions using the same parameters. His performance during the following season was very good; he batted over .300. However, during one entire season the player refrained from training and had a disappointing outcome. In the subsequent year, the player requested assistance for only four to five sessions of neurofeedback and ultimately became more seriously interested in the Interactive Metronome. He completed 10 full sessions together with the neurofeedback thus creating the A-C-A design (A = control period with no training, C= intense training with NFB and IM). His hitting performance rose accordingly to over .300 following each training period.

During one season of this 10-year period, the player opted not to participate in training until the end of the season. After experiencing reasonably good performance up to mid-season, his batting average in the last two months of the season was around only .220, which is generally unacceptable in baseball. With three games remaining in the regular season, he sought our assistance once again. The situation called for a highly intensive training regimen. He participated in six sessions of neurofeedback with the same parameters, together with back-to-back sessions of IM over a three-day period. By the end of that training experience, the player had increased his batting average from .220 to .245. In the next few games, he went on to bat over .300 in the first five post-season playoff games leading up to the World Series, eventually hitting an average of over .500 in the World Series. These results confirmed what we suspected; that is, intense training during the critical periods of competition served this player better than a regular training program (two to three times weekly for four to five weeks) before the season started.

The neurofeedback training also included counseling to frame and reframe the results of each training session. One of the early insights gained was learning the player's paradoxical reaction to instructions about the need to relax. Initially, when it was suggested that he relax and let his brain do the work, he produced produce more and more tension. Over the course of training he discovered that by trying to relax, there was a paradoxical negative effect. Later, he was able to think about letting go to achieve a greater relaxation response, and as a result, it improved his performance on neurofeedback and IM in the training sessions as well as on the field of play. As this consulting experience continues throughout publication of this book, it is clear that the neurofeedback process and the metronome processes work very well together in allowing the player to explore the essence of highly alert focus and concentration approached from both a cognitive route and from exercises involving rhythm and timing (i.e., the IM). It should be noted, however, that skills training in relaxation and stress management were also integral components to this player's success.

Appendix II

The 10-Step Performance Routine to Minimize Performance Breakdowns

Step 1: Establish a rhythmic pattern for breathing and maintain through entire routine.

Keywords: Breathe deeply and rhythmically.

Step 2: Release any tension from jaws, shoulders, and necks to remain relaxed and poised for play. Let all excess tension drain away with each exhalation of air.

Keywords: Release jaws, shoulders, and neck. Just let go.

Step 3: Line up all shots, including putting, from behind the ball. In your mind's eye (brain), the path of the ball is being created from the target, back to the ball.

Keywords: Visually focus on the target and create a path back to the ball.

Step 4: With a mental blueprint, see and sense the putts going in the hole. Be totally absorbed in the process of putting in the present moment of time.

Keywords: Create success with ideal strokes in your mind's eye.

Step 5: Create a target spot along the path of the ball to guide the aiming process.

Keywords: A target spot creates an alignment line.

Step 6. Maintain grip while moving into position over the ball to embrace the feel of it.

Keywords: Maintain blueprint, grip, and feel while positioning over the ball.

Step 7: Allow the intermediate target line and the ball location to help find the ideal position for stance, alignment, and for perpendicular face line of the putter.

Keywords: Line up the intermediate target, the ball, and the putter face.

Step 8: While the target line and the image of the ball path are driving the process for potentially ideal strokes, check for good breathing and automatic relaxation.

Keywords: The target, the path, the breathing, and relaxation drive the process.

Step 9: Gather gently just before the shot, then initiate the backstroke, make a good stroke, follow through, and hold the finish momentarily.

Keywords: Gather and follow through as if on automatic pilot.

Step 10: Immediately after making the putt according to blueprint, bring out a sense of joy or satisfaction to reinforce the sensation if it is an optimal outcome, or learn from the experience about what to do differently on the next stroke if the shot outcome was lacking.

Keywords: Enjoy good outcomes but learn from the poor outcomes.

We consider pre-performance routines to be a critical element in all of closed sport performances (golf shots, free throws, etc.). Adopted from Wes Sime, 2008

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Strategies and Techniques for Enhancing the Learning and Transfer of Self-Regulation Skills to Competition
Chapter 12

by

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Abstract

Among the fundamental mental skills consistent with expert performers is the ability to regulate physiological and psychological processes in response to the stresses of intense competition. Training individuals to gain control of physiological processes associated with emotions and cognitions is one primary function and purpose of biofeedback training (Hatfield & Hillman, 2001). The self-regulation skills needed by athletes to perform well can be learned and enhanced through biofeedback training. A frequent frustration for many athletes using biofeedback training is that they can successfully demonstrate self-regulation skills in controlled office or clinic settings but are unable to implement those skills in competition when they need them most. This chapter will discuss the concept of transfer of training as it relates to the learning of self-regulation skills through biofeedback training. Topics to be discussed include the stages of learning, developing effective concentration routines, internal and external feedback, and strategies for practicing self-regulation.

Chapter Outline

I. Introduction

II. Stages of Learning

a) Stage 1: Cognitive Stage

Stage 2: Associative Stage

Stage 3: Autonomous Stage

III. Cycle of Improvement

IV. Practice/Training Considerations for Biofeedback

a) Practice/Training for Skill Development

Practice/Training for Skill Performance

V. Summary

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Introduction

Among the fundamental mental skills consistent with expert performers is the ability to regulate physiological and psychological processes in response to the stresses of intense competition. Noted sport psychology consultant Ken Ravizza has used the term “self-control” to refer to an athlete’s ability to become aware of one’s internal processes that can interfere with performance (Ravizza & Hansen, 1995). These include discursive, negative self-talk; emotions; increased heart rate; muscle tension, and inappropriate focus. An effective method for dealing with these forms of interference is to teach the athlete skills that will help him or her reduce heart rate, relieve excess muscle tension, quiet distracting thoughts, and redirect focus on appropriate stimuli. Training individuals to gain control of physiological processes associated with emotions and cognitions is one primary function and purpose of biofeedback training (Hatfield & Hillman, 2001). The self-regulation skills needed by athletes to perform well can be learned and enhanced through biofeedback training. With the emergence of affordable, portable, and reliable computer technology, more sport psychology consultants and coaches are using biofeedback training to help athletes develop effective self-regulation skills for enhanced performance.

A fundamental question for any consultant, trainer, or coach is when does one know that learning has occurred? When do we know when the student, athlete, and/or client has actually learned the skills he was being taught? If we look at biofeedback training for athletes, when can the trainer feel confident that the athlete has developed the ability to control his or her anxiety to a degree that it does not interfere with performance? Obviously, the true test of learning is when the individual can demonstrate the skill consistently when it is most needed. Although self-regulation skills are needed during training and practice, they are most important during actual competition. A challenge for some athletes using biofeedback training is that they can successfully demonstrate improvements in self-regulation skills in controlled office or clinic settings but are unable to implement those skills in competition when they need them the most. In motor learning terms, this ability to consistently and correctly execute skills learned in practice in game performances is called "transfer of training." This chapter will discuss the concept of transfer of training as it relates to the learning of self-regulation skills through biofeedback training.

Stages of Learning

Most learning theorists agree that learning occurs gradually and sequentially (Wrisberg, 2001). As individuals learn new skills, including self-regulation skills, their learning will proceed through stages. According to Fitts and Posner (1967), performers progress through three stages as they learn motor skills. The initial stage is called the cognitive stage. This is followed by the associative stage and finally the autonomous stage. It is extremely helpful for the trainer and the athlete to understand these three stages because, as the student progresses through each stage, different training and teaching strategies are used to enhance learning.

Stage 1: Cognitive Stage

The first stage of learning is called the cognitive stage. During this stage, the athlete is introduced to the new skill in a very controlled, distraction-free environment. The term "cognitive" is used because, at this stage, the athlete must consciously think about practically every aspect of the skill. There is a lot of self-talk and thought associated with the cognitive stage of learning. It is very easy for the athlete to get overloaded with thoughts and external stimuli during this period. This is why it is best to introduce new skills in a relatively quiet and stress-free environment, unlike the actual conditions that are characteristic of competition. Therefore, initial biofeedback training sessions are most effective when conducted in an office or clinic-type setting.

When learning new skills, the athlete relies almost entirely on external feedback to gauge if he is executing the skill correctly. For example, when an athlete is being trained to regulate arousal through biofeedback training, he uses the visual and/or audio feedback from a single or various modalities of arousal (e.g., skin conductance, GSR, respiration, HR). During the first stage of learning it is essential for the athlete to have this feedback available. Without this feedback, the athlete will have to rely on his internal awareness of what is occurring. This internal awareness is often incorrect at this stage of learning.

In the early phases of biofeedback training, it is not uncommon for the athlete to produce the opposite result he is intending. When instructed to raise the temperature of their hands for the first time, athletes often find that as they try to raise the temperature they receive the feedback that their hand temperature is dropping. This is a result of the athlete not being able to execute the correct skill that is being required (or he is trying too hard); in this case, it is relaxation of the arterioles. When the athlete tries too hard he activates the autonomic system responsible for arteriole size. It is not until he learns the correct skill of letting go that he will be able to warm his hands. There is a quality of ease that almost always accompanies the proficient execution and demonstration of skills. During the cognitive stage of learning, athletes often struggle to remain at ease because they are trying too hard to produce the desired results. This trying is what actually interferes with the successful execution of the skill.

During biofeedback training, the external feedback from the computer monitor provides the athlete with information relative to his or her intended goal. When the athlete receives feedback that his physiological function is moving in the intended direction, the feedback itself serves as reinforcement. The feedback, however, does not directly inform what the athlete did to produce the desired result. This concept is similar to the example of a golfer falsely concluding that because the putt went into the hole his technique and form must have been correct. Because the processes of the skills needed to regulate arousal include internal (not externally visible) dimensions, these skills are learned implicitly as the athlete experiences trial and error success through biofeedback training.

As discussed earlier, during the cognitive stage of learning, new skills are introduced. In these initial biofeedback training sessions—with an athlete trying to learn greater self-regulation—diaphragmatic breathing, thought stopping, imagery, and meditation may be among the skills introduced. When learning a new skill, the athlete will tend to think a lot about the mechanics of the skill, and this is often uncomfortable and can feel forced. It can be helpful to explain to the athlete that it takes time to move through this period from dis-ease to ease of performance. A distinct advantage of biofeedback training is the availability of immediate and accurate external feedback and the ability to adjust the sensitivity of the feedback to display small increments of change.

How to Maximize Learning During the Cognitive Stage

- Introduce and train new skills in a quiet and low-stress environment.
- Be very specific about what you want the student/athlete to focus on.
- Provide reinforcement at every instance the athlete makes positive progress.
- Provide accurate, immediate, and consistent external feedback.

Stage 2: Associative Stage

After the athlete is exposed to the techniques of self-regulation and several biofeedback practice/training sessions, he will move into the second stage of learning. The second stage is referred to as the associative stage because, at this stage, the athlete begins to associate internal awareness with external feedback.

During the cognitive stage, the athlete does a lot of searching and trial and error for the correct way to trigger the desired response goal. He is primarily guided by the feedback received from the computer monitor and trainer to judge how successful he was. The associative stage is characterized by at least two advances. First, the athlete's internal awareness becomes much more accurate. For example, the athlete feels he has achieved a lower heart rate during biofeedback training and this correctly matches what his heart rate is. Second, the athlete begins to understand the internal processes that produced the desired result or is at least able to consistently reproduce the state even if there is little awareness of how it was achieved. Typically, not only does the athlete reduce heart rate, he understands how it was achieved. In short, this phase of learning helps the athlete become less reliant upon external feedback to tell him the desired goal was achieved.

Moving through the associative stage may take longer than the other two stages (Schmidt & Wrisberg, 2004). The two primary goals of learning at this stage are 1) to enhance internal awareness and 2) to discover how to produce the desired results. There are several strategies to help the athlete progress through this stage.

Learning finer internal awareness can be enhanced by taking various physiological measures of arousal and displaying them on a computer screen for the athlete in the same way it was done during the cognitive stage. After instructing the athlete to lower his arousal or create a change in a specific modality, remove the external feedback from the athlete while continuing to monitor and record the changes yourself. When some time has passed, ask the athlete what changes he felt occurred. This question demands the athlete use information from within his body (internal awareness). After the athlete has made an assessment of what changes occurred, the practitioner/trainer can show the external data to compare what the athlete felt happened and what actually happened. Early in this stage, the athlete's assessment will most likely be different from the actual changes. Providing the external feedback after asking for the internal awareness will help the athlete begin to fine tune the accuracy of his internal awareness. Through this type of training, the athlete's internal awareness becomes as accurate as the external feedback.

Another strategy for helping an athlete progress through the associative stage is to guide the athlete to discover techniques for executing the skill correctly. This can be accomplished by asking the athlete what he felt or did when he produced the desired result or change in arousal. For example, during a biofeedback training session with an athlete, the trainer may instruct the athlete to raise the temperature of his hands (as measured with a thermister attached to the index finger). The trainer turns the computer monitor away from the athlete (removal of external feedback) while still recording temperature activity. The trainer observes and waits for the athlete to produce the desired result (raise temperature). After the athlete has been successful in accomplishing this, the trainer first asks what changes the athlete believes he produced. This question prompts the athlete to rely on his or her internal awareness. Next, the trainer can provide the athlete with the computer summary of what actual changes occurred (external feedback). This comparison of internal awareness and external feedback assists the athlete in working toward more accurate internal awareness. The external feedback can help calibrate the internal awareness mechanisms. Next, the trainer asks the athlete what he did to raise the temperature of his hand. This question prompts the athlete to discover what techniques helped him execute this skill and to figure out for himself what he did to produce the correct changes. Often, the athlete may struggle to both identify precisely what he did and how to describe it in words. By continuing to prompt the athlete to become aware of internal states, he will make the discovery of what he needs to do to produce the changes. Not only will this discovery add to the learning process, it empowers the athlete to feel more confident in his understanding that enhanced self-regulation is based on mechanisms within his control and not on outside (external) sources. Sometimes this alone creates significant changes in self-confidence in the sport arena.

Internal Awareness Exercise

You do not need biofeedback equipment to enhance the internal awareness of your self-regulation skills. Find a place where you will be free of distractions for a few minutes and just sit naturally. Take a moment to scan your body and allow yourself to become aware of your overall level of muscle tension. Next, rate that level of tension on a scale from 0–10 with 10 being extremely tense and 0 being almost completely free of tension. Write or remember your rating and adjust your posture so that you are sitting upright with your back straight and your feet resting flat on the floor. Now take a deep breath, inhaling through your nose, feeling your abdominal region move out and your lower ribs expand slightly outward. As your lungs fill up, exhale slowly and gently through the mouth and let your shoulders drop as you exhale for a longer period than you inhale. Repeat this breath two more times. After you have taken three deep breaths, scan your body once more and rate your overall level of tension. The rating usually comes down and now you have an external reference (0–10) to associate with an internal sensation of having slowed your heart rate and lessened the muscle tension in your shoulders. As you repeat this exercise you will become much more aware of subtle differences in fast respiration and muscle tension and, eventually, you will learn to self regulate.

During the cognitive stage of learning, the trainer uses prompts and instruction to help the athlete cognitively understand the techniques and skills. As the athlete moves into the associative stage this feedback changes to allow the athlete to explore and discover what it feels like to produce the desired changes. The trainer shifts from providing feedback to asking for feedback.

In the first two stages of learning, a great deal of conscious energy and activity is used to produce the desired changes. In high-level competition and performance, an athlete cannot allocate conscious energy to regulating his physiological processes. There are too many specific skills and too little time to process that much information. Further, the competitive environment provides many varying stimuli that the athlete must consciously contend with.

How to Maximize Learning During the Associative Stage

- Gradually replace external feedback with internal feedback.
- Utilize specific and descriptive feedback rather than general feedback.
- Use rating scales (1–10) instead of subjective evaluation (good, bad, etc.).
- Ask the athlete for feedback rather than providing instruction.

Stage 3: Autonomous Stage

After a good deal of practice is executed in the cognitive and associative stages, the athlete enters the third stage of learning in which the skill is developed to a degree that he does not have to consciously think about how to perform the skill. The third stage of learning is called the autonomous stage because the skill is performed relatively automatically with very little or no conscious thought. For self-regulation skills, when an athlete has progressed to the third stage of learning he can demonstrate the ability to produce the desired physiological state on command. In many cases, these physiological changes may occur with the presentation of a stimulus that allows conscious activity to be bypassed altogether. For example, a baseball hitter who has developed the ability to achieve a calm physiological state when batting may trigger that state just by stepping into the batters' box. This automaticity can be developed and enhanced in a number of ways. As the athlete learns to self regulate through biofeedback training sessions, a trigger can be introduced. A trigger is a stimulus that is repeatedly paired with the desired physiological state. For example, when training an athlete to reduce tension in the trapezius or shoulder muscles, a specific word or phrase can be stated as the athlete achieves the desired reduction in tension. After several pairings are made between the word or phrase and the action of relaxing muscle tension, the word or phrase can be used to trigger the response. In the movie For Love of the Game the pitcher used the phrase "release the mechanism" to trigger the quieting of his mind.

Another method of developing automaticity is through the use of concentration routines. A concentration routine is a sequence of behaviors leading up to the performance of a play or skill. The purpose of a concentration routine is to consistently get the athlete to his or her optimal performance state. This optimal performance state includes the physiological and psychological state that gives the athlete the best chance for success. What often interferes or prevents the athlete from achieving this state are anxiety-producing thoughts. Because the conscious mind has a limited attentional capacity, directing one's focus to things that do not create anxiety or result in a relaxed state serves as a buffer against anxious thoughts. The concentration routine fills the athlete's mind with activities designed to facilitate performance and leaves no space in the mind for fear or doubt.

Sample Pre-Shot Routine for a Golfer

1. Evaluate the situation
    a. Determine distance from flag
    b. Assess how the ball lies
    c. Check wind, elevation changes
2. Make club selection
3. Rehearse the shot
    a. Visualize the shape of the shot
    b. Imagine the feel in the body that corresponds to the intended shot

c. Create this feel with a rehearsal swing or two

4. Take a deep breath to take excess tension out of the body
5. Tug one time on the bill of hat to trigger the quieting of the mind
6. Address the ball
7. Take one waggle to trigger commitment to shot
8. Execute the shot

A very common frustration for golfers is becoming too tense and nervous while trying to make a four-foot putt to save par. Providing the golfer with a concentration routine can be extremely effective in helping him feel more relaxed and focused while putting and subsequently helping him make more putts. The concentration routine for the golfer begins with the reading of the putt or eyeballing it. All of the golfer's attention is now on determining what path will get the ball to the hole. Next the golfer imagines the roll of the putt into the hole. This is followed by some rehearsal putts in which the golfer produces a putting stroke that feels completely in line with the imagined roll of the putt. Just before the golfer steps up to the ball, a deep breath is taken to help shift the body into the desired physiological and mental state. The golfer then whispers a word or short phrase as he settles over the ball to trigger the action or feeling he desires. Then the putt is executed. Some of the components of the routine may differ among golfers and athletes in other sports but the principles remain the same. If the golfer can completely fill his attention with the elements of the routine, there is no room in the conscious mind for anxiety-producing thoughts. Furthermore, if the golfer has learned appropriate self-regulation skills and has paired them with taking a deep breath and whispering a word or phrase, those triggers will help move the golfer into his desired performance state. These routines should be rehearsed in all practices and competitions to enhance the possibility of the routine being automatic during critical moments.

Learning and improvement does not cease once the athlete has reached the autonomous stage. Studies have found movement patterns can continue to improve over many years of continued practice (Schmidt & Wrisberg, 2004). The improvements may be very gradual and difficult to detect, but they do exist. It is important to convey this to athletes when teaching them self-regulation skills through biofeedback training. Self-regulation is not something that one attains; rather, it is a skill that one continues to enhance.

The learning of self-regulation skills follows these three stages. Obviously moving to the third stage takes time and the correct type of practice. It should be noted that most athletes advance to the third stage of learning with most skills, but fine-tuning a skill to this level does not guarantee he will perform consistently and efficiently under all competitive situations. A common frustration with athletes is they feel unable to get a handle on their arousal levels in competition but can regulate them masterfully in practice. Learning to transfer self-regulation skills from practice to competition can be enhanced through specific types of practice conditions. In order to understand the conditions of practice that best enhance the transfer to training it is important to understand the process one goes through as they improve.

How to Maximize Learning During the Autonomous Stage

- Develop a pre-execution routine that triggers the desired psychophysiological state.
- Practice in conditions that simulate the competitive environment.
- Use random and varied blocks of trials in practice.
- Utilize telemetry (wireless) devices for biofeedback training to create the desired state or zone during competition.

Cycle of Improvement

Improved performance of a skill or set of skills follows a cyclical series of steps that can be represented in the following model (see figure 12.1).

Figure 12.1: Cycle of Improvement.

The first step is the performance itself. The performance is the benchmark of how the athlete is progressing. It must be noted that performance is not limited to the end result of a competition. The end result is certainly one aspect of performance; however, performance can also be a measure of how well one executed a specified component of a skill or strategy decision. For example, how well did a golfer perform his pre-shot concentration routines? How relaxed did the athlete remain during competition?

The second step of this cycle is evaluation or assessment. Following performance, it is important to determine which aspects of performance were successful, which should be repeated, and which need to be adjusted. The evaluation step is a very crucial step in this cycle of improved performance because the information obtained from the evaluation of performance is what informs and directs how the athlete will practice. If the evaluation of performance does not diagnose the correct sources of execution or performance breakdowns, then the correct sources will not be addressed in practice. In short, practice will be ineffective at improving performance.

Before beginning biofeedback training with an athlete, it is important to perform an accurate assessment or evaluation of the self-regulation skills needed (see Chapter 3 on assessment-psychophysiology). Assessment informs the type of training that will be conducted. Not every athlete experiences competition stress in the same way. Different types of stress may elicit different stress response symptoms within a single individual. Thus, without accurate assessment and evaluation of what specifically happens during failure and success during competition, one is left guessing at a treatment plan.

There may be any number of ways to assess which self-regulation skills would be best to teach a particular athlete. The methods of assessment may range from extensive psychophysiological measurements to detailed, structured questionnaires, to informal interviews and journal records. Regardless of the approach, the goal is to identify exactly what physiological response or responses are interfering with that athlete's performance. It is not enough to generalize the problem to an inability to deal with stress. Different physiological reactions to stress affect different performance skills. Increased heart rate, for example, often affects an athlete's sense of timing. Tempo often becomes too fast, yet the athlete feels the tempo is correct. Increased muscle tension, on the other hand, may disrupt the biomechanical efficiency of fine motor skills such as a golfer gripping the club too tight on a delicate putt. Increased worry may lead to an overactive mind and reduction in an athlete's ability to pay attention to the correct stimuli from the environment.

The goal of assessment, as it relates to biofeedback training, is to identify the physiological responses that interfere with an athlete's performance and then develop a training program that will teach self-regulation skills that eliminate or reduce the interference. Thus, after making an accurate assessment, it is important to target the correct modalities with which to train the athlete. If, for example, increased heart rate is identified as a prime source of interference, biofeedback respiration and heart-rate training may be the most effective approach to take.

It is important to distinguish between evaluation and judgment. A judgment is defined as a subjective and often emotionally impacted assessment while evaluation refers to objective and rational assessment based on specific criteria. Judgments, such as good execution or bad execution contain no real information about performance. Further, judgments lead to emotions and emotions can inhibit the rational processing of information that is needed to progress through the cycle. Judgments grind the cycle of improvement to a halt.

Planning is the third step in this cycle. After obtaining information about performance through evaluation, a plan on how to use this information is developed. Planning an effective practice or treatment plan is a creative process. The goal is to create a method of training that will move the athlete in the most efficient way towards his performance goals. Part of this process involves understanding where the athlete is in terms of the stages of learning. An athlete in the cognitive stage of learning may require a much different plan than an athlete in the autonomous stage of learning.

Let us take, for example, the golfer with whom we just developed a pre-shot routine for putting. This golfer goes out and plays a tournament (performance) and, following that event, sits down to review how well he putted (evaluation). In evaluating putting performance from the tournament, the golfer and coach find the golfer executed his full routine before each putt yet still felt the tempo on the putts was too quick. Further insight reveals the golfer is not lowering his or her heart rate to the degree that is optimal for his putting. This may suggest that although the golfer is executing his or her routine consistently, the routine is not helping to lower heart rate enough. This evaluation highlights the possibility the golfer needs to further develop his ability to assess the actual heart rate and the ability to bring heart rate down. The subsequent plan for the golfer now includes additional biofeedback training sessions directed toward teaching the golfer to lower heart rate with additional training on awareness of when the optimal heart rate is not being met.

Practice is the final step in this cycle. As stated earlier, for practice to be effective at improving performance, it must address the real needs of the athlete. These needs are assessed through performance evaluation. Practice is the implementation of a planned approach to best fulfill what the athlete needs in order to perform better. More on practice will be discussed in the next section of this chapter.

The cycle of improvement is the process of how athletes improve on an overall level and learn to perform to their full potential. In order to maximize performance, the athlete must maximize the process. Evaluations of performance that misdiagnose the sources of performance decrement lead to ill-informed planning and ineffective practices. Athletes who are learning self-regulation skills can similarly engage in this inadequate process.

Practice/Training Considerations for Biofeedback

"Practice makes perfect" is a phrase that is often repeated by athletes in their quest for improvement. This notion is a very common misconception with regard to motor learning. While it is true that repeated practice of correctly executed skills does lead to improvement; most often, athletes spend a lot of time repeating incorrectly executed skills. The body adapts to repeated practice very specifically and learns exactly what is practiced (Lee, Chamberlin, & Hodges, 2001). Merely one flaw in the repeated skill becomes part of what is learned.

The goal of practice is, ultimately, to improve the athlete's performance in competition. To achieve this, the athlete must first learn and develop the necessary skills and then learn to perform those skills correctly and consistently. It is helpful for an athlete to develop a perfectionist personality when it comes to skill performance. Skill development and skill performance are two aspects of learning. Time must be allocated to practicing and developing both aspects.

Practice/Training for Skill Development

During the early stages of skill development, the focus of training is markedly different from the latter stages. The goal for the first several biofeedback sessions is to train the athlete to consistently regulate the targeted physiological responses. This is training for skill development. Because these are new skills, the training environment must be tightly controlled with as little outside distraction as possible. Outside interference and distraction will overload the athlete's conscious mind. Similarly, anxiety will reduce the athlete's capacity to process information. In short, the optimal learning environment when training for skill development is relaxed and free of distraction. The office or clinic provides an ideal environment for this because it can be easily controlled.

During these early training sessions, what the athlete feels is happening often does not match what is actually happening, or they simply have no idea. As was noted in the temperature-warming example, with increased training, the athlete begins to demonstrate the ability to quickly and consistently produce the desired physiological responses. This, in turn, increases his or her overall confidence. Some studies have found a link between biofeedback training and enhanced self-efficacy (Sellick & Fitzsimmons, 1989). It is a mistake, however, to assume at this point that complete learning has occurred. The ability to self-regulate heart rate and muscle tension in a controlled environment does not immediately transfer to the ability to produce the same results in a highly competitive stress environment. The confidence that was enhanced can be diminished very quickly when the athlete struggles with self-regulation during a stressful performance.

Practice/Training for Skill Performance

It is false to assume that learning has occurred when the athlete can demonstrate the ability to regulate targeted physiological processes in the office or clinic. The real test to decide if the athlete has successfully learned self-regulation is how well he is able to regulate these processes during the most intense and varied competitive situations. After the first few training sessions in the office or clinic, the experience of training becomes pleasant for the athlete. He or she has begun to master the skills and is reinforced immediately with the external feedback received from the computer. It is similar to the golfer who hits the ball well at the practice range. Ball after ball is hit with great precision and control. Unfortunately, there are no competitions for who is the best range-hitter in golf.

The next progression for the athlete is to shift the training emphasis from skill development to performance. There are several differences between the nuances of the office environment and the performance environment. First, external feedback is not available in the performance environment. The athlete must rely on his internal feedback and awareness to gauge what is happening within his or her body. Second, the dynamic of the performance environment is constantly changing. Many more potential stressors are present for the athlete. There are the particular stressors that the athlete has had a history with that are especially potent. For example, a golfer may be paired with another golfer with whom he had a difficult experience in the past. Finally, the call for self-regulation skills during performance is more intermittent and random than in the office or clinic. It is not packaged into a 30- or 45-minute session. A golfer may only have five minutes between shots.

Shifting the training from skill development to performance requires the enhancement of internal awareness and changing the training environment so it more closely simulates the performance environment. The method of enhancing internal awareness during biofeedback training includes gradually eliminating the presence of external feedback.

Simulation of the competitive environment can be approached in a number of ways. One method is to bring in video recordings of intense competitive environments and show those videos during the biofeedback training sessions. If possible, video of the athlete experiencing difficulty during competition would more closely simulate the environment. Another option is to bring the biofeedback equipment to the site of the competition and train the athlete in that setting. Many portable biofeedback units are now available and can be easily used at the athlete's practice and playing site.

Another method of enhancing the performance of self-regulation skills is to vary and randomize the targeted modalities. Frequently, athletes experience anxiety in varied ways. It is not uncommon for an athlete to report feeling overly tense on one occasion and to report having cold hands on another. Directing the athlete during biofeedback training sessions to regulate different but relevant physiological processes in a variable or random sequence of trials not only widens the scope of self-regulation ability, but actually enhances the transfer of those skills to competition. In motor learning terminology, this is referred to as the contextual interference effect (Shea & Morgan, 1979). During random or variable sequencing of practice, the context of the practice sequence (random or variable distribution of trials) creates more interference or challenge for the athlete than a blocked distribution of trials. In short, it is much easier to shoot 20 jump shots from the same spot than to shoot 20 jump shots from different spots. Structuring the practice environment by including more contextual interference can yield greater execution during competition because the demands of the competitive environment have similar interference.

Learned skills (including self-regulation skills) are believed to be stored in long-term memory in much the same way that saved documents are stored on a computer's hard drive (Schmidt, 1975). Even a minute variation of a learned skill, such as regulating heart rate as opposed to regulating muscle tension, is stored as a separate skill. Similar learned skills are stored as a group or program but they are still considered separate. When an athlete is performing a skill, the skill must be retrieved from long-term memory in order to be properly executed. If the skill is repeatedly executed without variation, subsequent attempts to execute that skill can be performed without having to retrieve it again from long-term memory. If however, there is a delay between execution attempts (more than 45 seconds) or other skills are performed in between, that skill must be retrieved again from long-term memory.

If one examines the demands of the competitive environment in regards to retrieving and executing skills, we notice that rarely does an athlete retrieve a single skill repeatedly without delay or the execution of some other skill. Thus, if the purpose of practice or training is to fully prepare the athlete to execute skills correctly and consistently, it must mimic this similar demand. When an athlete is unable to execute a skill correctly during competition that he could demonstrate in training (such as regulating heart rate) it is most likely attributed to not being able to efficiently retrieve the skill from long term memory.

A method to enhance this retrieval process is to conduct training sessions that require the athlete to retrieve skills in a random or varied block of trials. For example, a trainer could ask an athlete to reduce heart rate for two minutes, then reduce muscle tension for two minutes, followed by increasing hand temperature for two minutes, and then repeating this varied block of trials two or three times.

When the athlete is able to consistently demonstrate the ability to regulate targeted physiological processes in these simulated conditions, then greater transfer of these skills to actual competition is more likely to occur. The confidence gained by the athlete that he can control physiological responses in any situation will be enduring and not easily diminished.

Summary

The ability to control one’s emotions, thoughts, and behaviors is essential for athletes who are seeking excellence. Biofeedback training provides an effective means for helping athletes develop the self-regulation skills needed to be successful. As with learning motor skills, the learning of self-regulation skills progresses through various stages. At each stage, a different approach to training is required. Understanding these stages is essential if complete learning is to occur.

Assisting the athlete to transfer effective self-regulation skills from the office or clinic to the competitive environment is the goal of consulting. This can be enhanced by shifting the athlete from relying on external feedback to his internal feedback. As the internal feedback becomes as accurate as the external, the athlete is empowered with the confidence of self-control. In addition, utilizing variable and random distribution of trials is another technique that can assist the athlete in transferring their skill improvements to various playing conditions. Finally, conducting biofeedback training sessions in conditions that more closely simulate the athlete’s competitive environment (or in real-game environments with portable or wireless equipment) allows for more complete learning to take place.

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Ethical Considerations in the Application of Biofeedback and Neurofeedback in Sport Psychology
Chapter 13

by

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Abstract

Ethics is very important when consulting with athletes and especially as new developments in the field occur and often non- professional individuals (i.e. media, other athletes, athletes' family members) are involved. In this chapter, the following consulting considerations are reviewed: competence and training, confidentiality, informed consent, the referral process and dual relationships. The authors will present several case studies to illustrate these considerations. The chapter concludes with more specific ethical considerations in Biofeedback and Neurofeedback.

Chapter Outline

I. Introduction

   a) Case example 1

II. Consulting Considerations

   a) Competence and training

   Confidentiality

   Informed consent

   When to refer an athlete to another consultant

III. Dual Relationships

IV. Case Studies

   a) Case example 2

   b) Case example 3

   c) Case example 4

V. Biofeedback/Neurofeedback Considerations: Methodology and research

VI. Conclusions

VII. References & Appendix

Introduction

Case Example 1

While participating in biofeedback and neurofeedback training, a 15-year-old athlete shows a significant inability to focus during the sessions. Upon confirming with the parents and the athlete that there are problems in school related to attention, the practitioner believes the athlete may have attention deficit disorder and asks the parents to refer the athlete for professional assessment. The parents request the coach not be told. However, the coach is the person who brought the practitioner in to test/train the athlete with the understanding that the information would be shared with the coach. What should the practitioner do?

This chapter presents ethical considerations in the use of biofeedback and neurofeedback with athletes. Ethics, as applied to the practice of sport psychology, is a set of moral standards and principles that guide the conduct of professionals in the field. The primary goal of such guidelines is to protect the welfare of the individuals and groups who seek the services of qualified professionals. The consultation process, as in the case example described above, is, at times, complex with numerous ethical issues to consider, including confidentiality, informed consent, training expectations, consultation selection, dual relationships, mental health concerns, and competence to practice. Both the athlete and the consultant should be aware of issues that may arise during consultation to minimize chances of the client experiencing emotional distress or exploitation and to maximize training success. We will discuss these and other issues in this chapter using additional case examples, so readers (consultant, coach, parent, athlete) can recognize, constructively approach, and resolve ethical dilemmas while sustaining high-level quality of care and delivery of services to the athlete.

This chapter is not intended to be an exhaustive review of the ethical issues inherent in the consultation process. Instead, the concepts and principles discussed are major themes from which the reader can gain a basic understanding of important variables to consider before practicing or teaching the techniques in this book. For a more thorough review, readers can direct their attention to the appropriate governing bodies within the fields of sport psychology and psychophysiology (see references at the end of the chapter for AASP, AAPB, BCIA, and APA Division 47 ethical guidelines). Other suggested readings from various sources are listed at the conclusion of this chapter. Regardless of the consultant's educational background or professional experience, decisions regarding professional conduct should always take into account all applicable ethical codes and/or the law. This chapter is important for both clinicians and clients to understand what entails an appropriate relationship between the athlete and consultant before consultation begins and during the delivery of sport psychology services.

Do No Harm

Research in the fields of biofeedback and neurofeedback has documented the negative effects that may occur from inappropriate training (Hammond & Kirk, 2008). Unlicensed and unqualified providers may pose a risk to the public and to the integrity of consultants who utilize these new techniques. It is important to follow standards of care that protect the public from providers who may use biofeedback and neurofeedback to work with conditions for which they are not experienced and certified to work. Some professionals are recommending providers obtain licenses as a way to establish standards of care and address ethical concerns although this is not a general consensus and may take some time to be accepted in all countries.

Consulting Considerations

Competency and Selecting an Experienced Sport Psychology Consultant

Many biofeedback/neurofeedback therapists and sports consultants have excellent credentials including relevant training, years of experience, extensive work with professional and Olympic athletes, and research publications. Experience and competence is only one essential piece to finding an appropriate consultant. Without the intention of limiting a consultant's qualifications to the subsequent list, a competent consultant should have at least the following:

- Credentials, certification (see appendix 1), or a comprehensive educational and training background in sport psychology, sport sciences, and psychophysiology.
- Knowledge in the specific sport for which the consumer is requesting services.
- Awareness about his/her limitations to practice, treat, or train in a given area.
- Supervised training experience working with athletes and psychophysiological monitoring devices.
- Knowledge and commitment to ethical guidelines of organizations such as Association for Applied Sport Psychology, International Society for Neurofeedback and Research, Association for Applied Psychophysiology and Biofeedback, Biofeedback Certification Institute of America, and the American Psychological Association.
- Acquisition on a regular basis of continuing education credits and an ongoing process to keep their knowledge base current.
- Trainer's own neurofeedback and biofeedback experience: There is one kind of professional experience that is most relevant, and that is the trainer's own personal experience doing biofeedback and neurofeedback. There are questions frequently asked by the client, such as "How do you notice that you are successful?" and "What does success feel like?" which the trainer can best answer from personal experience doing his or her own training.

Confidentiality

Confidentiality is always an important part of the consultation process with athletes, coaches, and organizations. Confidentiality is the legal and ethical right of the client and should be discussed throughout the consultation process. No professional, coach, or practitioner has immunity from legal requests for information nor can the professional promise confidentiality if the client or others may be in harm's way.

Many athletes prefer to keep private their work with a sports consultant for various reasons (privacy, avoidance of perceived stigmas, not to inform coaches or opponents of a potential weakness), especially as other parties might be called on or included over time (i.e., parents, coaches, media, agents, etc.). First and foremost, the identified client holds privilege and confidentiality. Therefore it is important to clearly identify who is the client. Typically, confidentiality is granted to the individual who is requesting the service and the client if he or she is 18 years old or older. However, if an athlete's agent (or parent or coach) requests the service for the athlete, this can create confusion about who is the actual client. In any case, confidentiality and its limits should be discussed on an ongoing basis with all parties involved.

Some athletes are quick to say yes to signing a release of information to have the consultant talk to their agent, coach, teammate, the media, or other person of authority because they might be able to help, in the athlete's mind. It is the duty of the consultant to forewarn the athlete about such exchange of information and the potential problems (as well as benefits) that may arise and to assure the client's situation is not exploited. When a third party is contacted, after written consent is obtained from the client, confidentiality should be closely monitored. The type and extent of information that will be disclosed should be thoroughly considered and discussed, preferably in writing, as the management and dissemination of this information will vary depending on whom the consultant is talking with. It is recommended that any signed release be very specific as to the limits of the information to be discussed.

Informed Consent

Ethical problems and potential conflicts between client and professional are more likely to occur when there is a difference in expectations, with either goals or the training process. It is, therefore, always advisable to construct an informed consent form that lays out the training process in detail, the goals, and the limits of what should be expected. For example, it is important for the client to be aware that biofeedback may be an "experimental procedure." And while it is likely the client will experience greater mastery over his or her physiology, there is no guarantee this will translate into measurable gains in the particular sport in which the client competes. The process of informed consent will also explain procedures, such as the application of electrodes to the body and head. This will let the client know, beforehand, that some physical touching will take place.

Informed consent should also let the athlete know he has the right to terminate training at any time. By going over this information with the athlete, asking if he understands and if he has any questions, and finally, having him sign the informed consent, the consultant ensures that he has agreement to proceed. If the athlete is under 18 years of age, parental consent is needed or, when at training camps and the coach has the *parental en loci*, the coach will be held responsible for signing the consent.

When to Refer an Athlete to Another Consultant (Competence and Expertise)

Sport psychology consultants and biofeedback/neurofeedback clinicians may work in all areas of sports or specialize in only one or a few sports (e.g., golf). If the athlete decides to work with a consultant who is not experienced in a particular sport, the consultant may need to consult with an expert in that specific sport. A consultant who has knowledge in a certain topic related to an intervention does not mean he has expertise to practice that intervention. It is the consultant's responsibility to obtain the advice or supervision of another consultant who does have expertise in the sport area in question or receive adequate coursework or formal training before initiating an intervention. Yet in some cases, the needs of the client or urgency may supersede the aforementioned, and a referral may be more appropriate. Anderson &Van Raalte (2005) provide a useful checklist of issues to consider before a consultant should refer a client to another expert. He also provides other recommendations for athlete issues that require special consideration, how to build an effective referral network, when to refer out, and important steps to consider in the referral process. Van Raalte & Anderson (1996) provide a useful discussion of problems that may require referral in the athletic population, depending on the expertise and professional role of the consultant. Potential referrals may be made because of physical issues (technical training of a sport task, medical concerns such as pain from a recurring injury), personal/interpersonal issues (aggression or sexual issues), location (athlete is traded), or psychopathology (anxiety disorders, depression, eating disorders, etc.).

In addition, every athlete's success with biofeedback and neurofeedback will be different. Issues such as psychiatric disorders, medications, drug and alcohol use, motivation, and family/team environment may affect training results. If an athlete is not achieving successful or beneficial results, a trainer may consult with another therapist for additional training ideas. At times, this consultation may result in the athlete being referred to a consultant who has more expertise or a specialization in a given area. When a sport psychologist uses a consultant while continuing to see the client, he or she should maintain case management status. In addition, if an athlete is not making progress in biofeedback training or in competition performance within a reasonable timeframe, discontinuation of training may be warranted.

Dual Relationships

Just as in other areas of training and clinical work, falling into dual relationships presents ethical concerns. What is a dual relationship? Any client/professional relationship engenders an imbalance of power with the potential for coercion. Dual relationships may include situations in which the sport consultant functions in more than one professional relationship leading to role blurring and potential conflict of interest. For example, if a sport consultant is also a friend of the athlete, the consultant may not be able to maintain objectivity and maintain both the professional and personal relationships at the same time. Entering into a business relationship with a client is another example of a dual relationship that can lead to a break or disruption in boundaries. Consultants who work with professional athletes, on rare occasion, choose to barter for services (exchange training services for tickets to sporting events, equipment, or sports apparel, etc.). This may pose problems because there is always the risk of taking unfair advantage or of the client being unable to make an unbiased independent decision. In the rare case where such a relationship appears justifiable, the professional should obtain outside consultation from colleagues or a second opinion as to its appropriateness. The well being and trust of the client is of the utmost importance, and consultants should procure the relationship in such ways (i.e., consulting with other professionals) that minimize the blending of roles and any possible exploitation of the client.

Case Studies

The case studies presented below are composite profiles of various athletes. Information about the athletes is altered to secure individual identity. We recognize that many of the ethical concerns that arise in sport consultation are complex and often unpredictable. Therefore, there is no simple answer or solution that would apply across the board to all the possible consulting quandaries. With this in mind, we provide a few examples of ethical dilemmas with potential solutions:

Case Example 2

A 21-year-old softball player sought services from a nonclinical sport psychology consultant for a specific throwing problem called the throwing yips. The client was a catcher who had developed a fear-linked throwing problem that prohibited her from making accurate throws back to the pitcher (she would throw it in the dirt or over the pitcher's head with jerky, uncoordinated throwing mechanics). The problem developed after she inadvertently hit the pitcher in the buttocks while trying to throw out a base runner who was trying to steal second base. Teammates, fans, and coaching staff reacted with laughter, and the client reported she felt humiliated and embarrassed. The mother of the client had initiated contact with the consultant with concern that the client was feeling down emotionally and was having thoughts about quitting. Following several sessions working with the consultant, the consultant introduced some imagery exercises to help the client work through her throwing problem. Upon visualizing herself throwing in a game, the client began crying in session. The consultant immediately stopped the imagery exercise to question what the client was experiencing. After a few more sessions, the client did not show improvement and the consultant received a desperate phone message from the client's mother who, with a tearful voice, expressed her concern about the client's condition and lack of progress. The client's grades were beginning to drop, and she was beginning to argue more with her parents at home.

Questions to consider:

1. Is a clinical referral appropriate here? What transpired in this session that might suggest to the consultant that he should make a clinical referral?
2. Once a referral is made to a clinical/counseling psychologist, should the consultant discontinue his services or can he continue working with the athlete? What are the role and boundary issues between consultant and psychologist if both practitioners were to stay involved?

Answers:

1. Yes. Many athletes, when performing poorly, can present feeling “bummed out” or depressed. This may not mean the client is struggling with a clinical issue and does not preclude nonclinical performance enhancement consultants from being able to help this particular client. The difference in this example is that progress over time was not occurring; in fact, the client was getting worse on multiple levels. Second, her performance experiences were affecting her at a significant level beyond her participation in sport. Her grades were dropping, and she was experiencing increased interpersonal difficulties. The mother’s voice message also suggests there may be family dynamics that need to be addressed from a therapeutic standpoint (possibly over-investment or an enmeshed relationship). Most important, the performance consultant recognized the athlete’s emotional problems were possibly related to issues outside the consultant’s area of expertise.
2. The nonclinical consultant can and should continue to work with the athlete, minimally, to reinforce the importance of the referral, and assist in the transition to the clinical consultant. The clinical consultant can then begin to help the athlete work through therapeutic issues while the nonclinical consultant continues to address performance enhancement issues. Note: The two consultants should have a signed release of information from the athlete prior to working together.

> Although there may be some overlap in the work performed (e.g., confidence/self-esteem building techniques), the consultants can carry out a professional dialogue that clarifies role boundaries, who will be performing which services, and how to best help the client. Consultant roles should also be discussed with the client to avoid confusion about which consultant is treating what problem. For example, it is made clear that discussion around family dynamics or debilitating anxiety should be reserved for the clinical consultant. Issues around proper execution of imagery rehearsal or pre-performance routines should be reserved for the nonclinical consultant.

Case Example 3

A 20-year-old, first-round baseball draft pick is referred by his sports agent to a clinical sport psychologist because of suspected psychological components impeding injury recovery. The agent himself had consulted several times with the psychologist before the referral about problems he was having with other athlete clients. The agent and the psychologist had a long-term, working, professional relationship with each other; however, this was the first direct referral from the agent to the psychologist. Presenting problem: The athlete complained he was emotionally up and down because of sporadic improvements in his recovery from arm surgery. “Every time I feel better, I push myself and then re-injure my arm.” Prior to the injury, the athlete had very specific goals for how he was going to make it to the Major Leagues. He was the type of player who wore his heart on his sleeve and refused to allow his injury to hold him back. The athlete’s 'charge hard and give 110 percent' attitude, which most likely helped him attain his current status and success, was now complicating his recovery because he was not setting good boundaries with himself during rehabilitation. During the course of a three-month consultation process, the client started to spiral out of emotional control, becoming increasingly resistant to following his physician’s and physical therapist’s rehabilitation recommendations, placing himself at risk for re-injury. On several occasions, the father of the client and the referring agent called the consulting practitioner requesting specific information regarding the client and details about the content of what was being discussed with the client during sessions. The agent had also requested the psychologist call the athlete's father to help calm the father down as the agent believed the father was over-involved and further complicating the athlete's progress.

Questions to consider:

1. Who is the identified client?

2. What are the confidentiality issues surrounding the psychologist's interactions/conversations with all parties involved (client/parent/agent)?

3. How can the psychologist be sure to maintain good boundaries with the referring agent while preserving a good business relationship and level of trust?

Answers:

1. The primary client is the athlete. What makes this case complicated is the fact that the agent had consulted with the psychologist about other athletes before he referred the athlete in this example. This might imply the agent is the client. However, in this case, the athlete was receiving the service, not the agent; therefore, he holds the privilege of confidentiality. It is important that this is clarified with the agent (and all parties involved) before services commence, especially as the agent was accustomed to receiving feedback to a certain degree with an expected amount of detail from the psychologist. The amount of feedback in this case would be appropriately modified to protect any outstanding potential concerns from the athlete. For example, the athlete could be concerned that leaking information to the agent about the athlete's emotional struggles or issues may negatively impact the agent's motivation to get him the best deal.

2. Another complication for the psychologist is that the athlete gave consent to the psychologist to speak openly to the father and the agent about the therapeutic relationship even though the athlete had concerns about how this information would be

received and used. The agent had an obvious role in influencing future business decisions, and the father was emotionally controlling and interfering with the client's ability to make his own decisions. The psychologist decided it was in the client's best interest to share only basic information with both the agent and the father about the therapeutic goals and the client's progress toward those goals while leaving out information about his specific emotional and relationship struggles.

3. The best solution is to be clear and upfront with the agent about the importance of confidence and trust in the therapeutic relationship and how a lack of trust may hinder the athlete's progress or desire to share vulnerabilities or concerns that have held him back. If the agent is clear that this is in the best interest of the client, he will be more likely to accept the necessary boundaries of the professional relationship. These boundaries, furthermore, can be spelled out in any release the athlete signs, so there is a clear guideline for discussions when they occur.

4. Another way of addressing this issue is to have a joint session with the athlete, father, and agent.

Case Example 4

A tennis player was referred by her parents to one of the authors to help deal with performance anxiety and "choking" under pressure. It was clear this young athlete pushed herself hard and would get very disappointed in herself when she made mistakes. She was particularly hard on herself when she double faulted. In addressing her self-talk and attempting to help her become more accepting, it was obvious she was taking her lead from her parents and how hard they were pushing her. It was not possible for her to be accepting, as she was always noticing what she was not doing adequately.

The game was no longer fun for this young woman, and she was preoccupied with worry about her game and whether she was going to disappoint her parents. In the inquiry process, it was clear the athlete had not recognized the connection between her tension and worry and the demands of her parents, partly because she had bought into the same philosophy. It was also apparent the parents felt they, in fact, had been letting up, and they were not as demanding as they were previously.

Questions to consider:

1. Is it the sport psychologist's role and responsibility to address the pressure placed on the athlete by the parents?
2. If it is appropriate, should the sport psychologist address this with the young athlete or with the parents?

Answers:

1. The sport psychologist's function is to address factors affecting performance and to find ways of improving the performance of the athlete. Tension and fear are common factors that interfere with performance. Thus, it would be appropriate to address these issues in this case.
2. This is obviously a very sensitive issue and could be perceived as the psychologist going beyond the bounds of the agreed consulting. It could also be seen as a challenge to the parenting being conducted. An intervention would be pointless, whatever the need, if there was little chance of it leading to success. Furthermore, experience has shown that a threatening or challenging intervention with parents can result in termination of the professional relationship. What the psychologist chose to do in this situation was to begin by educating the athlete as to the relationship between her performance and her tension and worry and how placing pressure—either her own or from her parents—can add to this tension and distraction. This was followed by addressing self-acceptance and how to treat herself along with ways of doing this. It was then suggested that it might be helpful to bring in her parents to give them tools to help the athlete, which she agreed to. In the meeting with the parents, the strategy was for it to be very constructive. There was the assessment of tension and worry impacting performance. Then the parents were given assignments as to

how they can help with the tools the athlete was learning. They were instructed to help with breathing exercises and to actually do these with the athlete. Visualization exercises were incorporated into the process that used words such as let go and acceptance. From this point, there was a mutual discussion of what things were compatible with these concepts. The process was successful in modeling for the parents and athlete and subtly getting the important points across.

Practicing Biofeedback/Neurofeedback: Research/Methodology Considerations and Recommendations

Methodology & Research

As noted in previous chapters, research in the area of sport and biofeedback has been quite extensive. However, despite an exciting amount of data collection, especially in the past decade, the nature of how biofeedback training is conducted continues to present challenges in clearly defining protocol efficacy for the enhancement of performance. Presented below are a few areas in research and practice that need to be addressed to continue to assure biofeedback can be practiced as an efficacious performance intervention. These are general guidelines and observational recommendations; therefore, careful consideration should be taken, as not all of these suggestions will apply to every athlete and every sport.

- **Training to a criterion:** Typically, biofeedback research protocols have not included clear and specific training criteria that will lead to performance improvements. For example, some consultants observe, in their clinics, EMG levels below a certain number (i.e., 5 microvolts) are a good target for training. However, research does not indicate that teaching an athlete to lower EMG levels to one level (e.g., 4 microvolts) will necessarily produce more performance improvements for a specific task compared to training EMG levels at another level (e.g., 3 microvolts). We may postulate that general decreases in muscle tension bode well for performance; however, there is a gap in the research for delineating which measure to use, for what sport and task, and how long training should last to determine learning has occurred and performance has improved. There are several ways to address this issue: 1) compare the athlete's individual performance over time. Is there a relationship between the drop in EMG in the office training and the self-report of the athlete or coach in the reduction of muscle tension when playing? Does the athlete make fewer errors related to muscle relaxation (more rhythm, better accuracy, etc.)? Thus, obtain baseline measures and then retest. 2) Decide beforehand what the purpose of the training is (e.g., stamina, focus, calmness, etc.). A clear purpose will help determine which measures, protocols, and criteria to select. 3) Develop clearly defined and operationalized criteria for successful use of the measure in question (e.g., neurofeedback Theta/Beta ratio cutoff scores for ADHD). 4) Use wireless devices to compare in-office training to measurements in competition. 5) Compare changes in measures (e.g., EMG, neurofeedback) with actual performance changes across time as well as self-evaluation changes from the athlete and evaluations from coaches.

- **Length of training sessions:** Several of the early biofeedback studies used only a brief number of training sessions. It is necessary for future research to begin to determine how many training sessions are necessary and the length of training required with each physiological measure (HRV, EMG, EEG, etc.). The difficulty in accomplishing this is that sports and sports tasks vary to such a great degree it makes it challenging to discover the precise recipe for success for each individual athlete. Training and statistical norms need to be established for various sports and sport tasks.

The number of biofeedback training sessions typically reported by clinicians in sport is usually within the range of 5–15. Sessions are typically 30–50 minutes in duration; however, some researchers are using sessions of much shorter duration. Recommended training length for athletes is still under investigation and needs to be determined. It is suggested clients be queried frequently as to their reactions to training, with the trainer gaining a sense of preferences and parameters that appear most successful over time. Peripheral biofeedback sessions in excess of 15 should be explained with a specific range of sessions proposed depending on the results of the particular athlete's biofeedback stress profile assessment (see Chapter 3 of this book) and training goals. If an athlete is not showing any progress after 10–15 sessions, the practitioner should question the effectiveness of the training.

The number of neurofeedback sessions for clinical populations varies, ranging from 10–60. A higher number of sessions are necessary in the athlete who also has a formal diagnosis of attention deficit hyperactivity disorder (ADHD), learning disabilities, anxiety, depression, head injuries, autism, or psychological disorders. Some neurofeedback therapists will recommend that a QEEG brain map analysis be conducted prior to the onset of neurofeedback training to determine the most specific and individualized neurofeedback training protocols. More traditional training sessions are conducted in an office setting or laboratory although recent improvements in computer technology (portable and wireless equipment) is allowing many consultants to use their equipment with athletes on the playing field.

- **Methods of information display:** Information can be presented in auditory, visual, or tactile modalities. Frequently these are combined. There has been very little research comparing all the various types and combinations of information presentation. Some trainers display an animation that is static when criteria are not met and animated when criteria is met. If the clinician is using two screens, the clinician's screen would display the raw data while the trainee sees only the animation. Some trainers believe more specific information about the EEG is helpful. Again, the appropriate research has not been performed to be able to say which is the more effective approach or under which circumstances one approach is better than another. The practitioner needs to experiment with each sport to see which display more closely matches the requirement of the sport. For example, a moving target seems more appropriate for sports with moving objects, such as tennis or baseball or an athlete may prefer to train while viewing video of his performance. Some athletes also have strong opinions of like and dislikes regarding displays, and thus, experimentation on which fits the athlete is necessary.

- **Biofeedback equipment:** Using the most recent/appropriate biofeedback and neurofeedback equipment is another important methodological issue. Biofeedback instruments have been used since the 1960s, and some older analog equipment with meters versus digital and computerized feedback still exists. Newer equipment is not always better as some equipment manufacturers build less-expensive instruments that have not been through the proper approval process. Many of the most common instruments have received FDA approval for relaxation purposes and underwent the stringent FDA approval process.

- **Generalization of training:** A common complaint among athletes is the difficulty they experience in transferring successful execution of skills from practice to competition (see chapter 12 by Sverduk). This same problem exists in transferring the skills learned in the biofeedback laboratory (relaxation/energizing) to the playing field. Some of the chapters in this book address this issue. Suggestions include taking the equipment out onto the playing field and training in the competitive sport environment. The advent of wireless equipment is making this approach more possible. Creating ways of instilling pressure or stress into the training situation can insure hardier skills and better skill development.

- **Home training considerations:** There are different levels of home training enhancing mental skills and performance. There are relaxation and visualization exercises that can be performed as homework along with other assignments. There is also a growing interest in home biofeedback and neurofeedback training. It is important that the professional and the athlete are in agreement as to the assignment and that the athlete makes a clear commitment to the assignment. When dealing with home training of neurofeedback, it is important that the athlete or parent is sufficiently trained in setting up the equipment, operating the software, and applying electrodes in order to insure good connections and signals. The athlete should have frequent monitoring in the clinician's office approximately every 10 sessions or once a month if possible. An appropriate quality control should be in place that would optimally include the professional being able to take over the athlete's computer in order to check out procedures and recordings. The athlete also needs to demonstrate an understanding of the measures being taken and have the skills to be able to make progress on the measures being monitored. It is the practitioner's responsibility to consistently check on the quality of the home practice (test in the office) and checking to ascertain whether the home training is creating the desired effect.

Conclusion

While there is a growing number of sport psychologists and related professionals using biofeedback and neurofeedback to help athletes improve their performance, there are few controlled studies employing these techniques. As a result, it is important for professionals to be cautious in how they promote their practice and to avoid implying inappropriate expectations. As noted previously, this process can be facilitated through a clear setting of goals and noting baseline levels of both physiology and performance. It should be indicated in most instances that procedures are still experimental in nature. Periodic review of results and comparison of those results with training goals and expectations are important considerations before a decision is made to continue with biofeedback or neurofeedback training.

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Appendix I

Certification in Biofeedback/Neurofeedback and Sports Psychology

In the areas of biofeedback and EEG biofeedback (neurofeedback), there is a national certification organization called the Biofeedback Certification Institute of America (BCIA) based in Colorado that certifies therapists in both biofeedback and neurofeedback (see www.bcia.org). The BCIA certification process requires a certain amount of supervised hours of experience (by a BCIA certified therapist) in biofeedback or neurofeedback. A thorough examination must be taken and passed. BCIA certifies therapists in several categories, from beginner to fellow.

In the area of sport psychology, there are a few certification organizations. The Association for Applied Sport Psychology (AASP) is the most prominent governing body of sport psychology in the United States. AASP offers certification to consultants who wish to acquire a level of competency to practice consistent with AASP standards. A smaller group of consultants acquire membership or approval to be listed on the United States Olympic Committee (USOC) registry. The USOC has standards similar to AASP that require its members to have accrued certain standards in competence related to experience, education, and ethics.

Many biofeedback therapists, neurofeedback therapists, and sport psychology consultants are experienced but are not certified. This may be because of various reasons and does not necessarily preclude them from doing good work. Consumers should be cautious in who they select as a consultant and should use the guidelines suggested above.

Athletes with ADHD and Autistic Spectrum Disorder (ASD)
Chapter 14

by

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Abstract

This chapter begins with an overview of ADD and Autistic Spectrum Disorder (ASD) . The chapter describes how ADD and ASD effects and even can benefit athletes in various sports . Assessment and treatment of ADHD and ASD are presented . The chapter ends by discussing several professional athletes who have ADD and/or ASD, reviewing their QEEG brain maps assessments and their successful results from the use of biofeedback and neurofeedback treatments.

Chapter Outline

Overview of ADD

Overview of Autistic Spectrum Disorder

Athletes with ADD and ASD

Assessment of ADD/ASD

a.) Clinical interview

b.) Behavior rating scales

c.) Continuous performance tests

d.) QEEG mapping evaluation

VIII. Professional Athletes with ADHD

a.) NBA player with ADHD: Kris Kaman, NBA L.A. Clippers

b.) MLB player with ADHD and anxiety

c.) Professional athlete with Asperger's: Clay Marzo

IX. Summary

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Overview of ADD

An estimated 10 (possibly up to 20) percent of professional athletes have attention deficit-hyperactivity disorder (ADHD), compared to four to eight percent of the general population of adults. Many athletes with Asperger's are undiagnosed and excel at technical positions such as catcher, goalie, surfing, running, and martial arts.

The three core characteristics of ADHD are inattention, impulsivity (acting before thinking), and hyperactivity. ADHD is genetic, begins in childhood, and lasts more than six months. ADHD is diagnosed using behavior rating scales, family history, continuous performance tests, and brain functioning tests (i.e., QEEG).

There are several different types of Attention Deficit Disorder. The inattentive type (ADD) is more distracted, forgetful, unorganized, off-task, and has slow reaction time. The hyperactive type (ADHD) can be hyperactive and/or impulsive. People with ADHD are more likely to be fidgety and restless, to jump offside, or get into impulsive fights, but can have quick reaction times. A less common type of ADHD is the over-focused or busy brain pattern that frequently experiences anxiety. Other types of ADHD occur together with depression and learning disabilities.

The most common treatment for ADD/ADHD is stimulant medication. Stimulants such as Ritalin, Adderall, and Concerta are successful with approximately 60 percent of children, but less than 50 percent of adults. However, the effects of these medications are temporary, and adults with ADD are more likely to experience side effects then children because 85 percent of adults with ADD have co-occurring anxiety and/or depression, and 50 percent may have alcohol and/or drug problems. Common side effects of stimulants are appetite suppression/weight loss, anxiety, insomnia, irritability, rebound withdrawal, and sedation. Many athletes complain that while taking stimulants, their reaction times are slower during their sport performances. Moreover, currently, most professional sport organizations do not allow athletes to use stimulants during training and events.

Neurofeedback or EEG biofeedback has been used with individuals with ADD since 1976 (Lubar, 1976) and is becoming more widespread as a non-drug treatment for ADD/ADHD that has lasting effects without side effects. The success rate of Neurofeedback is approximately 80 to 90 percent.

In the past 10 years, neurofeedback is being individualized by basing the protocols on a brain functioning test called the QEEG map. The QEEG map results in identification of subtypes of ADD/ADHD, including an over-focused type that often becomes worse with activating treatments (i.e., stimulant medication) (Chabot, 1996). The QEEG maps determines what brain-specific locations and speeds (frequencies) are imbalanced and can be improved with neurofeedback. Common results from neurofeedback are the ability to remain calm under pressure, decreased performance anxiety, increased focus or “zone” states, and performance.

Overview of Autistic Spectrum Disorder (ASD)

Individuals with autism have three main areas of difficulties: communication, socialization, and unique stereotyped behaviors, such as hand flapping, rocking, and stemming. High-functioning autistic individuals have only mild communication and language problems. Asperger’s Syndrome is the most under-diagnosed of the ASD because often these individuals are very bright and articulate and can over-focus intensely on technical aspects such as goalie techniques and golf swings.

ASD has traditionally been diagnosed by the behavior observations of language/communication and socialization delays early in childhood. Asperger’s is often diagnosed much later in childhood, adolescence, or even adulthood. However, since 2004, researchers have been utilizing QEEG brain mapping patterns to confirm not only diagnoses of autism and Asperger’s but to determine specific subtypes of ASD for more individualized and successful treatments (Linden, 2004; Coben, Linden, & Meyer, 2010).

Common treatments for ASD initially focused on improving children’s communication and language skills using behavior therapies and then improving social skills later in childhood through skills training groups. However, there have yet to be any medications that have been specifically developed to treat ASD although several antidepressants (e.g., Prozac, Lexipro) and atypical antipsychotics (e.g., Risperdal, Abilify) are commonly used. These medications may target ASD symptoms such as anxiety and obsessiveness but often have undesirable side effects such as sedation, emotional numbness, and weight gain.

Neurofeedback with ASD began in 2002 (Jarusiewicz). Since 2004, researchers and clinicians (Linden, Coben) have been using QEEG guided neurofeedback with individuals with ASD to specifically target improvements in communication, socialization, anxiety, obsessiveness, and overactive behavior.

Athletes with ADD & ASD

Many athletes who have mild to moderate ADHD or autistic spectrum disorder are able to excel in sports if they find the right fit. Some individuals and athletes have both ADD/ADHD and Asperger's. If their ADHD or Asperger's symptoms are severe, most of them will need to be treated. However, the use of medication is often not allowed in most professional sports. Baseball is an exception, where recently MLB has allowed the use of stimulants based on an official diagnosis of ADHD.

The following professional athletes have reportedly been diagnosed with ADHD: Michael Phelps, Terry Bradshaw, Pete Rose, Bruce Jenner, Magic Johnson, Jackie Stewart, Babe Ruth, Michael Jordan, Nolan Ryan, Jason Kidd, Greg Louganis, Adam LaRoche, Alex Trevino, Derek Lowe, Scott Eyre, and Tom Gorzelanny.

What are some of the individual sport advantages of having ADHD? Some sports do not require intense concentration for long periods but rather short bouts of attention (15 seconds) or short shifts as in football or hockey. Athletes with ADHD perform better in individualized or fast sports; they have quick speed and reaction time if they can control their impulsivity. Athletes with ADHD have a heightened awareness of their environment. They have the ability to do well under pressure and under chaotic situations, for example, a quarterback rolling out to avoid a rush and completing a pass across the field. Athletes with ADHD have unique and creative problem solving abilities and can make a novel play out of a problem situation. Because their impulsivity leads them to often live in the present, they also have a lack of concern about losing at the moment.

On the other hand, sometimes athletes with ADHD will need to be referred to a sport psychologist who is experienced with ADHD. An athlete may be performing inconsistently or be streaky. They may perform well in practice but not in games or be bored or unmotivated in practices. Athletes with ADHD may perform well in unstructured situations and poorly in important and structured situations. They have breakdowns in concentration, such as taking their eyes off the ball, and may be forgetful (e.g., plays, time outs remaining). Athletes with ADHD may be late to or miss practices, which can lead to conflicts with coaches and teammates. They may become easily frustrated and act impulsively, throwing equipment or getting into a fight. They often have problems going to sleep because they cannot stop their thoughts or calm down at night and may use prescription medications or drugs/alcohol to help them relax or sleep.

Many athletes with autism and Asperger's are undiagnosed yet excel at technical positions (e.g., catcher, goalie, surfing, running, martial arts). The following athletes have reportedly been diagnosed with high-functioning Autism and/or Asperger's: Clay Marzo (surfing), Jim Eisenreich (MLB), and T. Mac (high school basketball). We have also had experience with several hockey goalies and field goal kickers. These athletes are often described as quirky, or loners and develop numerous routines that need to be followed in order for them to be successful.

Some of the advantages of having Asperger's in sports are being able to over-focus on technical aspects, such as throwing a curveball, three-point shooting, making the perfect jump in skiing, turning in surfing, or goalie save techniques. They are able to hyper-focus on their techniques and practice for long periods of time. The most successful athletes can increase their hyper-focusing when necessary, such as a pitcher in a full pitch count or a goalie in a shootout. In addition, athletes with Asperger's have a greater ability to stay calm in high-pressure situations and when they make a mistake as a result of having less emotional responsivity.

Some of the reasons to refer athletes with Asperger's or high-functioning autism to a sport psychologist who is experienced with ASD are if they have difficulty with unfair or incorrect official/referee calls. All games have bad or inaccurate calls, but athletes with Asperger's may not be able to let go of these calls and become frustrated and thus lose focus.

They also often have difficulty with lack of structure, such as overtime or extra innings. Changes in their environment can also pose problems. For example, competing in a new or loud stadium, staying in a new team hotel, or having to wear a different uniform fabric or number after being traded. Athletes with Asperger's will have difficulty socially bonding with other players and end up playing positions that are more individualized, such as goalies, relief pitchers, or field goal kickers. Finally, they may remain over-focused on techniques, even if these techniques are unsuccessful—for example, a quarterback's or relief pitcher's throwing motion.

Assessment of ADHD/ASD

The following tests are recommended to accurately assess ADD/ADHD/ASD. For additional information, please refer to www.attentionlearningcenter.com.

Clinical Interview

The clinical interview includes obtaining certain developmental and childhood history such as age of onset, duration, developmental history, history of any head injuries, other medical factors, and family history. For athletes, the interview should inquire about their focusing, confusion, performance, and consistency during practice and competitions in both stressful and non-stressful situations and environments.

Behavior Rating Scales

Behavior rating scales are completed by coaches, parents, and teachers for students and adults and their significant others. Behaviors about inattention, impulsivity, hyperactivity, and social skills are rated on a degree scale and compared to norms of people the individual's age who either have or do not have ADHD or ASD.

Continuous Performance Tests

Continuous performance tests (CPT) require subjects to pay attention to a 10- to 22-minute monotonous task and respond differentially to both target and non-target stimuli.

The intermediate variables of attention (IVA) uses both auditory and visual stimuli (numbers) over a 15-minute period of time. It measures inattention, impulsivity (response control), reaction time, and consistency in both modalities. The IVA also measures auditory and visual information processing. The IVA is sensitive to subtle treatment effects of medication or neurofeedback. The scoring of the IVA is based on a score of 100 being average with a standard deviation of 15. An individual's IVA score lower than 85 is impaired. IVA scores should be within 15 points of one's intelligence (IQ) scores.

QEEG Mapping Evaluation

Quantitative electroencephalography (QEEG) is the statistical analysis of the electrical activity of the brain. It is a brain-mapping tool used to evaluate differences in brain function compared to a database of people without difficulties. The QEEG is based on an EEG recording monopolar electrodes from 19 scalp locations according to the international 10–20 system referenced to the right and left earlobes. Delta (0-4Hz), Theta (4–8Hz), Alpha (8–12Hz), Beta (15–20Hz), SMR (12–15Hz), and EMG (20–32Hz) brainwave frequencies are recorded during eyes-open visual attention, reading, and eyes-closed conditions.

In the brain maps below, the color green and one color gradation above and below on the scale represents the normal range. The hotter colors represent excesses of brain electrical activity and colder deficits of brain activity. Some of these excesses and deficits are abnormal and are related to specific behavioral and/or attention difficulties, ASD, anxiety, or mood disorders. QEEG enables the formulation of treatment options guided by the brain patterns associated with abnormal behaviors rather than relying only on symptoms and behavioral measures. This procedure has been normed on thousands of children—adults in several multisite research studies. The research studies on the QEEG indicate sensitivity and specificity greater than 88 percent for attention deficit-hyperactivity disorder (Neuropsychology, 1999, 2001). Biological brain-imaging tests such as the QEEG, SPECT, and PET scans are becoming the most accurate tests for diagnosing biological-based ADHD and ASD.

A recent application of QEEG Mapping in sports is in the area of concussions. The QEEG Map usually displays an abnormal pattern of slow activity and coherence/connectivity abnormalities in the area where a closed head injury or concussion occurred. Neurofeedback can be used to treat concussion symptoms such as headaches and memory loss, for additional information refer to www.mpccares.com/QEEGNeurofeedbackwithconcussionssum2009.pdf.

Professional Athletes with ADHD

NBA Player with ADHD: Kris Kaman, NBA Los Angeles Clippers

Kris was diagnosed ADHD as child. He was prescribed stimulant medication, had negative side effects, and then discontinued use. QEEG map analysis as an adult reportedly revealed a high Beta pattern, which often doesn't respond to stimulant medications. Kris trained with neurofeedback and significantly improved his scoring and rebound average the following season and was one of the most improved players in the NBA and continues to maintain his performance improvements.

MLB player with ADHD and Anxiety

Randy (name changed to protect his confidentiality) was diagnosed with ADHD and anxiety. He was prescribed the stimulant medication Adderall but had side effects. Randy underachieved in college baseball his first few years. A QEEG map was administered (see Figure 15.1), and the results indicated high Theta (daydreaming, ADHD) and high Beta (anxiety). Randy was trained using QEEG guided neurofeedback to enhance SMR (lowers impulsivity and anxiety, increases relaxation), inhibit Theta (decreases distraction, increases focus) and inhibit Beta brainwaves (lowers anxiety).

Randy also was trained with HRV and GSR biofeedback to decrease anxiety and increase batting performance. Furthermore, he was trained in the use of mental skills such as visualization. As a result of Randy's training, he became more successful in college baseball and was drafted by a MLB team.

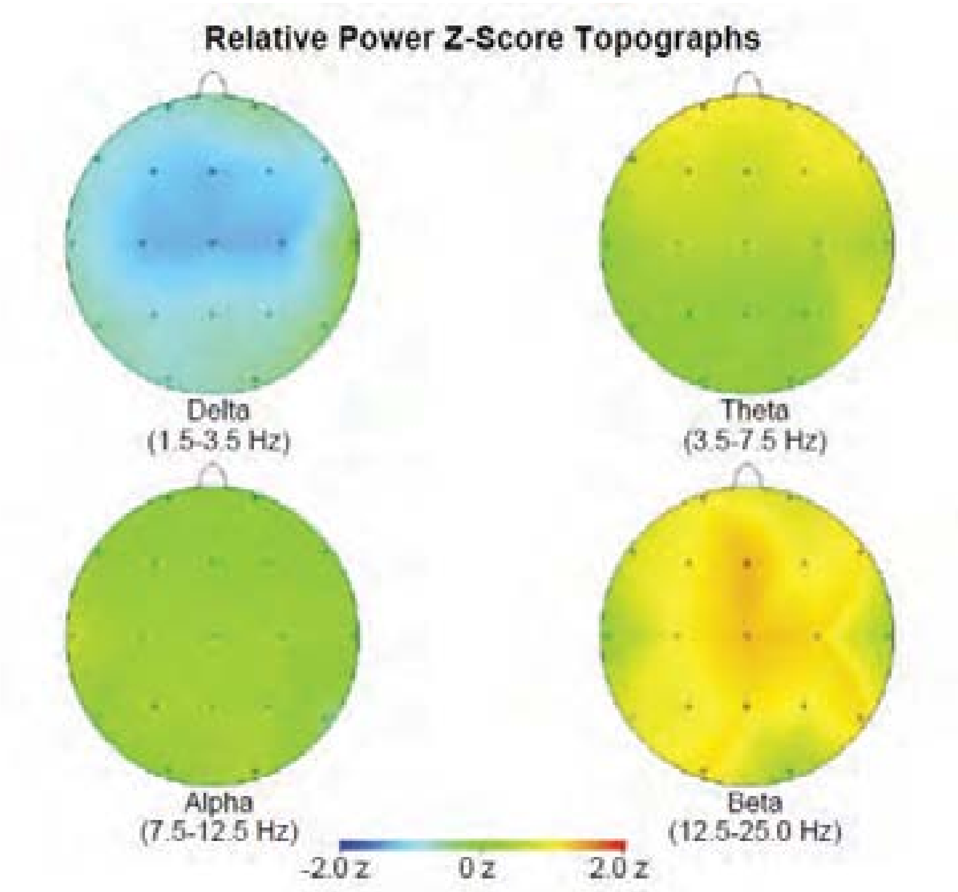


Figure 15.1: Randy's QEEG Map.

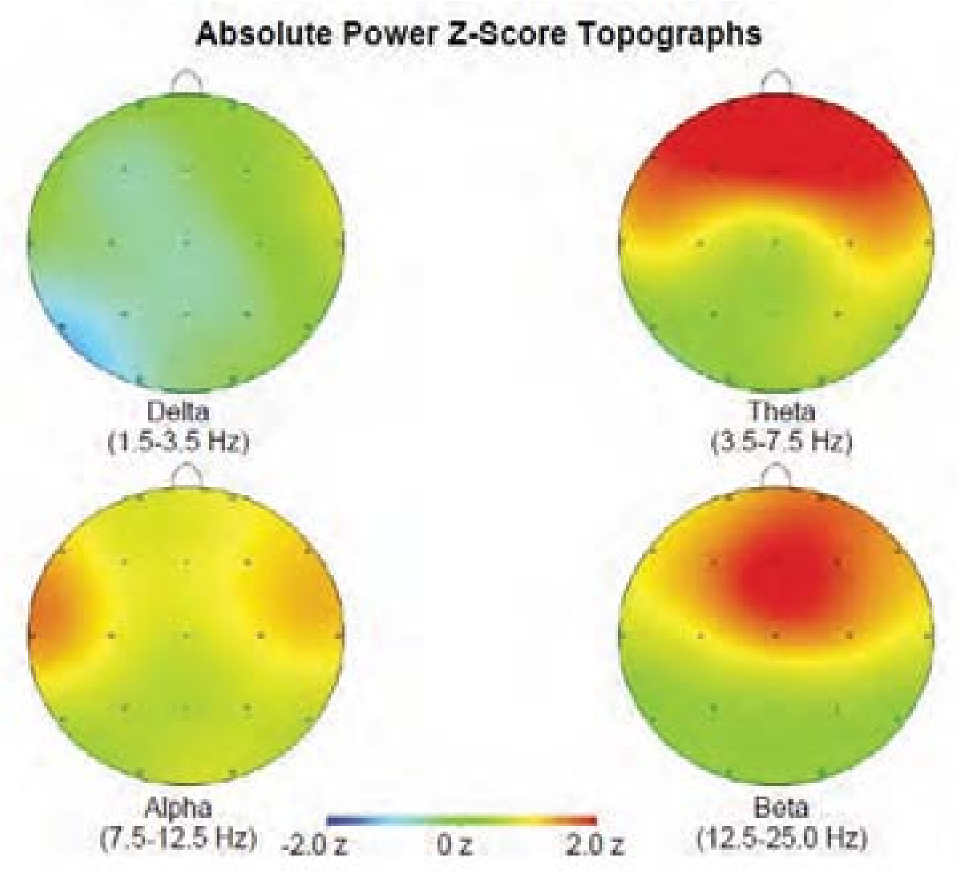
Professional Athlete with Asperger's: Clay Marzo

Clay spent 10 years searching for an accurate diagnosis while being raised in Hawaii. He was diagnosed with Asperger's at Attention Learning Center in 2007 using QEEG mapping ASD subtype analysis developed by Michael Linden (Linden, 2004). Clay's story was featured in August 2009 on the ESPN60 TV show (www.espn60.com), in Outside Magazine in September 2009, in ESPN The Magazine on September 7, 2009 (www.espn.com), and in Rolling Stone Magazine in September 2010.

Asperger's Athlete—QEEG Map

Clay Marzo's QEEG brain map (Figure 15.2) indicates increased (red) Theta (slow activity related to inattention and impulsivity and increased (red) Beta (fast activity related to anxiety, over-focusing, and obsessiveness). According to research at Attention Learning Center (Linden, 2004; Coben, Linden, & Meyers, 2010), high Beta is one of the most common patterns in individuals with Asperger's.

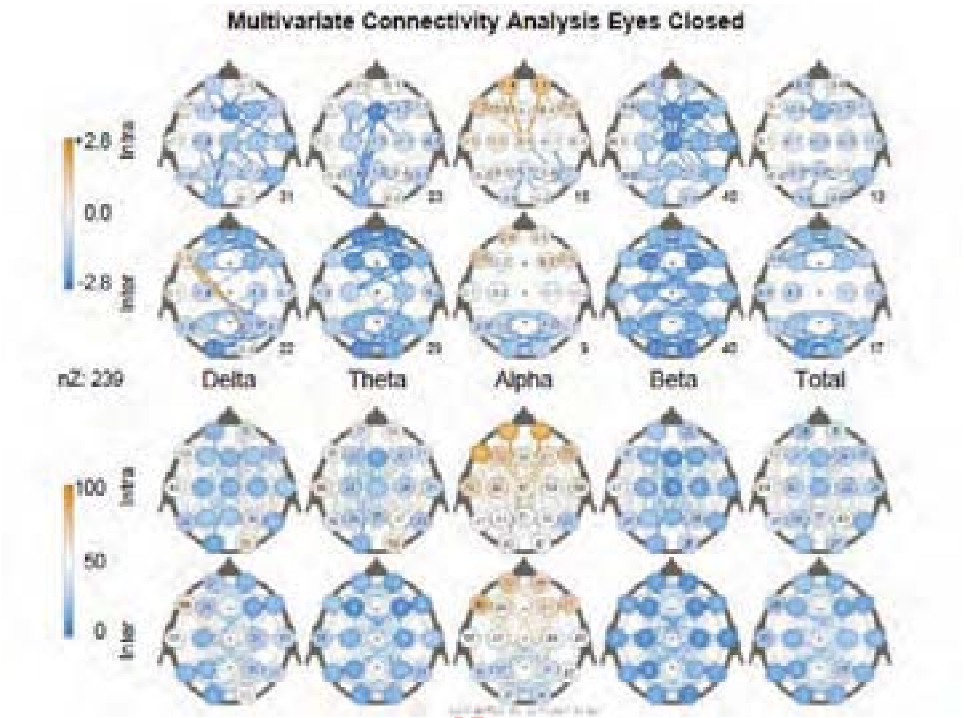
Figure 15.2: Clay Marzo.



Asperger's Athlete—QEEG Map Coherence

Figure 15.3 indicates hyper-coherence (too highly connected) in frontal Alpha brainwaves (orange) and hypo-coherence (dark blue) in right parietal areas in many brain frequencies. The frontal part of the brain is involved in over-focusing and the right parietal area of the brain is related to social and emotional functions. According to Attention Learning Centers research (Linden, 2004; Coben, Linden, & Meyers, 2010), right parietal hypo-coherence is a common pattern in individuals with Asperger's.

Figure 15.3



Summary

This chapter began with an overview of ADHD and ASD, including standard common techniques and treatment methods. The chapter described athletes with ADHD and ASD, including strengths and weaknesses. We explained state-of-the-art assessment tests, including computerized CPT tests and QEEG mapping brain imaging. Examples of professional athletes in basketball, baseball, and surfing with ADHD and ASD were discussed, including reviewing their QEEG maps.

It is likely that athletes will become more open to investigating a diagnosis of ADHD or ASD as knowledge of more accurate brain functioning assessment, such as QEEG, increases and more awareness of non-drug treatment without side effects such as neurofeedback occurs. This should create alternative options for these athletes to improve their performance and overall functioning while decreasing concerns of side effects and prohibited medication use.

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